1. Accepted: abstract by International Food Conference (25-8-2021)
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2. Submitted: Full paper to International Food Conference 2021 (22-9-2021)
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4. First Revision: Major Revision (10-3-2022)
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5. Second Revision:Linguistic Aspects (19-3-2022)
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6. Third Revision: Final Revision (21-3-2022)
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8. Paper Corrected Before Published (27-4-2023)
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Gmail

Paini Sri Widyawati <paini@ukwms.ac.id>

Abstract Acceptance

International Food Conference 2021 <ifc@ukwms.ac.id> Wed, Aug 25, 2021 at 8:00 AM
To: paini@ukwms.ac.id

Dear Participant,
First of all, congratulations! Your abstract is accepted! Through this email, we would like to attach some important information for the next step. We also attach the guidelines books below and hopefully these can help you. Thank you and once again, congratulations!

Best regards,
IFC Committee

2 attachments

Guidelines IFC 2021.pdf
4411K

Acceptance Letter IFC 2021_Paini Sri Widyawati (RDP-87).pdf
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INTERNATIONAL FOOD CONFERENCE 2021
AGRICULTURAL TECHNOLOGY FACULTY
WIDYA MANDALA SURABAYA CATHOLIC UNIVERSITY
Jl. Dinoyo 42 – 44 Surabaya 60265

IFC 2021 International Food Conference

Surabaya, August 22th 2021

No. : 37/FTP-IFC/8/2021

Subject : 3rd Circular Abstract Acceptance

Paini Sri Widyawati

Widya Mandala Surabaya Catholic University

Dear Paini Sri Widyawati,

On behalf of the INTERNATIONAL FOOD CONFERENCE (IFC) 2021 Organizing Committee, we are pleased to inform you that your abstract entitled **Potency of Pluchea (Pluchea indica Less) Leaves to Increase Functional Value of Wet Noodles** with **RDP-85** has been selected for the **POSTER** presentation at the IFC 2021, which will be held on November 3rd, 2021, as an online conference. Congratulations!

Please prepare your full paper with an appropriate template according to the type of publication you choose. Templates are available on link below:

- https://www.myfoodresearch.com/author-guidelines.html (Food Research Journal)
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No.	Publication	Additional charge
1.	Food Research (Q3 Scopus-Indexed Journal)	USD 350
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Please submit the full paper online through website http://ocs.wima.ac.id/index.php/IFC2021/home by September 10th 2021 through your account (see attached IFC Guidelines page 25). Should there be any other information needed, feel free to reach out to us.

We are looking forward to meeting you at the conference.

Best regards,

Anita Maya Sutedja, PhD
Chair Person of Organizing Committee

Dr. Ignatius Srianta
Dean of Agriculture Technology
Widya Mandala Surabaya Catholic University
Surabaya, Indonesia

IFC 2021

International Food Conference

Website User Guide

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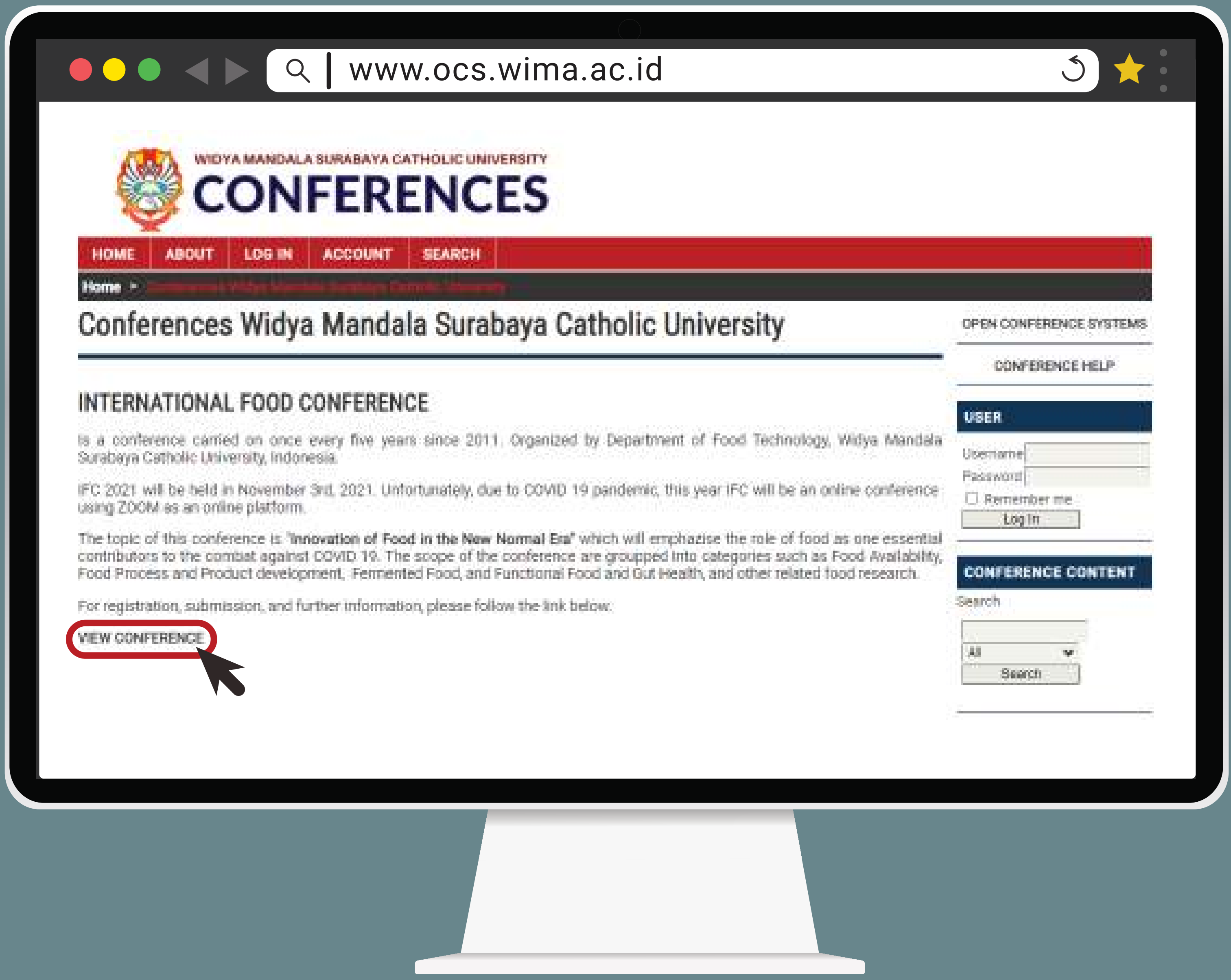
Then select "view conference" for entering IFC website



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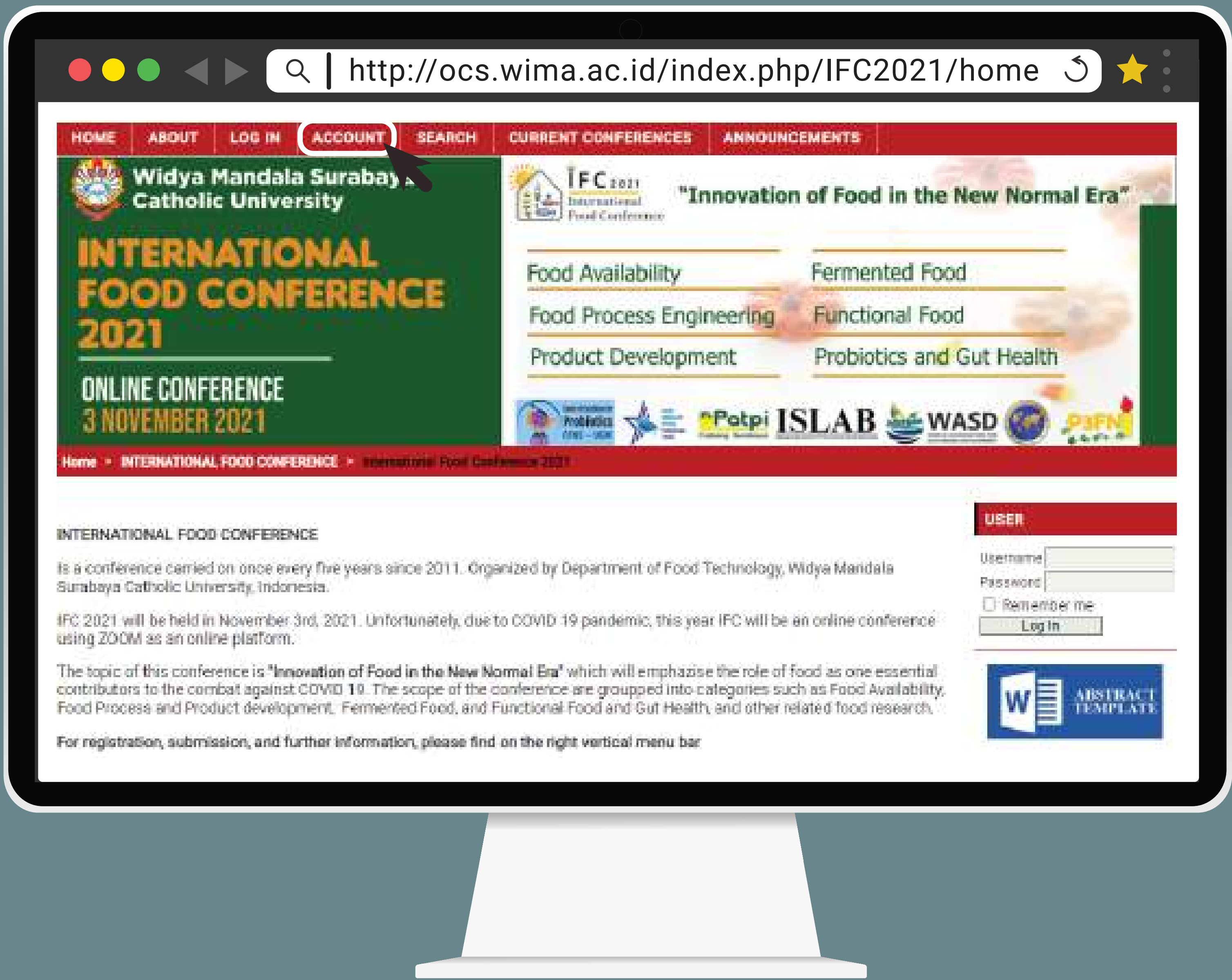

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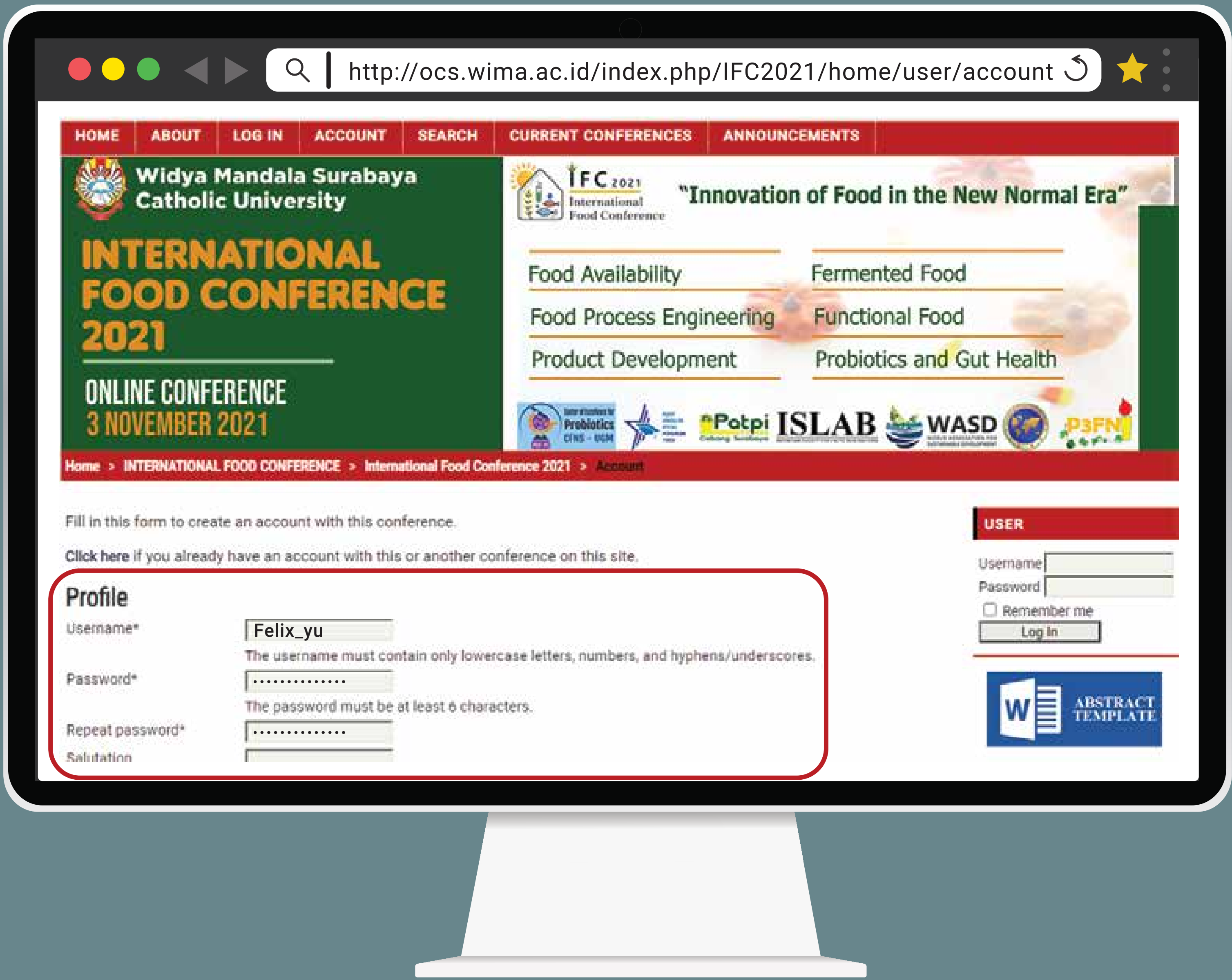

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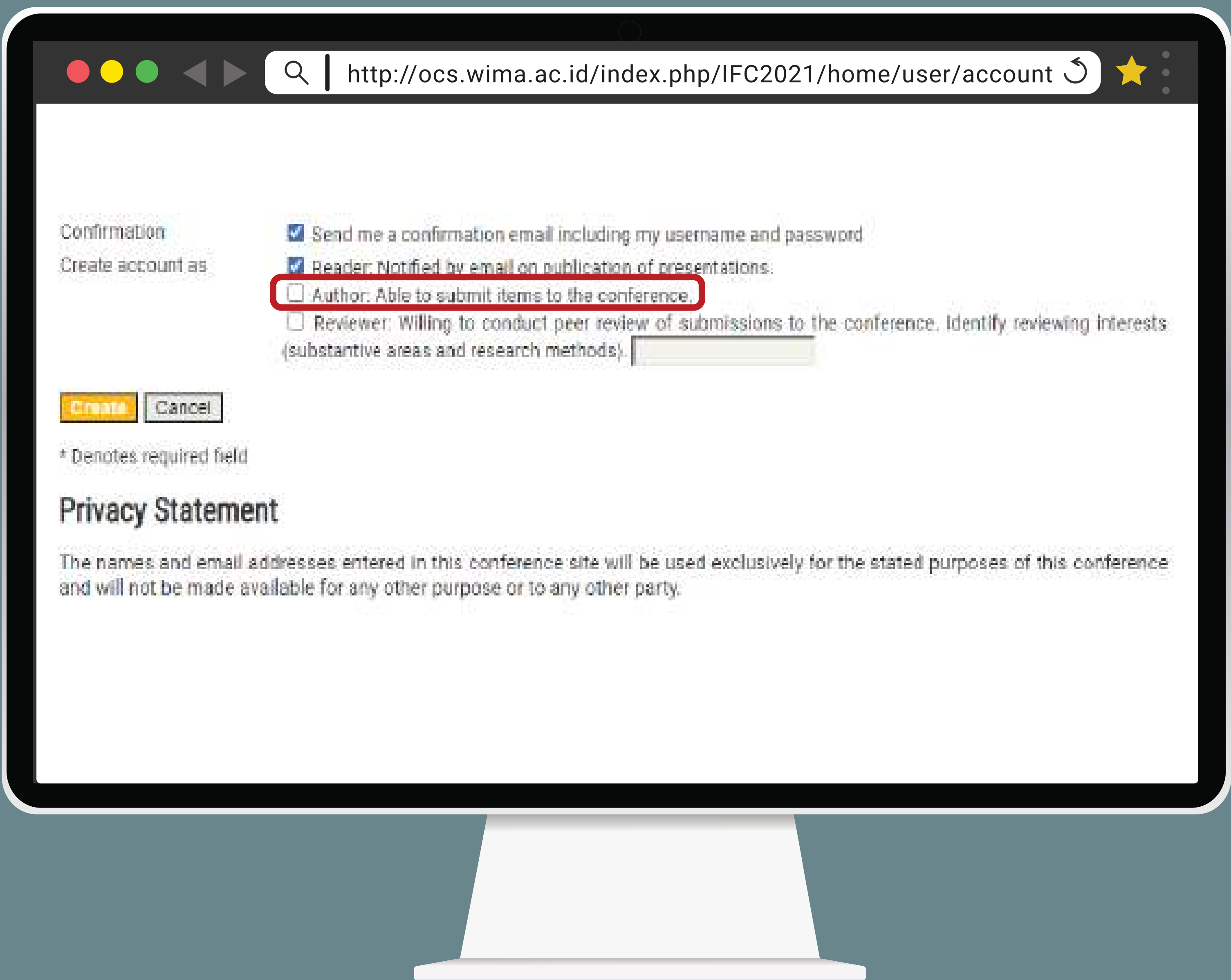

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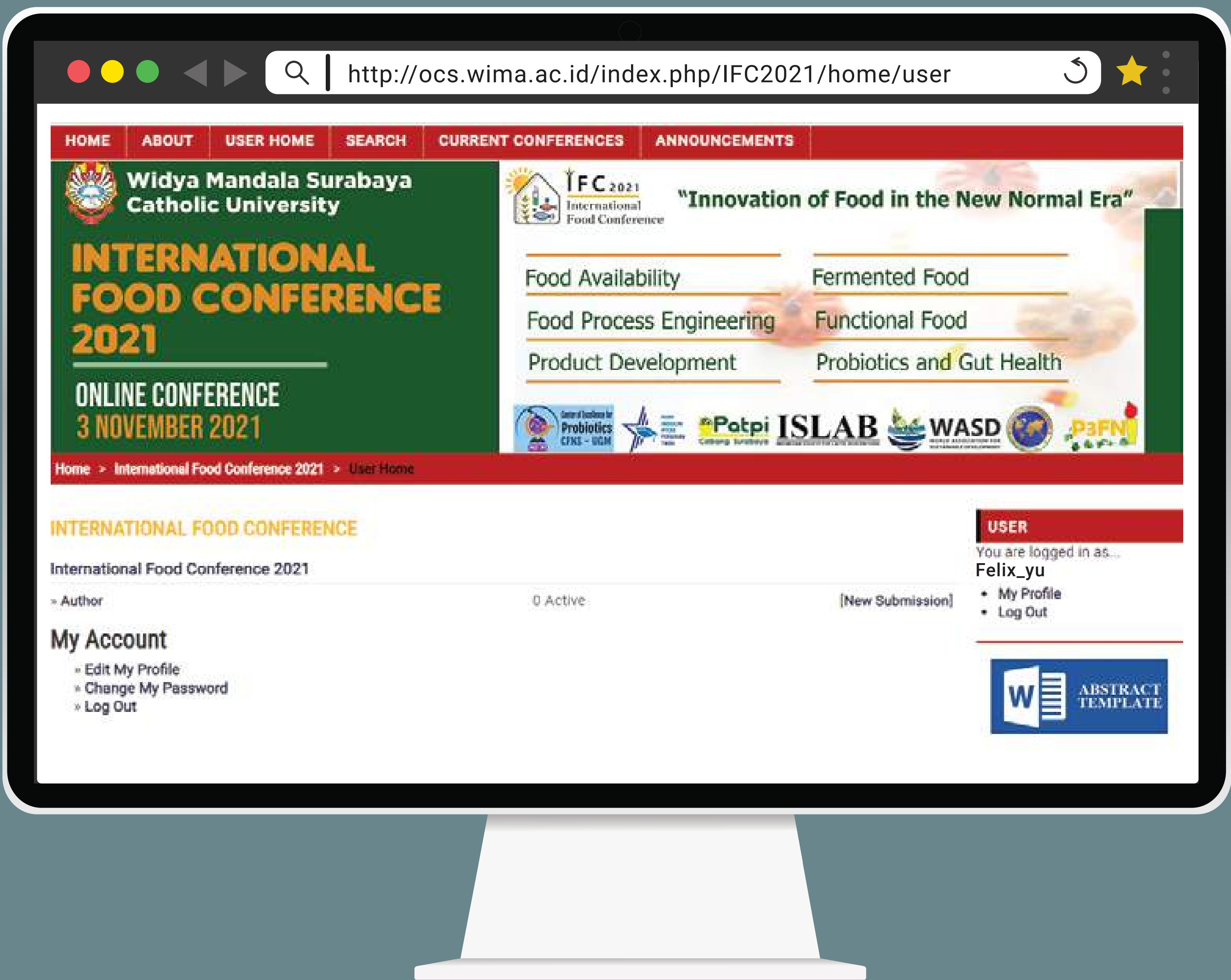

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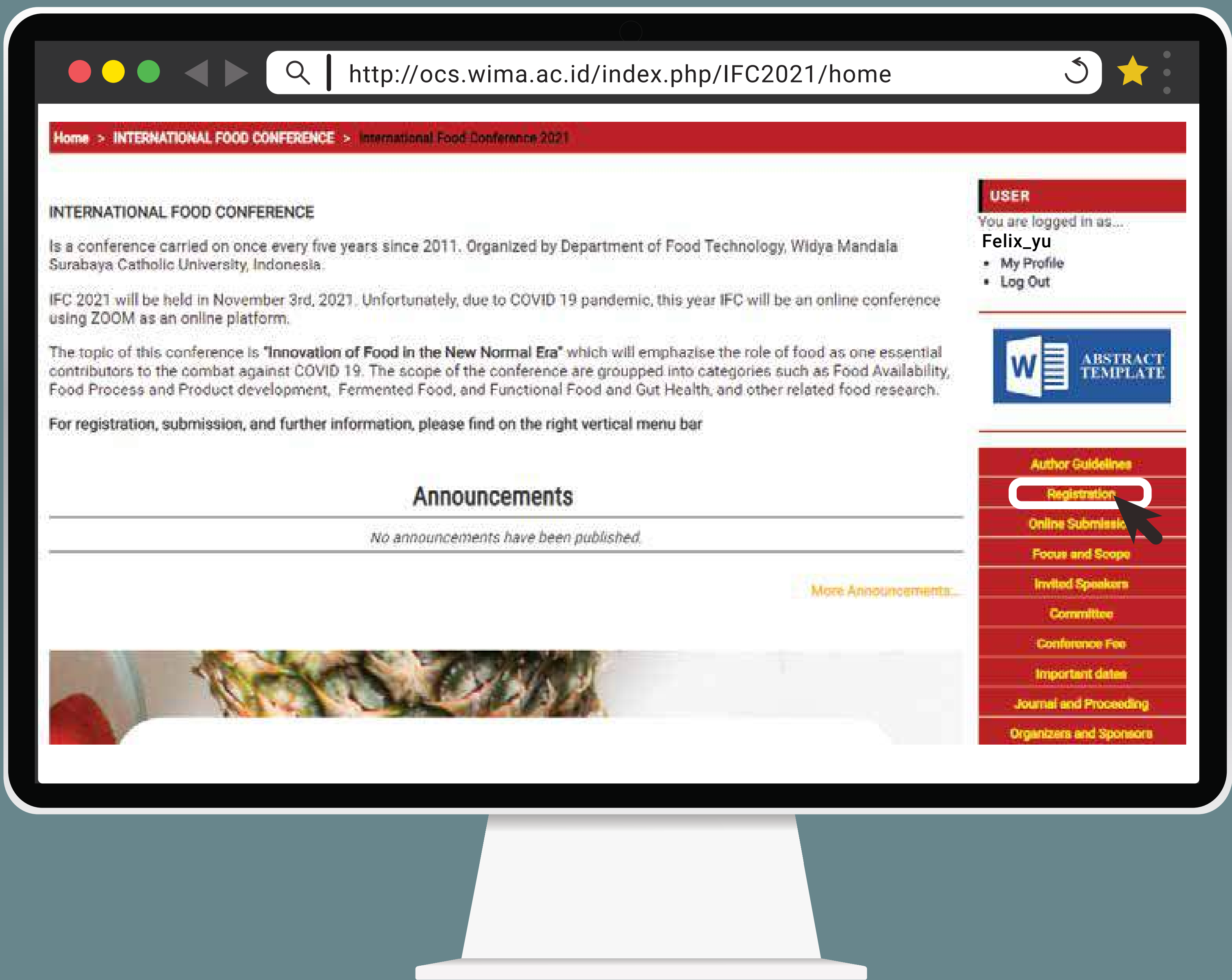

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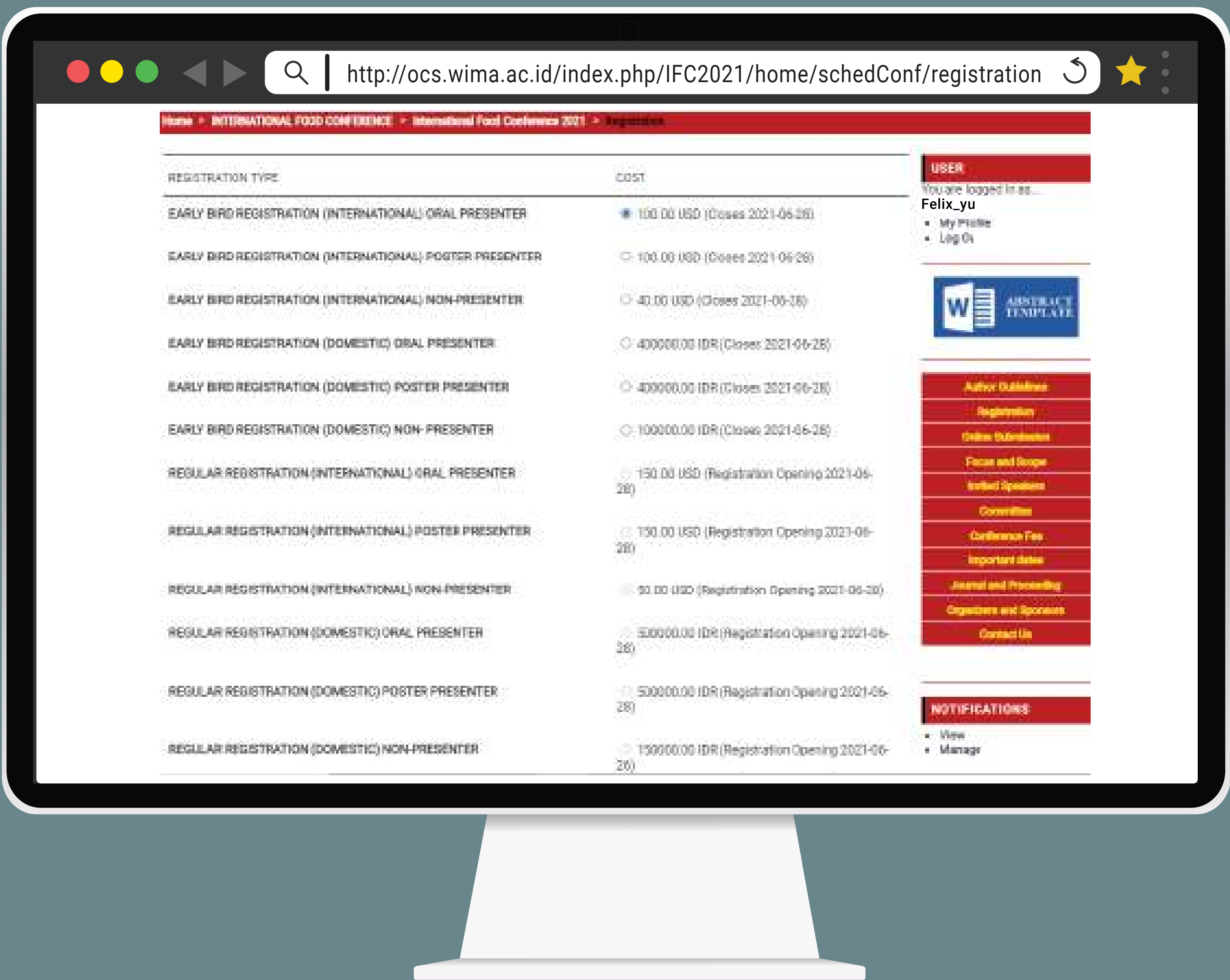

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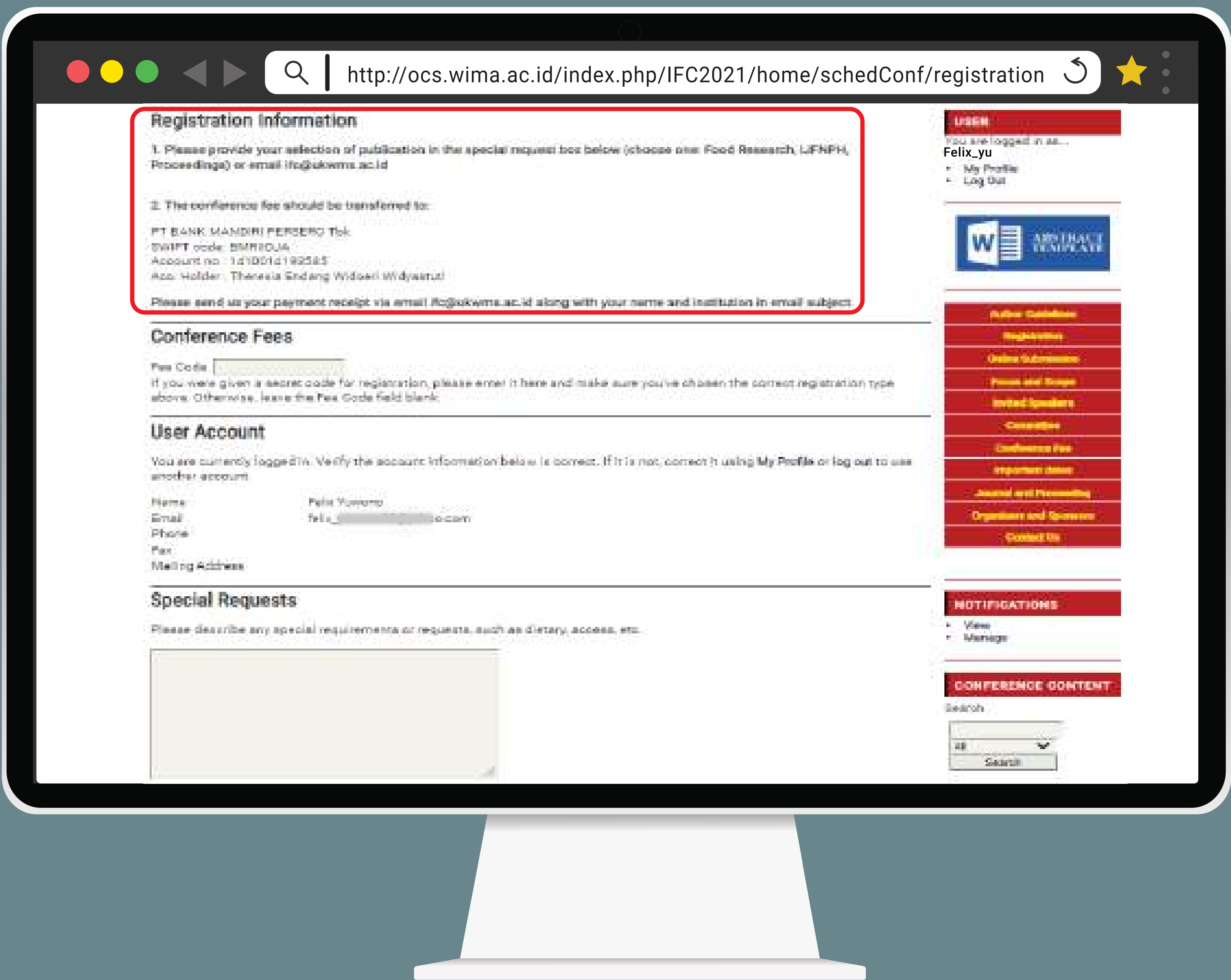

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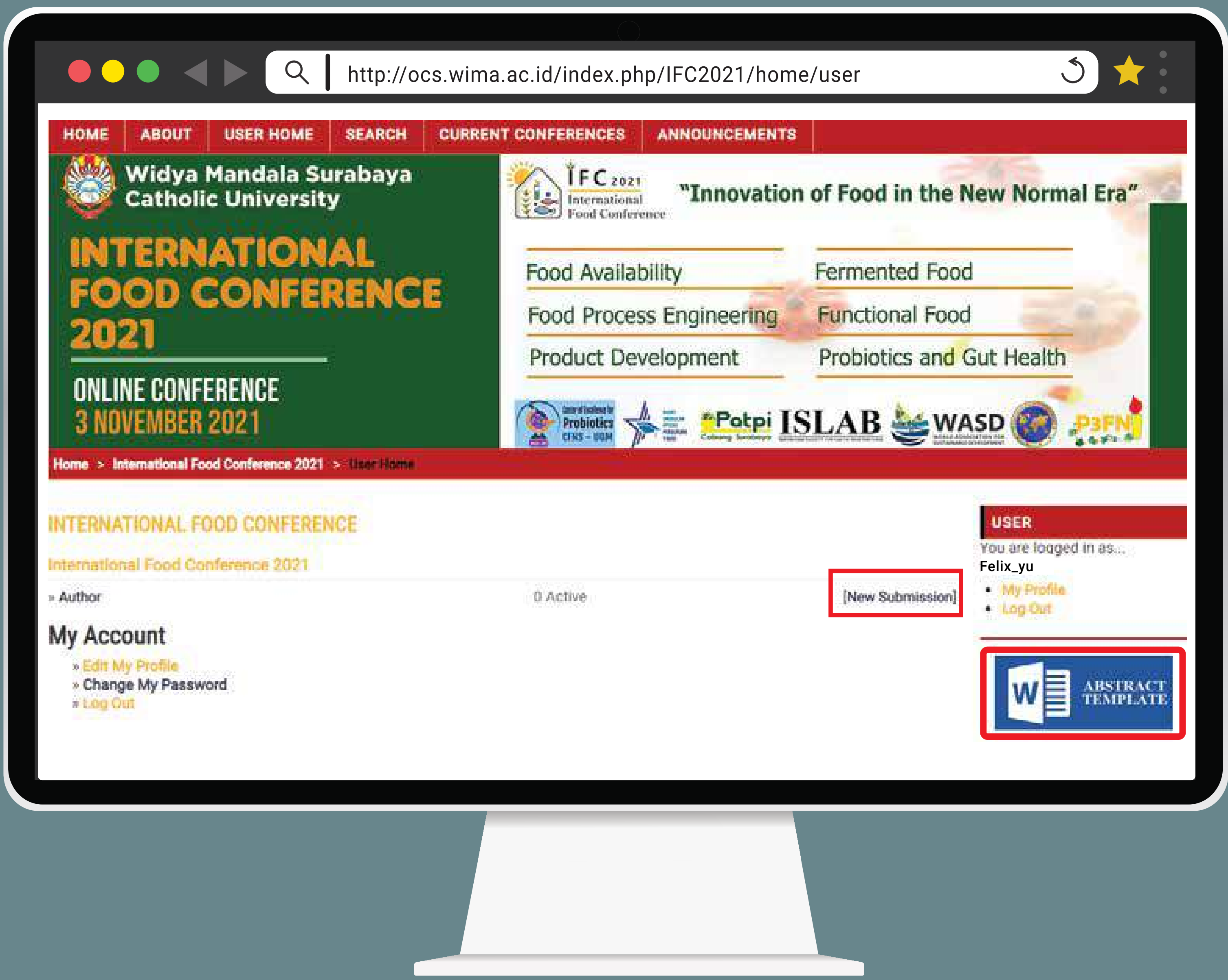

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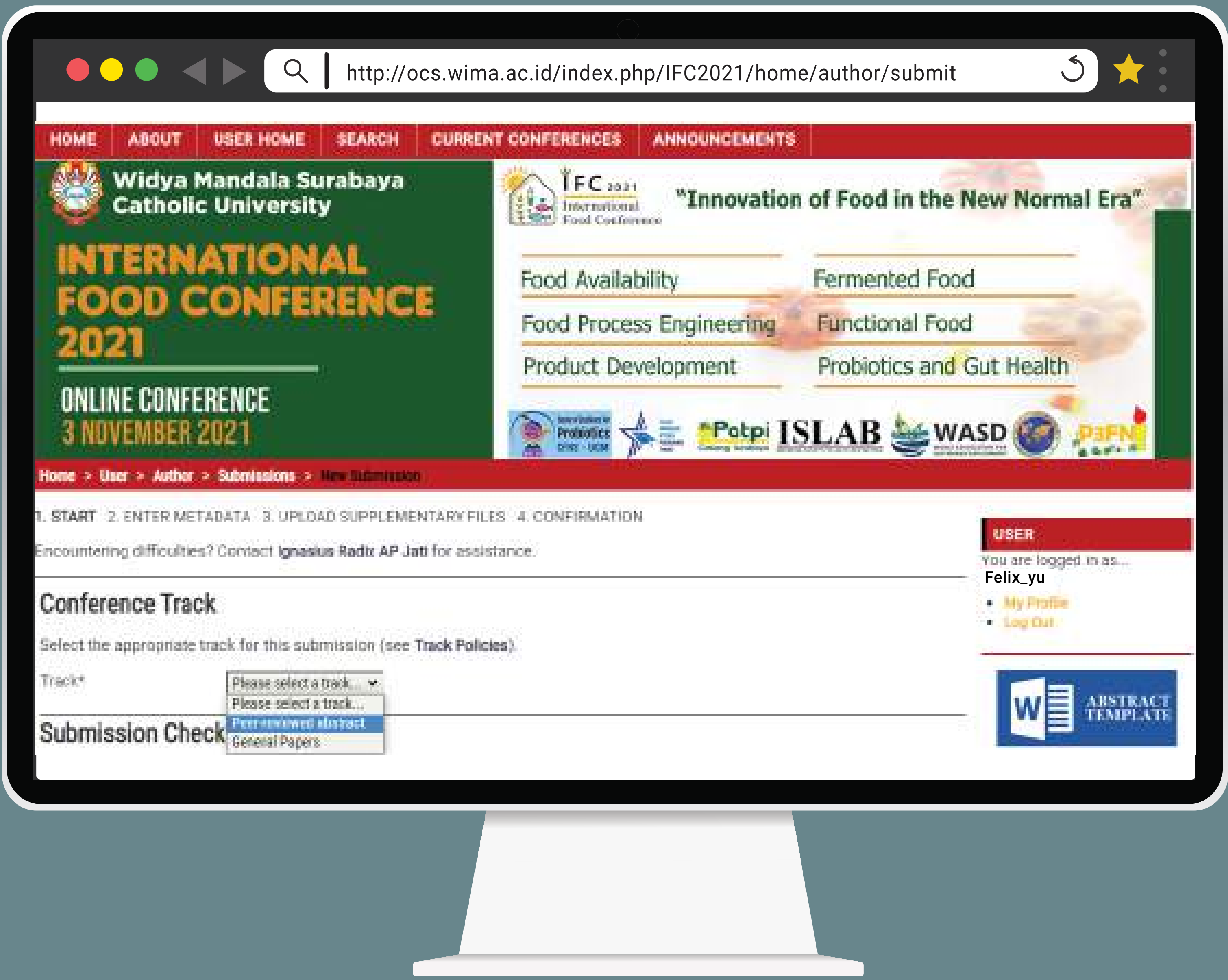

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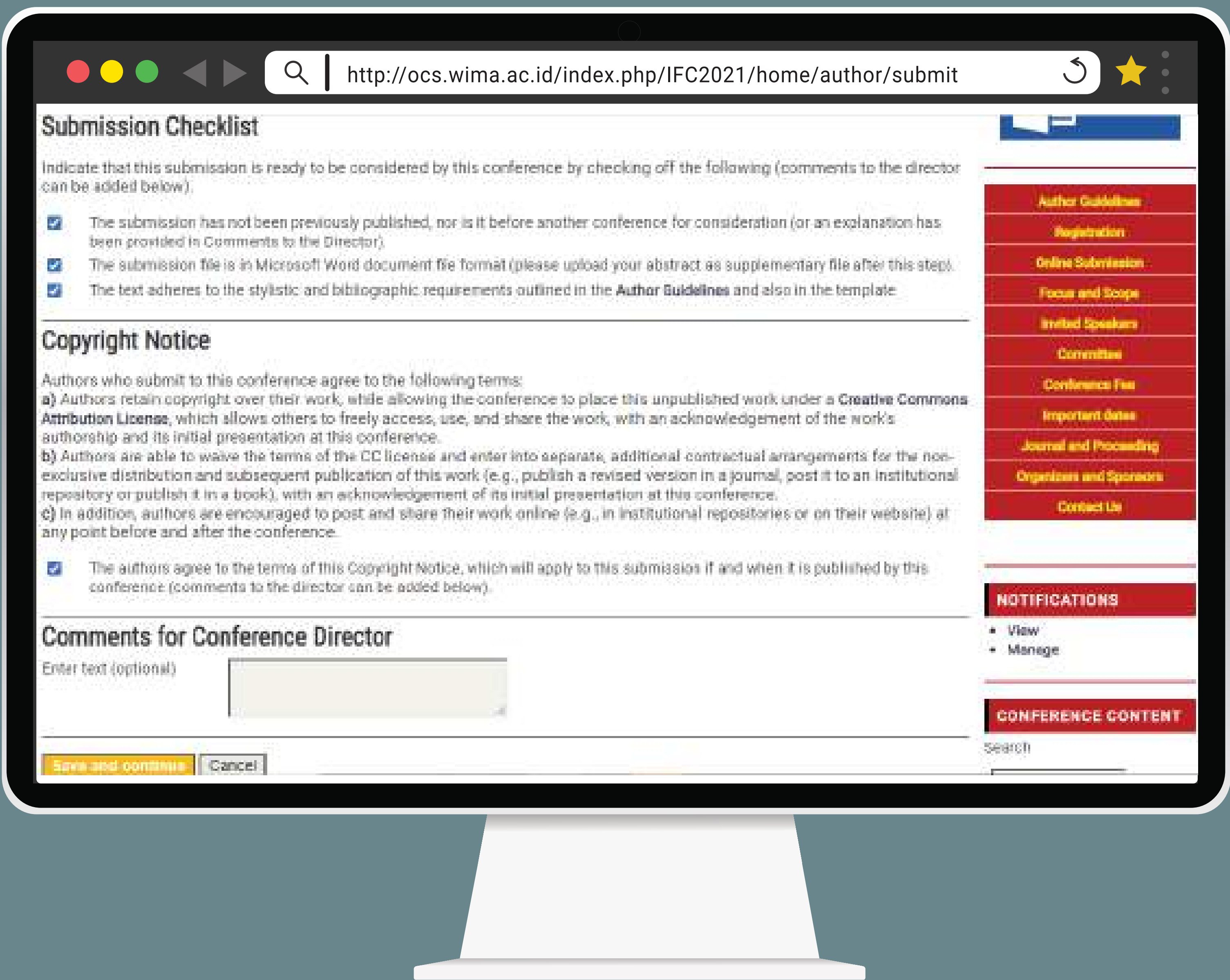

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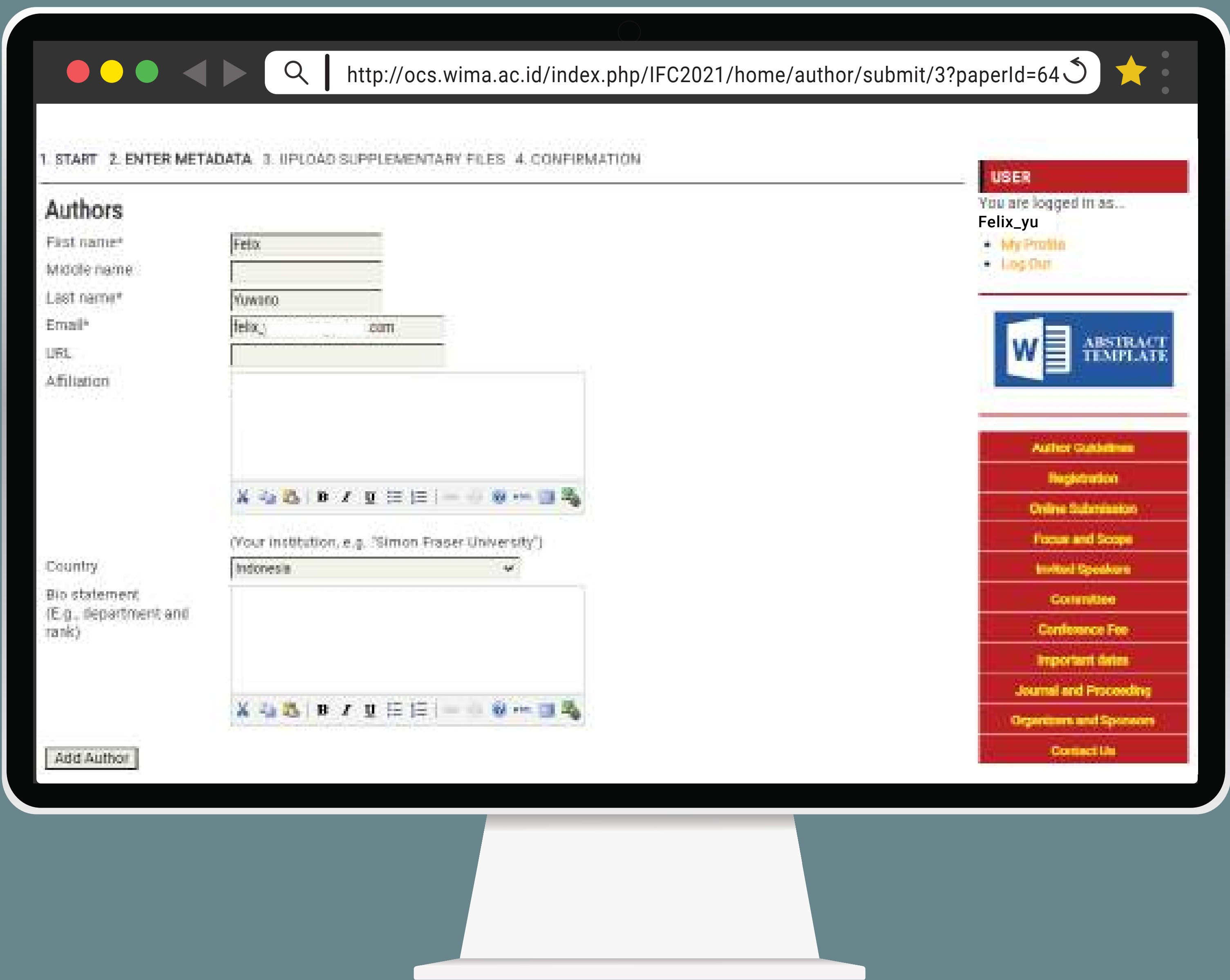

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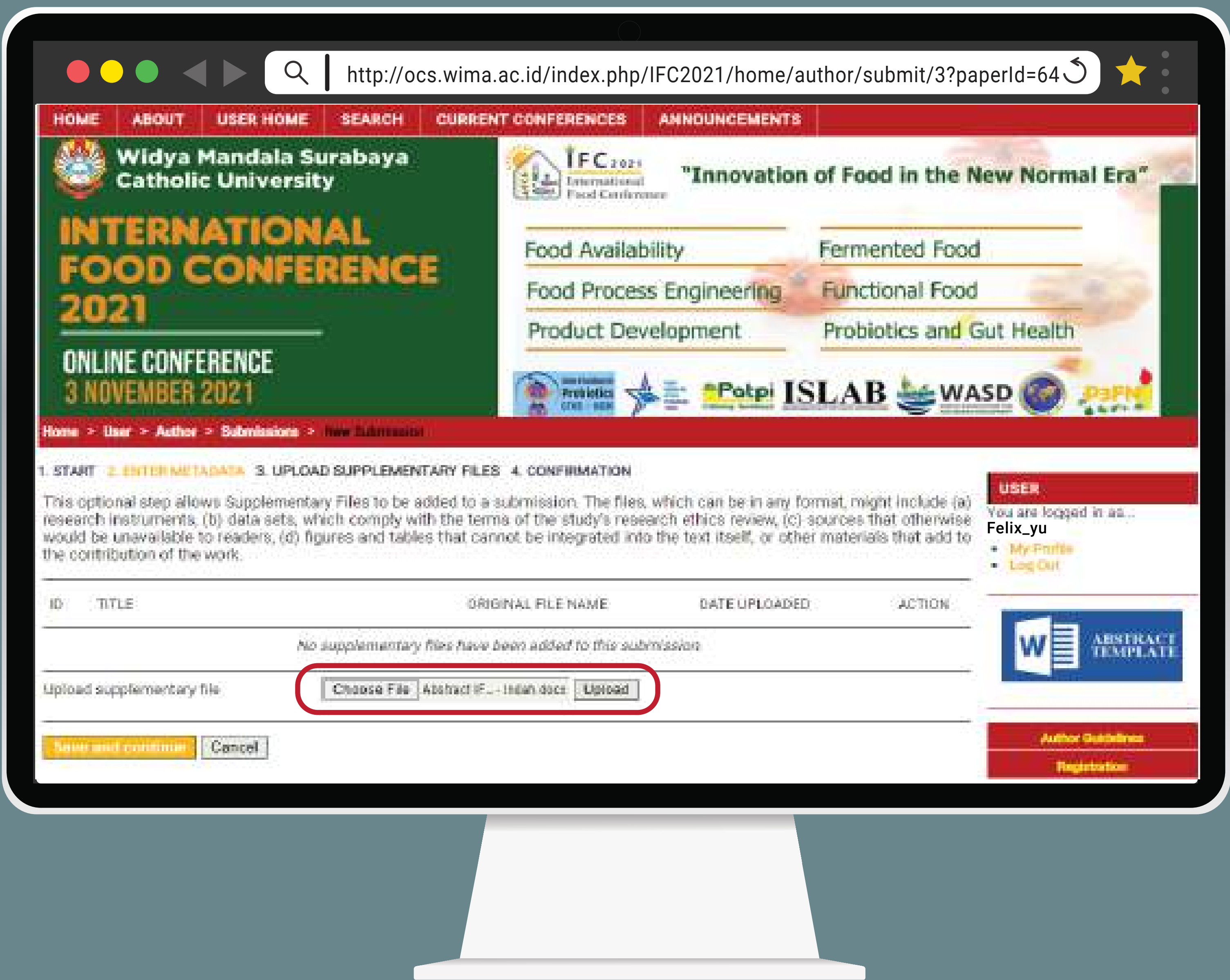

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6

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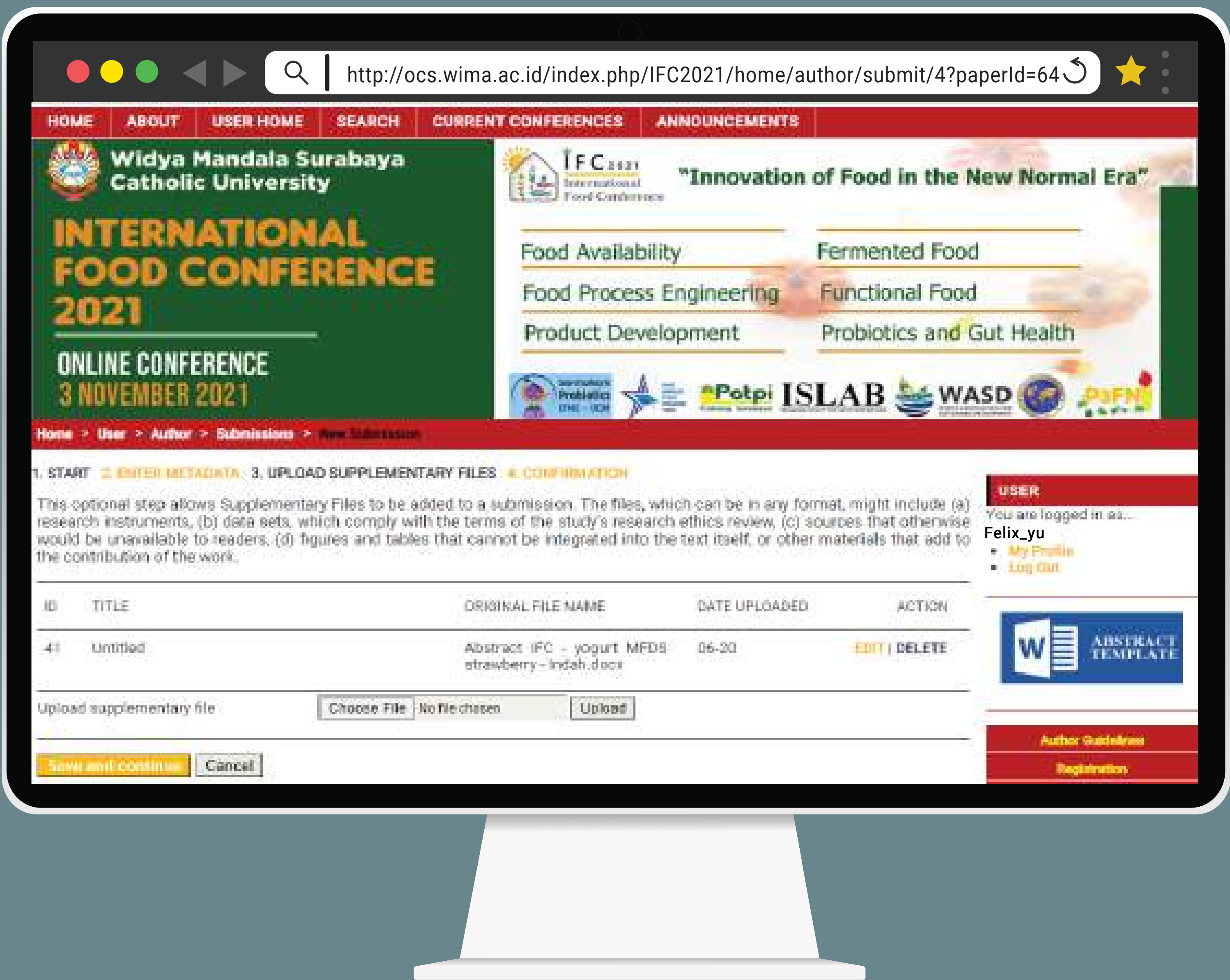

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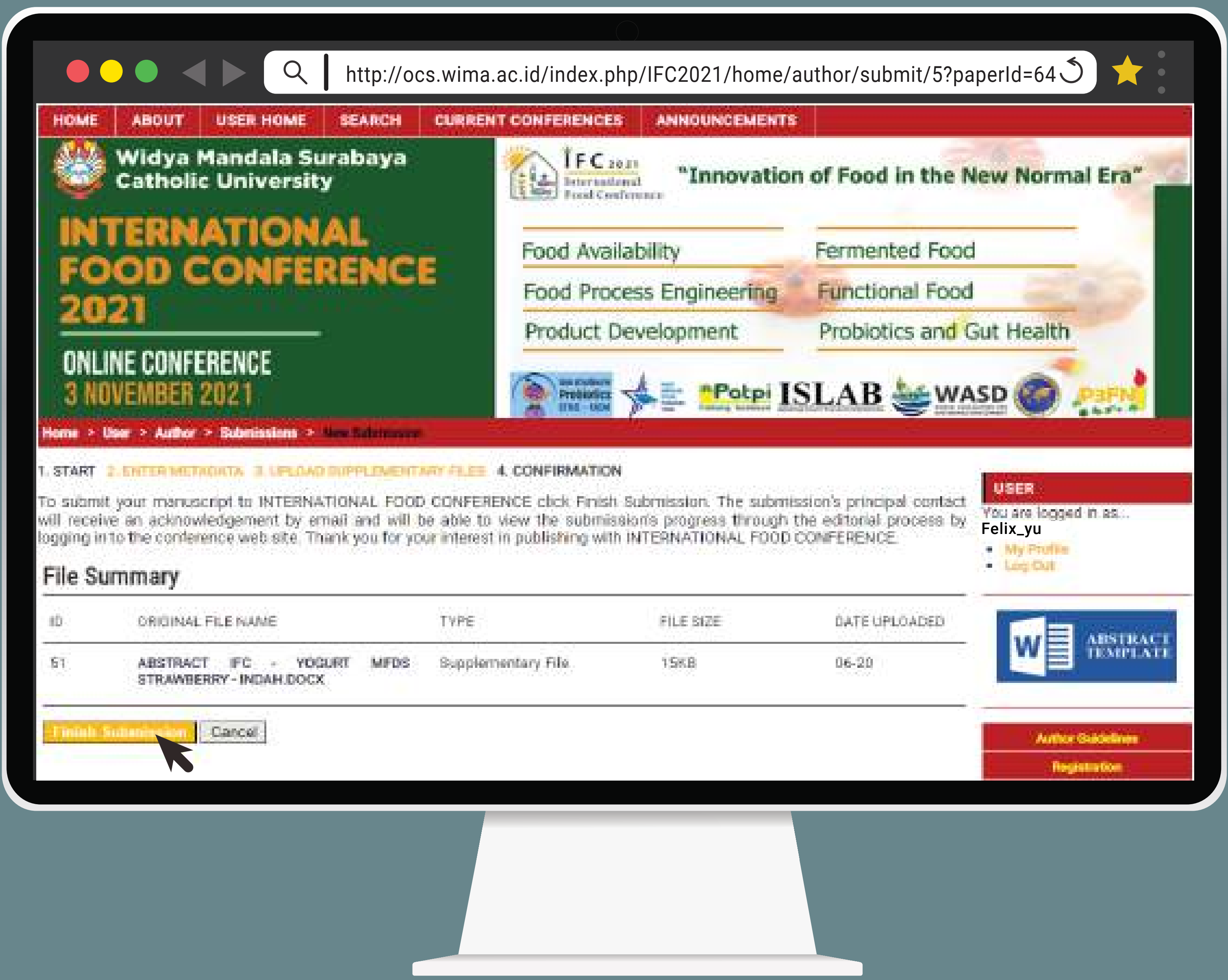

IFC 2021

International Food Conference

IFC Secretary

Gmail

Paini Sri Widyawati <paini@ukwms.ac.id>

Abstract Acceptance

International Food Conference 2021 <ifc@ukwms.ac.id> Thu, Aug 26, 2021 at 8:00 AM
To: paini@ukwms.ac.id

Dear Participant,
We're very sorry for the inconvenience. The guidelines sent before weren't the latest version therefore we would like to resend the latest guidelines version. Once again we're truly sorry about this inconvenience

Thank you for your understanding, best regards
IFC Committee
[Quoted text hidden]

Guidelines IFC 2021 .pdf
6132K

2. Submitted: Full paper to International Food Conference 2021 (22-9-2021)

-Correspondence

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Paini Sri Widyawati <paini@ukwms.ac.id>

[REMINDER IFC 2021]

International Food Conference 2021 <ifc@ukwms.ac.id> Wed, Sep 22, 2021 at 4:29 PM
To: paini@ukwms.ac.id

Dear Participants,
Kindly remind for the participants to complete the submission process. Things you have to do to complete the submission process are:
- Send the payment proof of registration fee
- Upload your full paper file (word document) to our official website or send it via email

Due date 30th September 2021
Please reply to this email as soon as possible for all the datas above.

Warm Regards,

IFC Organizing Committee
Widya Mandala Surabaya Catholic University

Whatsapp: +6281313187071
Website: http://ocs.wima.ac.id

Potency of Pluchea (*Pluchea indica* Less) Leaves to Increase Functional Value of Wet Noodles

*Widyawati, P.S., Darmoatmodjo, L.M.Y.D., Wibisono, D.A.S., Putra, E.W., Dharma, A.W.

Department of Food Technology, Faculty of Agricultural Technology, Widya Mandala Surabaya Catholic University, Jalan Dinoyo 42-44, Surabaya, 60265, Indonesia

*Corresponding author: paini@ukwms.ac.id

Author No.1: ORCID

Author No. 2: ORCID

Author No. 3: ORCID

Author No. 4: ORCID

Author No. 5: ORCID

Abstract

Wet noodles are lack of nutritional components that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as sources of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. This research aimed to determine the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed to have a potency to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet

noodles, including antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Accordingly, the increase in phytochemical compounds in wet noodles can also affect the functional properties of wet noodles.

Keywords: *Pluchea indica* Less, wet noodles, functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles are noodles product that has water content of about 52% and is produced through the cooking stage of raw noodles before being marketed (Koswara, 2009). According to Estiasih et al. (2017), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 40 hours at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Abbas, 2020). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. Raw materials in the manufacture of noodles generally include wheat flour, eggs, water, and other additives so that noodles are known to be low in nutritional content that is beneficial to health (Suyanti, 2008). Therefore, various efforts have been made to overcome the shortcomings of these wet noodles products. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds in the manufacture of wet noodles, one of which is the addition of Pluchea leaves.

Pluchea (*Pluchea indica* Less) is a herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols so that they are potential sources of natural antioxidants (Widyawati et al., 2015). In addition, Pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah et al., 2003). The use of Pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodles product.

Currently, the use of Pluchea leaves is only limited as fresh vegetables and drinks, but there have been many studies on the use of Pluchea leaves in the food sector that continue to be developed, including making tempeh with Pluchea leaf extract (Magatra, 2013), Pluchea-black tea salted eggs (Adventi et al., 2015), effervescent powder based on Pluchea leaf extract (Hudha and Widyaningsih, 2015), Pluchea bun products (Chiang, 2018), Pluchea soy milk (Widyawati et al., 2019), Pluchea-green tea jelly drink (Wijaya, 2019), and Pluchea wet noodles (Wibisono, 2021). The use of Pluchea leaves in the manufacture of wet noodles needs to be studied further as an effort to develop functional food products that are beneficial to the health of the consumer's body.

2. Materials and Methods

Materials of this research were data from several appropriate literatures regarding the utilization of Pluchea (*Pluchea indica* Less) leaves in making wet noodles and the potency of Pluchea leaves in wet noodles by comparing the content of phytochemical compounds (represented by total flavonoid content (TFC) value) and antioxidant activity (represented by iron ion reducing power (RP) value) of Pluchea wet noodles with other similar products from several studies. This study used literature and comparative study method by collecting data that show the potency of Pluchea indica Less leaves in wet noodles.

3. Results and Discussion

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic et al., 2013; Sari, 2014). Marsono (2008) also stated that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Abbas, 2020). According to Abbas (2020), there are five categories of functional food, namely foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are then added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants as a source of functional food, namely a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil et al. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

3.1 Utilization of Pluchea Leaves in Making Wet Noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed so that noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are low (Suyanti, 2008). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with kenikir (*Cosmos caudatus* Kunth.) leaf extract (Norlaili et al., 2014), manufacture of herbal noodles with leaves of the maja plant (*Aegle marmelos*) (Shamim et al., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of Moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil et al., 2020), and using Pluchea (*Pluchea indica* Less) leaf powder steeped water in making Pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in Pluchea leaves, both in the form of fresh leaves and water steeped in powdered Pluchea leaves, have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan et al., 2010; Andarwulan et al., 2012). Research conducted by Widyawati et al. (2016) showed that the phytochemical compounds contained in the brewed water of Pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Penglly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of Pluchea leaves in food products continues to be developed through various studies as shown in Table 1., however, the use of Pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of Pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of Pluchea bun (Chiang, 2018) and Pluchea wet noodles (Wibisono, 2021), both of which use Pluchea leaf powder steeping water which is added to the product formulation.

3.2 The Effect of Pluchea Leaves on the Content of Phytochemical Compounds of Wet Noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman et al., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari et al., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo et al., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian et al., 2010; Vichapong et al., 2010; Chen, 2013). Flavonoids have the ability to chelate metals and donate hydrogen atoms so that they can act as antioxidants that are able to provide certain physiological effects on the human body (Erlidawati et al., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as Pluchea wet noodles.

Research by Wibisono (2021) showed that the use of Pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of Pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of Pluchea leaf powder steeping water), respectively. The potential use of Pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of Pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and Pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of Pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and Pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in Pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan et al., 2010; Andarwulan et al., 2012; Koirewoa et al., 2012; Mahasuari et al., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3’,4’,5,5’,6,7,8-heptametioxyflavones (Lakshmanashetty et al., 2010; Ullah et al., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan et al., 2010; Andarwulan et al., 2012). The TFC value of wet noodles with the addition of 5% concentration of Pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of Pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of Pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of Pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the Pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than Pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta’s research

(2018), while Pluchea wet noodles dough in Wibisono's study (2021) was made with using Pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of Pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of Pluchea leaf powder in steeping water. This shows that the flavonoids content of Pluchea wet noodles is higher than the flavonoids content of Pluchea bun even though the concentration of Pluchea leaf powder in steeping water in the manufacture of Pluchea wet noodles is lower than the concentration of Pluchea leaf powder in steeping water in the manufacture of Pluchea bun (the TFC of Pluchea wet noodles 5% is 2.54 times compared to Pluchea bun 10%). According to Li et al. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of Pluchea bun. On the other hand, Saikia and Mahanta (2013) stated that the high flavonoids content could be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of Pluchea wet noodles 5% showed that Pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also stated that the use of higher concentration of Pluchea leaf powder in steeping water in the formulation of wet noodles was able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding Pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in Pluchea wet noodles products, so the use of Pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

3.3 The Effect of Pluchea Leaves on the Functional Properties of Wet Noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati et al., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny *et al*., 2001). According to Widyawati, Suteja, Suseno *et al*. (2014), iron ion is one of the pro-oxidants that has the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of Pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of Pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of Pluchea wet noodles with other products such as rice flour paste and Pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of Pluchea wet noodles with rice flour paste and Pluchea bun can be seen in Figure 2.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of Pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya *et al*. (2013). The RP value indicates that the use of Pluchea leaf powder steeping water with 5% concentration of Pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of Pluchea wet noodles 5% which is greater than the TFC of Pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of Pluchea wet noodles 5% and Pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati, Budianta, Kusuma *et al*., 2014). The flavonoids content of Pluchea wet noodles which is higher than the flavonoids content of Pluchea bun can cause the iron ion reducing power of wet noodles is higher compared to Pluchea bun.

RP value of Pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati, Suteja, Suseno *et al*. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of Pluchea leaves in the study of Andarwulan *et al*. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of Pluchea wet noodles can be increased by using higher concentration of Pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of Pluchea wet noodles 5% shows the potency of Pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding Pluchea leaf powder steeping water on the antioxidant activity of Pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of Pluchea leaves in making wet noodles.

Research on the potency of Pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while Pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by Pluchea leaves in food products include activities as anti-warmed over flavor, anti-inflammatory, antidiabetic (Widyawati *et al*., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah *et al*., 2003). This ability is inseparable from the presence of bioactive compounds in Pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati, Budianta, Kusuma *et al*., 2014; Widyawati *et al*., 2015). According to Li *et al*. (2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari *et al*. (2009) stated that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

4. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of Pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of Pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

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Tables and Figures

Table 1. The use of Pluchea leaves in food sector

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea-black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi *et al.*, 2015

Effervescent powder	Water extract (infusion) and ethanol ectract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh Pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati *et al.*, 2019
Pluchea-green tea jelly drink	Pluchea lea powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

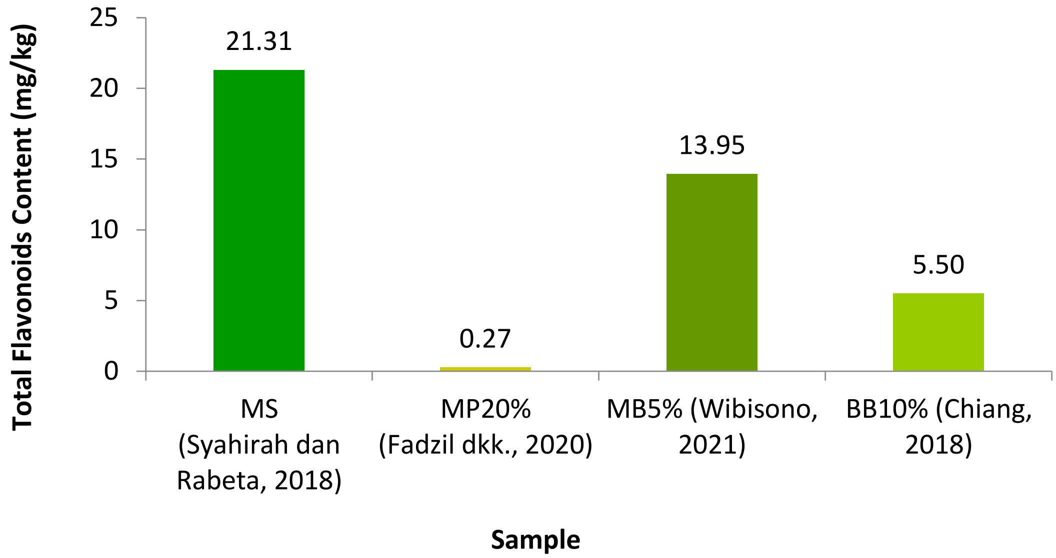

Figure 1. Total flavonoid content (TFC) of Pluchea wet noodles 5% (MB5%) compared to sidondo wet noodles (MS), pegagan wet noodles 60% (MP60%), and Pluchea bun 10% (BB10%). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of Pluchea noodles and Pluchea bun were expressed in terms of catechin equivalents per dry weight of freeze-dried results. TFC of MP20%, MB5%, and BB10% were expressed by the values that have been subtracted with the TFC of control from each study.

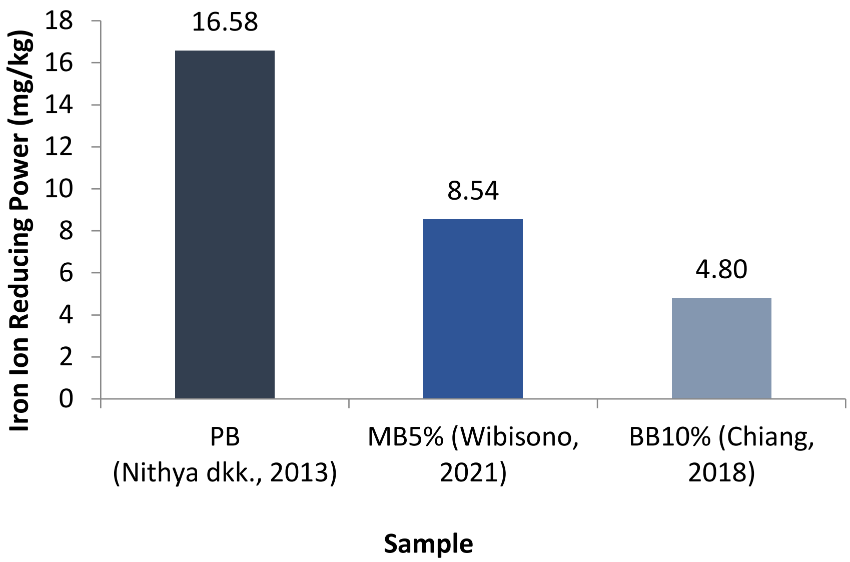

Figure 2. Iron ion reducing power (RP) of Pluchea wet noodles 5% (MB5%) compared to rice flour paste (PB) and Pluchea bun 10% (BB10%). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of Pluchea wet noodles and Pluchea bun was expressed in gallic acid equivalent per dry weight of freeze-dried results. Iron ion reducing power of MB5% and BB10% are expressed by the value that has been reduced by the RP value of control from each study.

3. Submitted to Food Research (5-2-2022)

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Authors: Widyawati, P.S., Darmoatmodjo, L.M.Y.D., Wibisono, D.A.S., Putra, E.W. and Dharma, A.W.

Manuscript title: Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

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Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

Abstract

Wet noodles are lack of nutritional components that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as sources of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. This research was aimed to determine the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Accordingly, the increase in phytochemical compounds in wet noodles could also affect the functional properties of wet noodles.

Commented [A1]: functional nutritional components?

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Keywords: *Pluchea indica* Less, wet noodles, functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles are noodles product that has water content of about 52% and is produced through the cooking stage of raw noodles before being marketed (Koswara, 2009). According to Estiasih *et al*. (2017), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 40 hours at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Abbas, 2020). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. Raw materials in the manufacture of noodles generally include wheat flour, eggs, water, and other additives so that noodles are known to be low in nutritional content that is beneficial to health (Suyanti, 2008). Therefore, various efforts have been made to overcome the shortcomings of these wet noodles products. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds in the manufacture of wet noodles, one of which is the addition of pluchea leaves.

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Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols so that they are potential sources of natural antioxidants (Widyawati *et al*., 2015). In addition, Pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah *et al*., 2003). The use of pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodles product.

Currently, the use of pluchea leaves is only limited as fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), Pluchea-black tea salted eggs (Adventi *et al*., 2015), effervescent powder based on Pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati *et al*., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Methods

Methods of this research were data collected from several appropriate literatures regarding the utilization of pluchea (*Pluchea indica* Less) leaves in making wet noodles and the potency of pluchea leaves in wet noodles by comparing the content of phytochemical compounds (represented by total flavonoid content (TFC) value) and antioxidant activity (represented by iron ion reducing power (RP) value) of pluchea wet noodles with other similar products from several studies. This study used literature and comparative study method by collecting data that show the potency of pluchea leaves in wet noodles.

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3. Results and Discussion

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Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic *et al*., 2013; Sari, 2014). Marsono (2008) also stated that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Abbas, 2020). According to Abbas (2020), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants is a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil *et al*. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

3.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed so that noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are low (Suyanti, 2008). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili *et al*., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim *et al*., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil *et al*., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves, have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). Research conducted by Widyawati *et al*. (2016) showed that the phytochemical compounds contained in the brewed water of Pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Penglly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1., however, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

3.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman *et al*., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari *et al*., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo *et al*., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian *et al*., 2010; Vichapong *et al*., 2010; Chen, 2013). Flavonoids have the ability to chelate metals and donate hydrogen atoms so that they can act as antioxidants that are able to provide certain physiological effects on the human body (Erlidawati *et al*., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

Research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012; Koirewoa *et al*., 2012; Mahasuari *et al*., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3',4',5,5',6,7,8-heptametioxyflavones (Lakshmanashetty *et al*., 2010; Ullah *et al*., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). The TFC value of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta's research (2018), while pluchea wet noodles dough in Wibisono's study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, Saikia and Mahanta (2013) stated that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also stated that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

3.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati *et al*., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny *et al*., 2001). According to Widyawati *et al*. (2014), iron ion is one of the pro-oxidants that has the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya *et al*. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati *et al*., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea b bun can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati *et al*. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan *et al*. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by pluchea leaves in food products include activities as anti-warmed over flavor, anti-inflammatory, antidiabetic (Widyawati *et al*., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah *et al*., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati *et al*., 2014; Widyawati *et al*., 2015). According to Li *et al*., 2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari *et al*. (2009) stated that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

4. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

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Wijaya, J.P. (2019). Effect of concentration of mixture of Pluchea (*Pluchea indica* L.) leaves powder – green tea (*Camellia sinensis* L.) 1:1 (b/b) in steeping water on antioxidant activity of jelly drink. Indonesia: Widya Mandala Surabaya Catholic University, Bachelor. Final Project. (In Bahasa).

Table 1.The use of Pluchea leaves in food sector

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea -black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi *et al*., 2015
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati *et al*., 2019
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

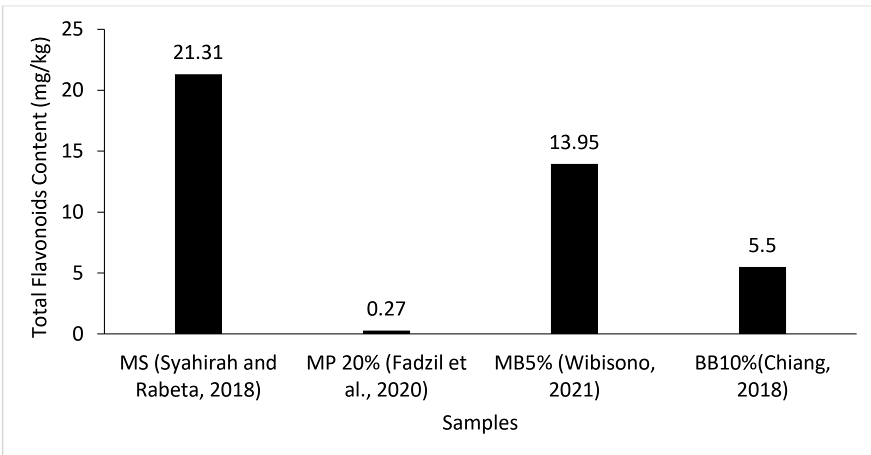

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB5%) compared to sidondo wet noodles (MS), pegagan wet noodles 60% (MP60%), and pluchea bun 10% (BB10%). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP20%, MB5%, and BB10% were expressed by the values that have been subtracted with the TFC of control from each study.

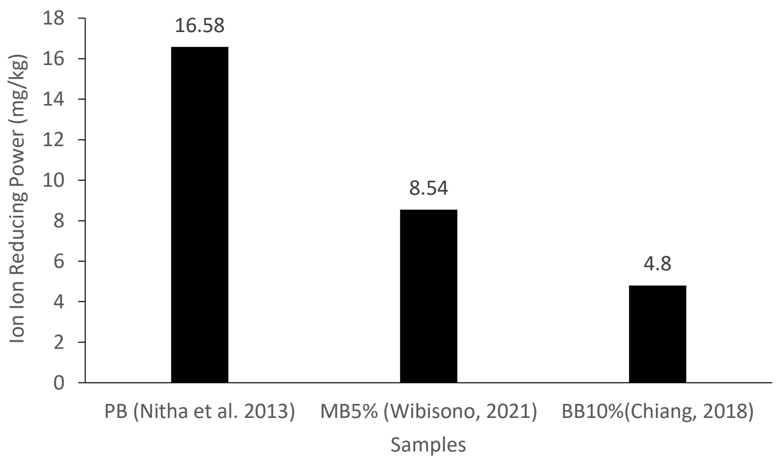

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB5%) compared to rice flour paste (PB) and pluchea bun 10% (BB10%). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB5% and BB10% are expressed by the value that has been reduced by the RP value of control from each study.

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Paini Sri Widyawati <paini@ukwms.ac.id>

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Paini Sri Widyawati <paini@ukwms.ac.id> Fri, Mar 18, 2022 at 2:31 PM
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The Best Regards

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FOOD RESEARCH

MANUSCRIPT EVALUATION FORM

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FOOD RESEARCH

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3.	**Keywords** *Min. 3 and Max. 6*	-
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Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

Abstract

Wet noodles are lack of functional nutritional components that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as sources of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Accordingly, the increase in phytochemical compounds in wet noodles could also affect the functional properties of wet noodles.

Keywords: *Pluchea indica* Less, wet noodles, functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles are noodles product that has water content of about ~~52%~~50-52% (Nuraida et al., 2009), 52,10-52,85% (Billina et al., 2014) 58-70% (Zhou et al., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina et al., 2014) ~~(Koswara, 2009)~~. According to Nuraida et al. (2009)~~Estiasih *et al.* (2017)~~, the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42~~0~~ hours at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa et al.,~~Abbas,~~ 2021~~0~~). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. Raw materials in the manufacture of noodles generally include wheat flour, eggs, water, and other additives so that noodles are known to be low in nutritional content that is beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). ~~Suyanti, 2008).~~ Therefore, various efforts have been made to overcome the shortcomings of these wet noodles products. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds in the manufacture of wet noodles, one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols so that they are potential sources of natural antioxidants (Widyawati et al., 2015). In addition, Pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah et al., 2003). The use of pluchea leaves in the manufacture of wet noodles is

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expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodles product.

Currently, the use of pluchea leaves is only limited as fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), Pluchea-black tea salted eggs (Adventi et al., 2015), effervescent powder based on Pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati et al., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2.—

3.2. Results and Discussion

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic et al., 2013; Sari, 2014). Marsono (2008) also stated that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa et al., 2021). According to Essa et al. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil et al. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed so that noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili et al., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim et al., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018),

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addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil et al., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves, have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan et al., 2010; Andarwulan et al., 2012). Research conducted by Widyawati et al. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Penglly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman et al., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari et al., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo et al., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian et al., 2010; Vichapong et al., 2010; Chen, 2013). Flavonoids have the ability to chelate metals and donate

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hydrogen atoms so that they can act as antioxidants that are able to provide certain physiological effects on the human body (Erlidawati et al., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

Research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan et al., 2010; Andarwulan et al., 2012; Koirewoa et al., 2012; Mahasuari et al., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3',4',5,5',6,7,8-heptametioxyflavones (Lakshmanashetty et al., 2010; Ullah et al., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan et al., 2010; Andarwulan et al., 2012). The TFC value of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta's research (2018), while pluchea wet noodles dough in Wibisono's study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and

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are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, Saikia and Mahanta (2013) stated that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also stated that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati et al., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny et al., 2001). According to Widyawati et al. (2014), iron ion is one of the pro-oxidants that has the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya et al. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet

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noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati et al., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea b bun can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati et al. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan et al. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by pluchea leaves in food products include activities as anti-warmed over flavor, anti-inflammatory, antidiabetic (Widyawati et al., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah et al., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati et al., 2014; Widyawati et al., 2015). According to Li et al., 2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari et al. (2009) stated that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

4.3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

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Conflict of interest

The authors declare no conflict of interest.

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Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea -black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi et al., 2015
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati et al., 2019
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

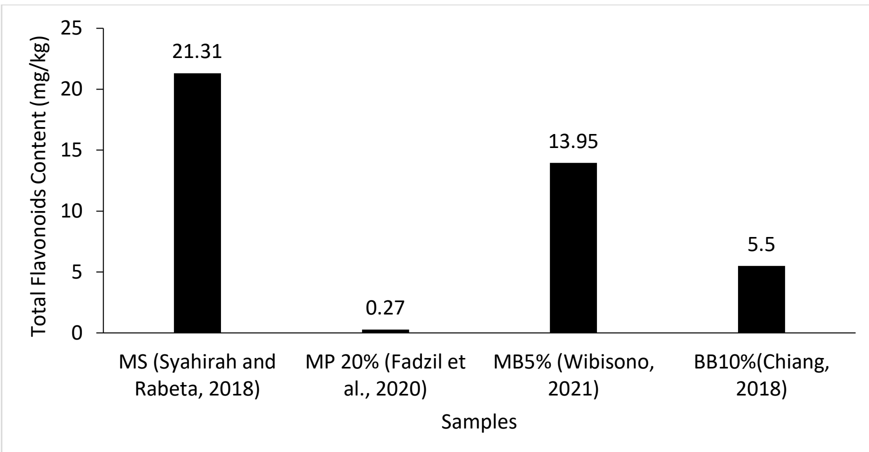

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB5%) compared to sidondo wet noodles (MS), pegagan wet noodles 60% (MP60%), and pluchea bun 10% (BB10%). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP20%, MB5%, and BB10% were expressed by the values that have been subtracted with the TFC of control from each study.

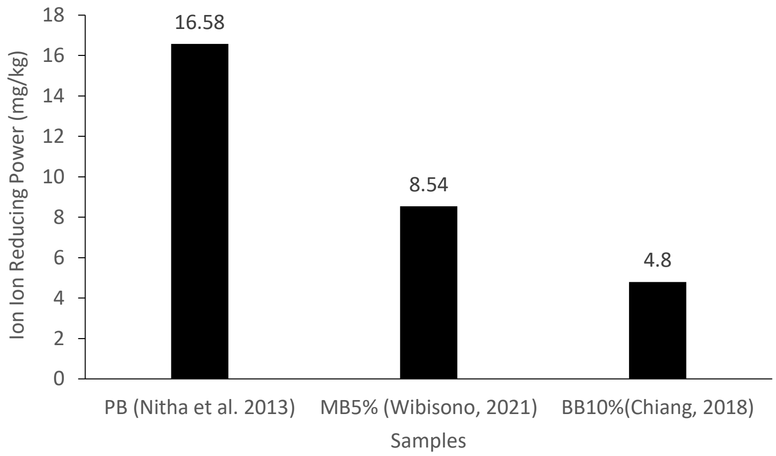

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB5%) compared to rice flour paste (PB) and pluchea bun 10% (BB10%). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB5% and BB10% are expressed by the value that has been reduced by the RP value of control from each study.

5. Second Revision: Linguistic Aspects (19-3-2022)
-Correspondence
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Gmail

Paini Sri Widyawati <paini@ukwms.ac.id>

manuscript revise

Food Research <foodresearch.my@outlook.com> Sat, Mar 19, 2022 at 3:41 AM
To: Paini Sri Widyawati <paini@ukwms.ac.id>

Dear Dr. Paini Sri Widyawati

Please revise the manuscript in terms of its linguistic aspects as well as the format. We would strongly recommend the manuscript be proofread by a native English speaker, those highlighted in green require grammatical and format revisions.

Best regards,
Son Radu, PhD
Chief Editor

From: Paini Sri Widyawati <paini@ukwms.ac.id>
Sent: Friday, 18 March, 2022 3:31 PM
To: Food Research <foodresearch.my@outlook.com>
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Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

Abstract

Wet noodles are lack of functional nutritional components that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as sources of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Accordingly, the increase in phytochemical compounds in wet noodles could also affect the functional properties of wet noodles.

Keywords: *Pluchea indica* Less, wet noodles, functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles are noodles product that has water content of about 50-52% (Nuraida et al., 2009), 52,10-52,85% (Billina et al., 2014) 58-70% (Zhou et al., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina et al., 2014) . According to Nuraida et al. (2009), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42 hours at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa et al., 2021). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. Raw materials in the manufacture of noodles generally include wheat flour, eggs, water, and other additives so that noodles are known to be low in nutritional content that is beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). Therefore, various efforts have been made to overcome the shortcomings of these wet noodles products. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds ~~in the manufacture of wet noodles~~, one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols so that they are potential sources of natural antioxidants (Widyawati et al., 2015). In addition, Pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah et al., 2003). The use of pluchea leaves in the manufacture of wet noodles is

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expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodles product.

Currently, the use of pluchea leaves is only limited to fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), Pluchea-black tea salted eggs (Adventi et al., 2015), effervescent powder based on Pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati et al., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Results and Discussion

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic et al., 2013; Sari, 2014). Marsono (2008) also stated that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa et al., 2021). According to Essa et al. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil et al. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed so that noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili et al., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim et al., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa

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(*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil et al., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan et al., 2010; Andarwulan et al., 2012). Research conducted by Widyawati et al. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Penglly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman et al., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari et al., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo et al., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian et al., 2010; Vichapong et al., 2010; Chen, 2013). Flavonoids have the ability to chelate metals and donate hydrogen atoms so that they can act as antioxidants that are able to provide certain physiological effects on the human body (Erlidawati et al., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

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Research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan et al., 2010; Andarwulan et al., 2012; Koirewoa et al., 2012; Mahasuari et al., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3',4',5,5',6,7,8-heptametioxyflavones (Lakshmanashetty et al., 2010; Ullah et al., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan et al., 2010; Andarwulan et al., 2012). The TFC value of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta's research (2018), while pluchea wet noodles dough in Wibisono's study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, Saikia and Mahanta (2013) stated that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that

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aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also stated that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

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2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati et al., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny et al., 2001). According to Widyawati et al. (2014), iron ion is one of the pro-oxidants that has the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

Pluchea wet noodles 5% in the Wibisono’s study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang’s research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya et al. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati et al., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea b bun can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati et al. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan et al. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by pluchea leaves in food products include activities as anti-warmed over flavor, anti-inflammatory, antidiabetic (Widyawati et al., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah et al., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati et al., 2014; Widyawati et al., 2015). According to Li et al., 2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari et al. (2009) stated that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea -black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi et al., 2015
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati et al., 2019
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

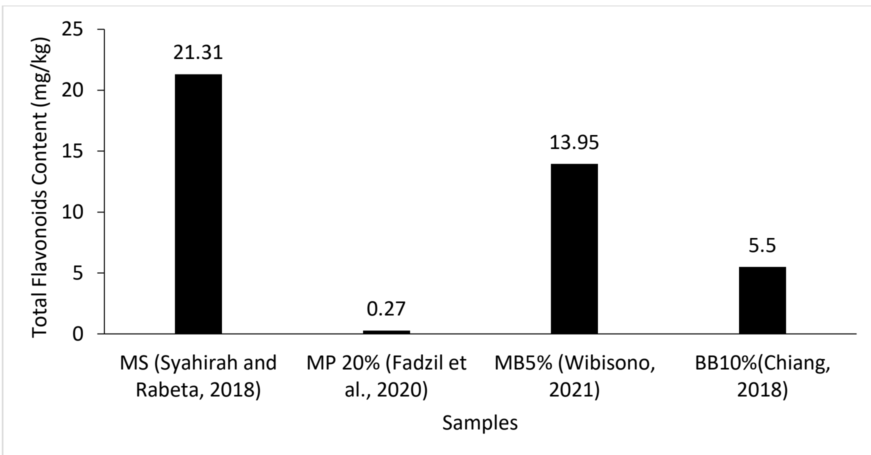

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB5%) compared to sidondo wet noodles (MS), pegagan wet noodles 60% (MP60%), and pluchea bun 10% (BB10%). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP20%, MB5%, and BB10% were expressed by the values that have been subtracted with the TFC of control from each study.

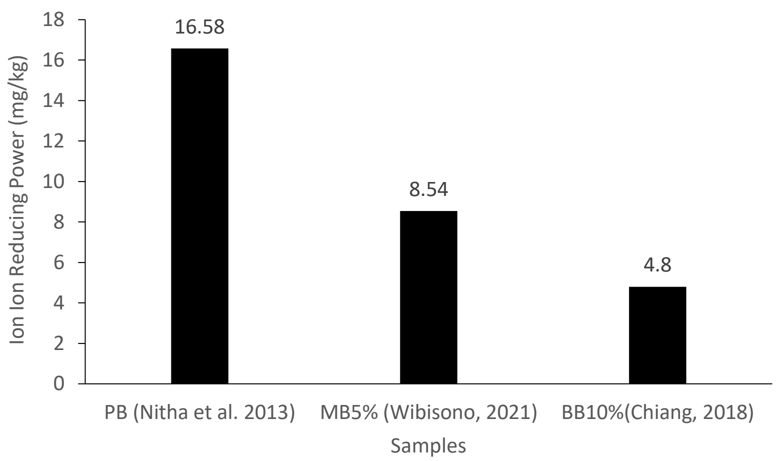

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB5%) compared to rice flour paste (PB) and pluchea bun 10% (BB10%). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB5% and BB10% are expressed by the value that has been reduced by the RP value of control from each study.

6. Third Revision: Final Revision (21-3-2022)
-Correspondence
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Gmail

Paini Sri Widyawati <paini@ukwms.ac.id>

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Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

Abstract

Wet noodles are lack of functional ~~nutritional components~~nutrients that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as a sources of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Thus~~Accordingly~~, the addition of pluchea leaves has potential to increase the functional value of wet noodles including the phytochemical content and functional properties.

~~increase in phytochemical compounds in wet noodles could also affect the functional properties of wet noodles.~~

Keywords: *Pluchea indica* Less, wet noodles, functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles ~~are noodles product~~ ~~that~~ have ~~s~~ water content of about 50-52% (Nuraida et al., 2009), 52,10-52,85% (Billina et al., 2014) 58-70% (Zhou et al., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina et al., 2014) . According to Nuraida et al. (2009), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42 hours at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa et al., 2021). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. The r~~R~~aw materials ~~in the manufacture of noodles~~of noodles generally include wheat flour, eggs, and water~~., and~~ However,~~other additives~~ ~~so that~~ no ~~no~~odles are known to be low in ~~nutritional content~~functional nutrients that are~~is~~ beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). Therefore, various efforts have been made to overcome the shortcomings of ~~these~~ wet noodle~~ss products~~. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compound~~ss in the manufacture of wet noodles,~~ , one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac

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glycosides, and sterols, ~~so~~ that ~~they~~ act as ~~are potential~~ sources of natural antioxidants (Widyawati et al., 2015). In addition, p~~P~~luchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah et al., 2003). The use of pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodles product.

Currently, the use of pluchea leaves is only limited ~~as~~ to fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), p~~P~~luchea-black tea salted eggs (Adventi et al., 2015), effervescent powder based on p~~P~~luchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati et al., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Results and Discussion

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic et al., 2013; Sari, 2014). Marsono (2008) also declared ~~stated~~ that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa et al., 2021). According to Essa et al. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil et al. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed, making the ~~so that~~ noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are relatively low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as

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making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili et al., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim et al., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil et al., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves, have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan et al., 2010; Andarwulan et al., 2012). Research conducted by Widyawati et al. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Penglly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman et al., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari et al., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo et al., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian et al., 2010; Vichapong et al., 2010; Chen, 2013). Flavonoids act as antioxidants by have the ability to

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~~chelate~~chelating metals and ~~donate~~ donating hydrogen atoms, thus ~~so that they can act as antioxidants that are able to~~ provide certain physiological effects on the human body (Erlidawati et al., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

Research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan et al., 2010; Andarwulan et al., 2012; Koirewoa et al., 2012; Mahasuari et al., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3',4',5,5',6,7,8-heptametioxyflavones (Lakshmanashetty et al., 2010; Ullah et al., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan et al., 2010; Andarwulan et al., 2012). The TFC value of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta's research (2018), while pluchea wet noodles dough in Wibisono's study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li et al. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during

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heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, a study conducted by Saikia and Mahanta (2013) ~~stated~~ showed that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

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The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also ~~stated~~ mentioned that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati et al., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny et al., 2001). According to Widyawati et al. (2014), iron ion is one of the pro-oxidants that have~~s~~ the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

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Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya et al. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati et al., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea ~~b~~ bun, can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati et al. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan et al. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by pluchea leaves in food products include activities as anti-warmed over flavor, anti-inflammatory, antidiabetic (Widyawati et al., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah et al., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati et al., 2014; Widyawati et al., 2015). According to Li et al. (~~,~~ 2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari et al. (2009) ~~stated~~ also proved that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

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3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

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Conflict of interest

The authors declare no conflict of interest.

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Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea -black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi et al., 2015
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati et al., 2019
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

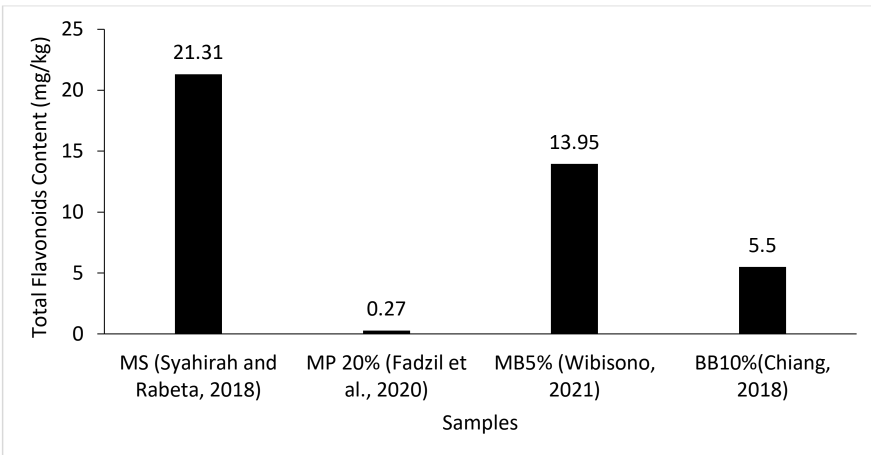

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB_5%) compared to sidondo wet noodles (MS), pegagan wet noodles 60% (MP_60%), and pluchea bun 10% (BB_10%). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP_20%, MB_5%, and BB_10% were expressed by the values that have been subtracted with the TFC of control from each study.

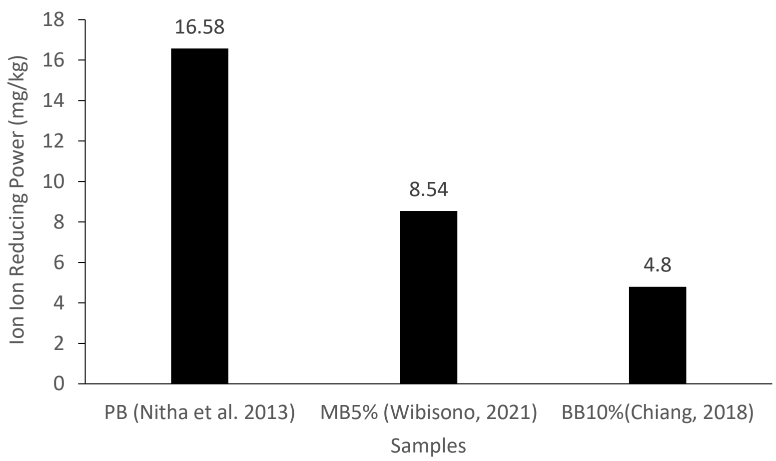

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB_5%) compared to rice flour paste (PB) and pluchea bun 10% (BB_10%). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB_5% and BB_10% are expressed by the value that has been reduced by the RP value of control from each study.

Gmail

Paini Sri Widyawati <paini@ukwms.ac.id>

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Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

*Widyawati, P.S., Darmoatmodjo, L.M.Y.D., Wibisono, D.A.S., Putra, E.W. and Dharma, A.W.
Department of Food Technology, Faculty of Agricultural Technology, Widya Mandala Catholic University Surabaya, Dinoyo Street Number 42-44, Surabaya, 60265, East Java, Indonesia
*Corresponding author: paini@ukwms.ac.id
Author No.1: https://orchid.org/0000-0003-2138-0690
Author No. 2: https://orchid.org/0000-0003-0890-4453

Abstract

Wet noodles are lack of functional nutrients that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as a source of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Thus, the addition of pluchea leaves has potential to increase the functional value of wet noodles including the phytochemical content and functional properties.

Keywords: *Pluchea indica* Less, Wet noodles, Functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles have water content of about 50-52% (Nuraida *et al*., 2009), 52.10-52.85% (Billina *et al*., 2014) 58-70% (Zhou *et al*., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina *et al*., 2014). According to Nuraida *et al*. (2009), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42 hours at room temperature storage.

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Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa *et al*., 2021). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. The raw materials of noodles generally include wheat flour, eggs, and water. However, noodles are known to be low in functional nutrients that are beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). Therefore, various efforts have been made to overcome the shortcomings of wet noodles. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds, one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols, that act as sources of natural antioxidants (Widyawati *et al*., 2015). In addition, pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah *et al*., 2003). The use of pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodle's product.

Currently, the use of pluchea leaves is only limited to fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), pluchea-black tea salted eggs (Adventi *et al*., 2015), effervescent powder based on pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati *et al*., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Pluchea leaves as functional supplement

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic *et al*., 2013; Sari, 2014). Marsono (2008) also declared that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa *et al*., 2021). According to Essa *et al*. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil *et al*. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed, making the noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are relatively low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili *et al*., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim *et al*., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil *et al*., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). Research conducted by Widyawati *et al*. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Penglly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

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The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman *et al*., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari *et al*., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo *et al*., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian *et al*., 2010; Vichapong *et al*., 2010; Chen, 2013). Flavonoids act as antioxidants by chelating metals and donating hydrogen atoms, thus provide certain physiological effects on the human body (Erlidawati *et al*., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

Research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012; Koirewoa *et al*., 2012; Mahasuari *et al*., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3’,4’,5,5’,6,7,8-heptametioxyflavones (Lakshmanashetty *et al*., 2010; Ullah *et al*., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). The TFC value of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta’s research (2018), while pluchea wet noodles dough in Wibisono’s study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, a study conducted by Saikia and Mahanta (2013) showed that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also mentioned that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati *et al*., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny *et al*., 2001). According to Widyawati *et al*. (2014), iron ion is one of the pro-oxidants that have the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya *et al*. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati *et al*., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea bun, can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati *et al*. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan *et al*. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by pluchea leaves in food products include activities as anti-warmed-over flavor, anti-inflammatory, antidiabetic (Widyawati *et al*., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah *et al*., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati *et al*., 2014; Widyawati *et al*., 2015). According to Li *et al*. (2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari *et al*. (2009) also proved that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea -black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi *et al*., 2015
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati *et al*., 2019
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

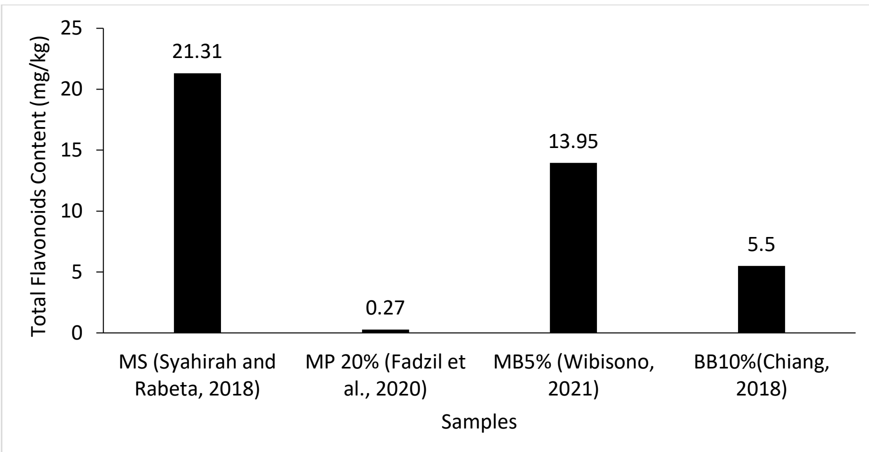

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB 5%) compared to sidondo wet noodles (MS), pegagan wet noodles 60% (MP 60%), and pluchea bun 10% (BB 10%). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP 20%, MB 5%, and BB 10% were expressed by the values that have been subtracted with the TFC of control from each study

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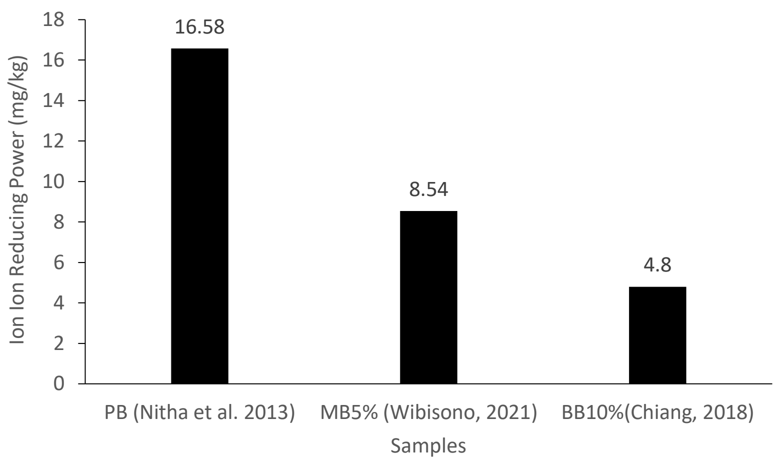

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB 5%) compared to rice flour paste (PB) and pluchea bun 10% (BB 10%). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB 5% and BB 10% are expressed by the value that has been reduced by the RP value of control from each study

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Gmail **Paini Sri Widyawati <paini@ukwms.ac.id>**

Manuscript ID: FR-IFC-021

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Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

*Widyawati, P.S., Darmoatmodjo, L.M.Y.D., Wibisono, D.A.S., Putra, E.W. and Dharma, A.W.
Department of Food Technology, Faculty of Agricultural Technology, Widya Mandala Catholic University Surabaya, Dinoyo Street Number 42-44, Surabaya, 60265, East Java, Indonesia
*Corresponding author: paini@ukwms.ac.id
Author No.1: https://orchid.org/0000-0003-2138-0690
Author No. 2: https://orchid.org/0000-0003-0890-4453

Abstract

Wet noodles are lack of functional nutrients that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as a source of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Thus, the addition of pluchea leaves has potential to increase the functional value of wet noodles including the phytochemical content and functional properties.

Keywords: *Pluchea indica* Less, Wet noodles, Functional value

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles have water content of about 50-52% (Nuraida *et al*., 2009), 52.10-52.85% (Billina *et al*., 2014) 58-70% (Zhou *et al*., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina *et al*., 2014). According to Nuraida *et al*. (2009), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42 hours at room temperature storage.

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Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa *et al*., 2021). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. The raw materials of noodles generally include wheat flour, eggs, and water. However, noodles are known to be low in functional nutrients that are beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). Therefore, various efforts have been made to overcome the shortcomings of wet noodles. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds, one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols, that act as sources of natural antioxidants (Widyawati *et al*., 2015). In addition, pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah *et al*., 2003). The use of pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodle's product.

Currently, the use of pluchea leaves is only limited to fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), pluchea-black tea salted eggs (Adventi *et al*., 2015), effervescent powder based on pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati *et al*., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Pluchea leaves as functional supplement

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic *et al*., 2013; Sari, 2014). Marsono (2008) also declared that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa *et al*., 2021). According to Essa *et al*. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil *et al*. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed, making the noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are relatively low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili *et al*., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim *et al*., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil *et al*., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). Research conducted by Widyawati *et al*. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Pengelly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

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The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman *et al*., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari *et al*., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo *et al*., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian *et al*., 2010; Vichapong *et al*., 2010; Chen, 2013). Flavonoids act as antioxidants by chelating metals and donating hydrogen atoms, thus provide certain physiological effects on the human body (Erlidawati *et al*., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

Research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012; Koirewoa *et al*., 2012; Mahasuari *et al*., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3’,4’,5,5’,6,7,8-heptametioxyflavones (Lakshmanashetty *et al*., 2010; Ullah *et al*., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). The TFC value of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta’s research (2018), while pluchea wet noodles dough in Wibisono’s study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, a study conducted by Saikia and Mahanta (2013) showed that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also mentioned that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati *et al*., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny *et al*., 2001). According to Widyawati *et al*. (2014), iron ion is one of the pro-oxidants that have the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya *et al*. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1., can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati *et al*., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea bun, can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati *et al*. (2014), white rice has total phenolic content (TPC) of 4.12 ± 0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan *et al*. (2010), which was 0.831 ± 0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be provided by pluchea leaves in food products include activities as anti-warmed-over flavor, anti-inflammatory, antidiabetic (Widyawati *et al*., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah *et al*., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati *et al*., 2014; Widyawati *et al*., 2015). According to Li *et al*. (2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari *et al*. (2009) also proved that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding tempeh yeast	Magatra, 2013
Pluchea-black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the ripening stage	Adventi *et al*., 2015
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih, 2015
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat eggs	Firdausi, 2017
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang, 2018
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati *et al*., 2019
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea powder	Wijaya, 2019
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono, 2021

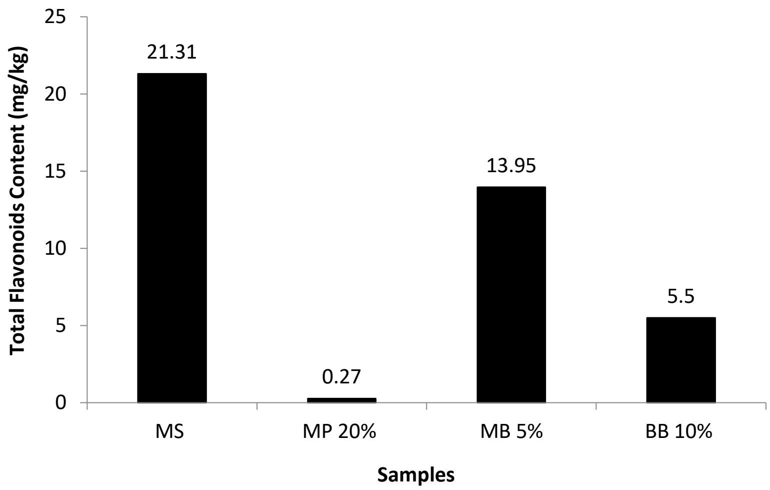

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB 5% (Wibisono, 2021)) compared to sidondo wet noodles (MS (Syahirah and Rabeta, 2018)), pegagan wet noodles 60% (MP 60% (Fadzil *et al*., 2020)), and pluchea bun 10% (BB 10% (Chiang, 2018)). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP 20%, MB 5%, and BB 10% were expressed by the values that have been subtracted with the TFC of control from each study

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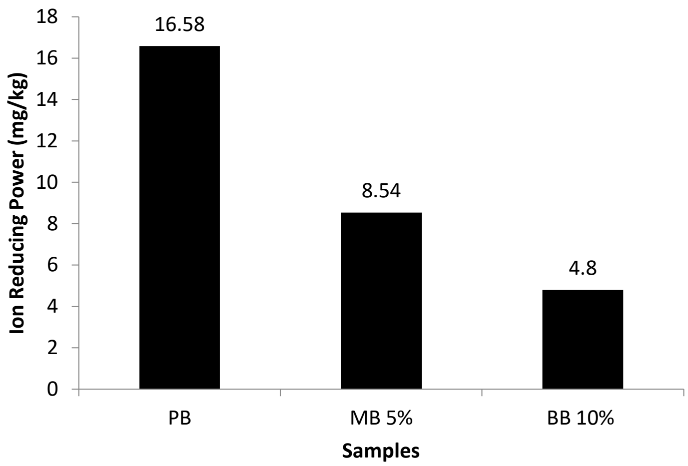

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB 5% (Wibisono, 2021)) compared to rice flour paste (PB (Nitha *et al.*, 2013)) and pluchea bun 10% (BB 10% (Chiang, 2018)). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB 5% and BB 10% are expressed by the value that has been reduced by the RP value of control from each study

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REVIEW ARTICLE

Functional foods and their impact on health

Musthafa Mohamed Essa[1,2,10] · Muhammed Bishir[3,4] · Abid Bhat[3,4] · Saravana Babu Chidambaram[3,4] · Buthaina Al-Balushi[1] · Hamdan Hamdan[5,6] · Nagamaniammai Govindarajan[7] · Robert P. Freidland[8] · M. Walid Qoronfleh[9]

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Abstract Functional foods play an important role in maintaining a healthy lifestyle and reducing the risk factors of various diseases. Most foods have a functional element which is responsible for improving the healthy state. All food substances such as fruits, vegetables, cereals, meat, fish, dairy contain functional ingredients. A wide range of naturally occurring substances from plant and animal sources having active components which play a role in physiological actions deserve attention for their optimal use in maintaining health. The market for functional food is keep on expanding, and the global market is projected to reach a value of at least 91 billion USD soon. Overwhelming evidence from preclinical (*in vitro* and *in vivo*) and clinical studies have shown that intake of functional foods could have an impact on the prevention of chronic diseases, especially cancer, cardiovascular diseases, gastrointestinal tract disorders and neurological diseases. Extensive research needs to be done to determine the

✉ Musthafa Mohamed Essa
drmdessa@gmail.com

1 Department of Food Science and Nutrition, CAMS, Sultan Qaboos University, Muscat, Oman

2 Ageing and Dementia Research Group, Sultan Qaboos University, Muscat, Oman

3 Dept. of Pharmacology, JSS College of Pharmacy, JSS Academy of Higher Education & Research, Mysuru, India

4 Centre for Experimental Pharmacology and Toxicology, Central Animal Facility, JSS Academy of Higher Education & Research, Mysuru, India

5 Department of Physiology, Al Faisal University, Riyadh, Saudi Arabia

6 Department of Neuroscience, Baylor College of Medicine, Houston, TX, USA

7 Department of Food Process Engineering, College of Engineering and Technology, SRM Institute of Science and Technology, Kattankulathur, Chengalpettu, Tamil Nadu, India

8 Department of Neurology, University of Louisville School of Medicine, Louisville, KY 40202, USA

9 Q3CG Research Institute (QRI), Research and Policy Division, 7227 Rachel Drive, Ypsilanti, MI 48917, USA

10 College of Agricultural and Marine Sciences, Sultan Qaboos University, P.O 34, Al-Khoud, Muscat 123, Sultanate of Oman

potential health benefits for the proper application of these foods to improve health state and combat chronic disease progression. The aim of this review is to conduct a thorough literature survey, to understand the various classification of functional foods and their health benefits.

Keywords Functional food · Nutraceuticals · Plant food · Fruits · Vegetables · Nuts · antioxidants · Probiotics

Introduction

Functional foods are regarded as foods that have potential beneficial effect on health beyond their basic nutritional value. They promote good health and lower the risk of diseases. Functional foods have received widespread popularity across the globe, and they are commonly known as "nutraceuticals" and "designer food". The concept of functional food was started and regulated by the Ministry of Health and Welfare, Japan, in the year 1980s and then progressed to North America and other markets (Mellentin et al. 2014). Amount of biologically active compounds are very less in the food items and their beneficial effect have been studied in rodent models and clinical studies. Results from epidemiological studies have shown that consumption of specific fruits, animal products and vegetables that are rich in bioactive compounds reduced the risk of various metabolic disorders and cancer (Karasawa and Mohan 2018) (Fig. 1).

Natural bioactive molecules such as curcumin, resveratrol, quercetin, sulforphane, epigallocatechin, lycopene, and ellagic acid have been studied for their direct and indirect effects on various molecular pathways. Curcumin is the major bioactive constituent in *Curcuma longa* and is found in the spice turmeric as well as other sources. It has been studied for its antioxidant and anti-inflammatory properties (Sneharani 2019). Resveratrol (3,5,4-trihydroxystilbene) is found in grapes and pomegranates and studies have shown its benefits on vascular function, immunity and the gut microbiota (Chaplin et al. 2018). Apples are abundant in quercetin, which has shown potent neuroprotective properties in neurodegenerative diseases (Elumalai and Lakshmi 2016). Cruciferous vegetables such as broccoli, cabbage and kale are abundant in sulforphane, which is a. potent activator of the Nrf2-ARE pathway and promoter of redox, thereby protecting from oxidative stress. In addition, sulforphane modulates Phase I and II xenobiotic-metabolizing enzymes and directly inhibits binding of carcinogens to DNA, preventing DNA adduct formation (Juengel et al. 2017). Epigallocatechins are a group of compounds found in in tea leaves which have been shown to have widespread pharmacological properties. Recent studies have determined that epigallocatechins inhibits the expression and activity of indoleamine 2,3-dioxygenase in human colorectal cancer cells (Ogawa et al. 2012). (Table 1). Food production and eating habits have a pivotal role in the health, environmental and social life of human beings. The aim of this review is to conduct a thorough literature survey, to understand the various classification of functional foods and their health benefits.

Classification of functional foods

Functional foods are classified into three categories: (1) conventionally used food, (2) modified food, (3) food ingredients. Conventionally used foods have not undergone any modification and appear as a whole such as vegetables, fruits, fish, diary, pulses and grains that have potent health benefits. Modified foods are those foods which have been enriched or fortified with a specific nutrient in order to promote health benefits. Modified foods include calcium, anti-oxidants and vitamin fortified beverages, calcium and folate enriched bread, products enriched with plant fibers, sterols and omega 3 fatty acids are common examples of modified functional foods (Hasler et al. 2009).

Fortification is a common term that describes the practice of enhancing the amount of a specific micronutrient in a food item. This is a sustainable, cost effective solution to overcome micronutrient deficiencies. Similar to fortification another common term used in the food enhancement is fortificants, which are normally found in the raw food, but lost during food processing. In order to overcome this issue techniques have been developed such as biofortification, in which the nutrient content of the food source had been increased through genetic engineering and selective breeding (Hasler et al. 2009).

The third class of functional foods is prebiotics. Gibson and Roberfroid were the first to define prebiotics, they defined it as "food components which nurture the growth and activity of a single and/or a specific group of microorganisms residing in the gastrointestinal tract, thereby improving the health condition of host".The most common form of prebiotics is inulin and oligofructose. They selectively upregulate the useful gut microorganisms such as bacteria and fungi. The concept of prebiotics was first introduced in 1995 by Glenn Gibson and Marcel Roberfroid. Oligofructose such as fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), and trans-galacto-oligosaccharides (TOS) are the most common prebiotics. Gut microbiota ferments these oligofructose to produce the short chain fatty acids (SCFAs) butyric acid, acetic acid and propionic acid which have potential health benefits. The major health benefits include improve cognition, immunity, Ca^{2+} absorption and decrease in the prevalence of irritable bowel syndrome (IBS) and colorectal cancer.

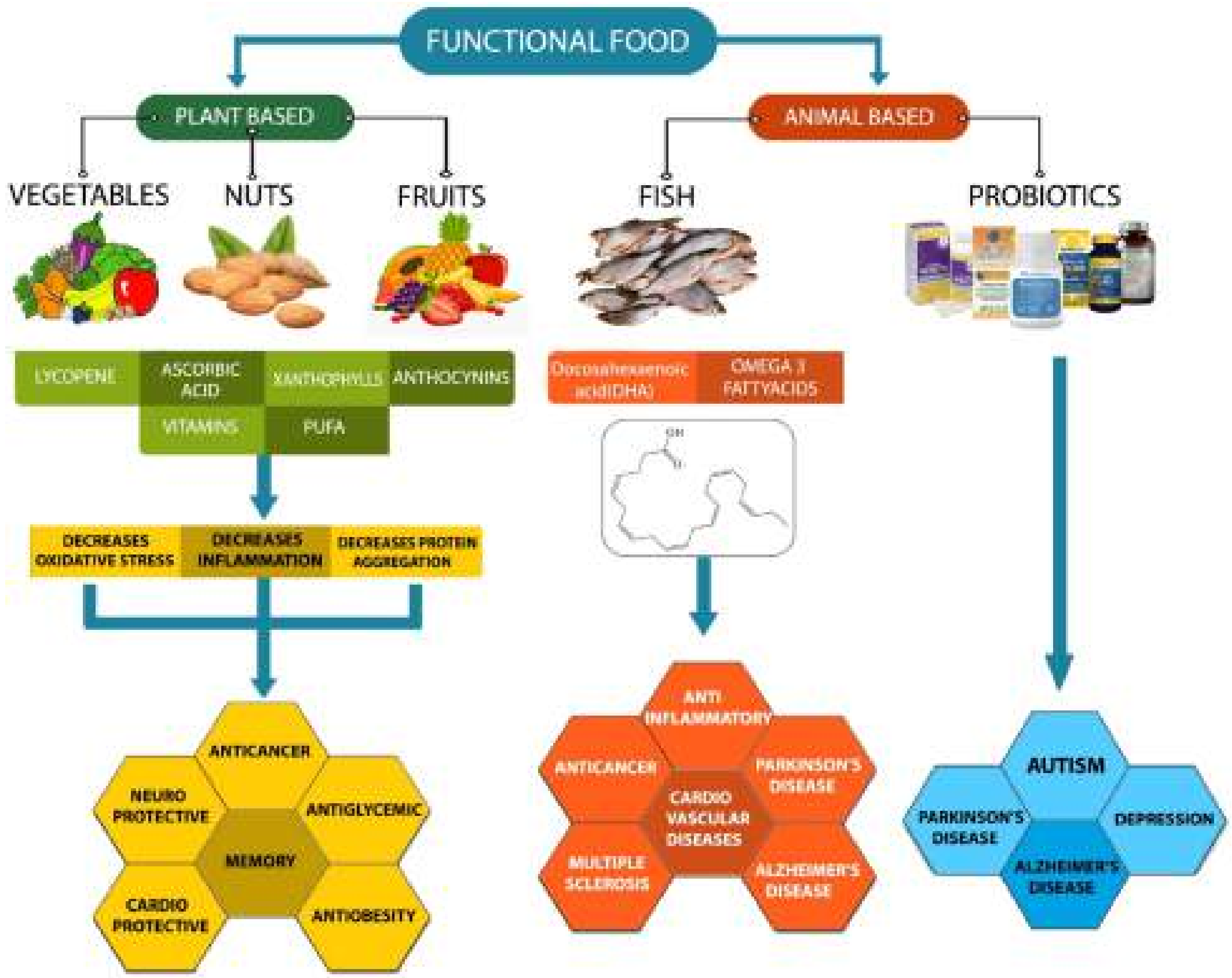


Fig. 1 Health benefits of functional foods

The bacteria that aerobically ferment dietary fiber produce the short chain fatty acids which enhance the integrity of the colonic epithelium intestinal epithelium improving the gut blood barrier. Short chain fatty acids also readily enter the bloodstream and pass the blood brain barrier producing satiety. They also epigenetically improve the production of regulatory lymphocytes that are actively anti-inflammatory (Blaak et al. 2020).

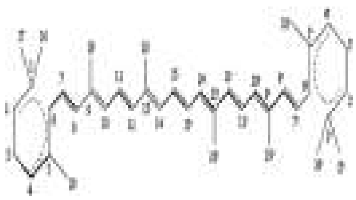
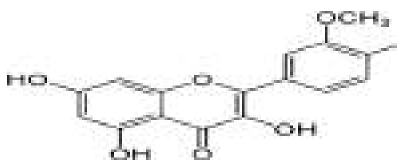
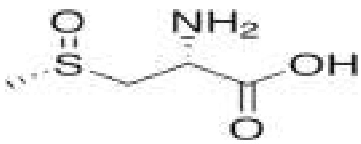
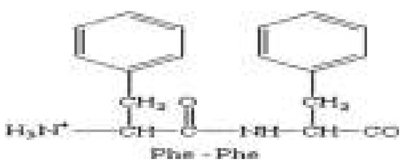
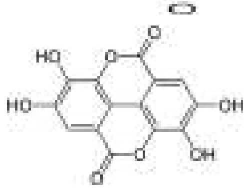
Functional food of plant origin

Plants are the rich source of natural oxidants and help to strengthen innate immunity and protects from the toxic effects of oxidants. Many molecules in living cells are prone to oxidation and antioxidant molecules which are present in the body and which are obtained from plant sources help to fight against the oxidants and their deleterious effects on the body. Natural antioxidants are widely distributed in food and medicinal plants. Polyphenols are a key bioactive ingredient responsible for antioxidant properties. Moreover, they are proven to have anti-allergic, anti-carcinogenic, anti-mutagenicity (Alshatwi et al. 2010) and neuroprotective properties (Yu et al. 2017). In this review, we discus some of the plant derived foods that are rich in polyphenols and other bioactive compounds.

Tomato

Tomatoes are the fruits of *Lycopersicon esculentum* and they originated in Mexico. They are regarded as vegetables and one of the highly consumed food products across the globe. The *Lycopersicon esculentum* has a deep red color which is associated with the carotenoid pigment synthesized during fruit ripening. Majority of the fruits and

Table 1 Chemical structures of some bioactive constituents

Bioactive constituent	Structure	Properties
Lycopene		Prevents DNA mutation (Lindshield et al. 2007), Improves lipid profile (Ibrahim et al. 2008), inhibits tumor growth (Tang et al. 2005)
Neoxanthin		Potent anti-oxidant properties (Lindshield et al. 2007)
Carotenoids		Potent anti-oxidant properties (Lindshield et al. 2007)
Isorhamnetin		Inhibits tumerogenesis (Damon et al. 2005)
S-methyl cysteine sulphoxide		Prevents DNA strand breakage. Inhibition of carcinogen activation by cytochrome P450 (H.Wiseman 2005)
peptide LPYPR		Reduces total cholesterol and LDL cholesterol (Yoshikawa et al. 2000)
Flavanoids		Potent antioxidant properties
Ellagic acid		Potent antioxidant and antiinflammatory properties (Akbar et al. 2015)
Punicalagin		Helps in reducing hypertension, arthritis, cancer, hyperglycaemia, oxidative stress and maintaining cholesterol levels (Zarfeshany et al. 2014)

vegetables contain which phenolic molecules belongs to the flavonoid family. Tomato contains a plethora of bioactive compounds such as lycopene, neoxanthin, violaxanthin, α-cryptoxanthin, zeaxanthin, lutein, β-cryptoxanthin, β-carotene, γ-carotene, ζ-carotene, α-carotene, phytoene, phytofluene, cyclo-lycopene-neurosporene, and β-carotene 5, 6-epoxide (Burns et al. 2003).

Lycopene is the prominent bioactive compound in tomatoes and it has been widely studied over the past decade. Approximately 100 g of tomato contains 12 mg of lycopene. Chemically lycopene is acyclic carotene with 11 conjugated double bonds, these double bonds are contingent to isomerism and their isomers are reported to be found in blood plasma. The human body by itself is unable to synthesize carotenoids so the body is completely dependent on dietary sources. Studies have been reported that 85% of the lycopene in the human diet is obtained from tomato and tomato-based food products. Moreover, lycopene is a key intermediate in the biosynthesis of other essential carotenoids like β-carotene, and xanthophylls (Ruiz-Sola and Rodríguez-Concepción 2012).

It has been reported that consumption of foods that are rich in vitamins, carotenoids and tannins protect the body from oxidative damage. Lycopene is a potent antioxidant, and can protect DNA from free radicals and thereby prevent mutations that lead to cancer (Lindshield et al. 2007). In addition, higher lycopene (20 mg lycopene/kg diet) from tomato sauce and ketchup was reported to improve the lipid profiles of the hyperlipidemic rats (Ibrahim et al. 2008). This result suggest that increase consumption of tomatoes is beneficial in hyperlipidemic patients. Lycopene is also noted to be a potent anti- carcinogen. A study from Alshatwi et al. (2010) had shown that lycopene can protect cells from chromosomal aberration. Lycopene traps the singlet oxygen, impairs the free radical formation and thereby protect DNA from oxidative damage. In addition, it improves gene functioning, carcinogen metabolizing enzymes, apoptotic pathways and immune function. Clinical research suggests that lycopene is beneficial in prostate cancer. Most of the *in vivo* and *in vitro* studies have concentrated on prostate gland cancer models. Studies from Tang et al. analyzed the effect of Lycopene on the growth rate of DU145 prostate gland cell lines in BALB/c nude mice. They had found that lycopene at 100 and 300 mg/kg inhibited the tumor growth by 56% and 76% respectively (Tang et al. 2005).

Dietary intake of tomato prevents the development of high fat diet induced hepatocellular carcinoma in BCO1/BCO2 double knockout mice by decreasing the mRNA expression of proinflammatory mediators, increased NAD^+ production by upregulating the expression of sirtuin 1 and nicotinamide phosphoribosyltransferase. This action is mediated by increased microbial richness and diversity and reducing the *Clostridium* and *Mucispirillum* abundance. Tomato seeds have also been found to reduce *Firmicutes/Bacteroidetes ratio, Rikenella, Enterorhabdus and increases abundance of Lactobacillusin mice* (Xia et al. 2018).

Several clinical trials have been conducted to evaluate the anti-cancer properties of the lycopene. Majority of the studies focused on the concentration of prostate specific antigen (PSA), which determines the risk of prostate cancer. A study from Chen et al. (2001), 32 prostate cancer patients where supplemented with tomato sauce for 21 days (30 mg lycopene/day). They found that tomato sauce consumption decreased the PSA level by 20%. Moreover, biochemical estimation of the prostate tissue revealed a decrease in the ratio of 8-hydroxy-2′-deoxyguanosine (8-OHdG) (oxidative stress marker associated with cancer) to 2′-deoxyguanosine (a marker of oxidative DNA damage) in patients supplemented with tomato sauce as compared to normal control patients. Similar results were found in the study from Grainger et al. (2008), they found that consumption of tomato products daily (lycopene 25 mg/day) for 56 days reduced the PSA levels in 34% of the patients. Phase 2 clinical trial of Lyc-o-Mato® 15 mg/day lycopene has also shown decrease in the PSA levels (Vaishampayan et al. 2007).

The protective effects of Lycopene are well studied in cardiovascular diseases. Potent free radical quenching properties of lycopene protects endothelial cells. Oxidative stress leads to endothelial damage due to decline in nitric oxide (NO) levels causing damage to endothelial cells. Lycopene reduces oxidative stress, enhances the availability of NO, promotes endothelial vasodilation, and alleviates DNA, lipids, and mitochondrial damage (Abdel-Daim et al. 2018). Hung et al. 2008 showed the beneficial role of lycopene in atherosclerosis and other inflammation induced cardiovascular events. They found that lycopene can inhibit Tumor Necrosis Factor (TNF-α) induced activation of Nuclear Factor Kappa B (NF-κB) and the expression of other molecules such as intracellular adhesion molecule-1 (ICAM-1). In addition, lycopene also inhibits the interaction between monocytes and endothelial cells, which may explain the beneficial role of lycopene in cardiovascular disease (Hung et al. 2008).

Some clinical studies have also reported the relationship between lycopene consumption and cardiovascular diseases. A randomized crossover study from Agarwal and Rao (1998) has reported significant decrease in the serum lipid peroxidation and LDL oxidation. The lipoprotein oxidation lag period, which is a measure of protection against oxidative stress was increased in healthy subjects consumed tomato soup for 15 days. Another clinical trial from Shen et al. (2007) treated 24 subjects with various tomato formulation (all the formulation delivering 40 mg lycopene/day) for 42 days, they found decrease in the triglyceride and LDL cholesterol levels and an increase in the High Density Lipoprotein levels.

Lycopene have been extensively studied in neurodegenerative diseases both in preclinical and clinical stages. Lycopene reduces oxidative stress, restores mitochondrial membrane potential and inhibited early apoptotic pathway activation in rat cortical neurons exposed to amyloid β. Lycopene administration in Tau Transgenic Mice increased the memory consolidation by reducing tau phosphorylation, malonaldehyde (MDA) concentrations and increased Glutathione peroxidase (GSH-Px) activities (Yu et al. 2017). Lycopene reduces neuronal damage and increased the expression of BDNF in hippocampus region of AD rats. Lycopene also inhibits depletion of dopamine in substantia nigra and striatum and prevents neuronal damage in rodent model of Parkinson's disease. In addition, lycopene have also been reported to have beneficial effects in Huntington's disease, depression, cerebral ischemia by reducing oxidative stress and inhibiting proinflammatory release (Chen et al. 2019) (Fig. 2).

Broccoli

Broccoli are the flowers of *Brassica oleracea var. italica*. Its flowering head, leaves and stalk are consumed as vegetables across the globe. Broccoli originated in the Roman empire by the primitive cultivators and then became popular in the Italian Peninsula and Sicily. Broccoli is commonly regarded as the "Crown Jewel of Nutrition" because, it is immensely rich in variety of nutrients such as vitamins, minerals, fibres and secondary metabolites. 100 g of broccoli contains: calories (31 g), protein (2.5 g), carbohydrate (6 g), sugar (1.5 g), Fiber (2.4 g) and fat (0.4 g). Broccoli is rich in sulphur containing compounds and their biometabolic products glucosinolates, isothiocyanates have been reported to have potent anti-cancer properties. Moreover, broccoli is also rich in polyphenols such as isorhamnetin, sinapic acid, quercetin and rutin. In addition, it is rich in Vitamin K, B_1, B_2 (Damon et al. 2005) and

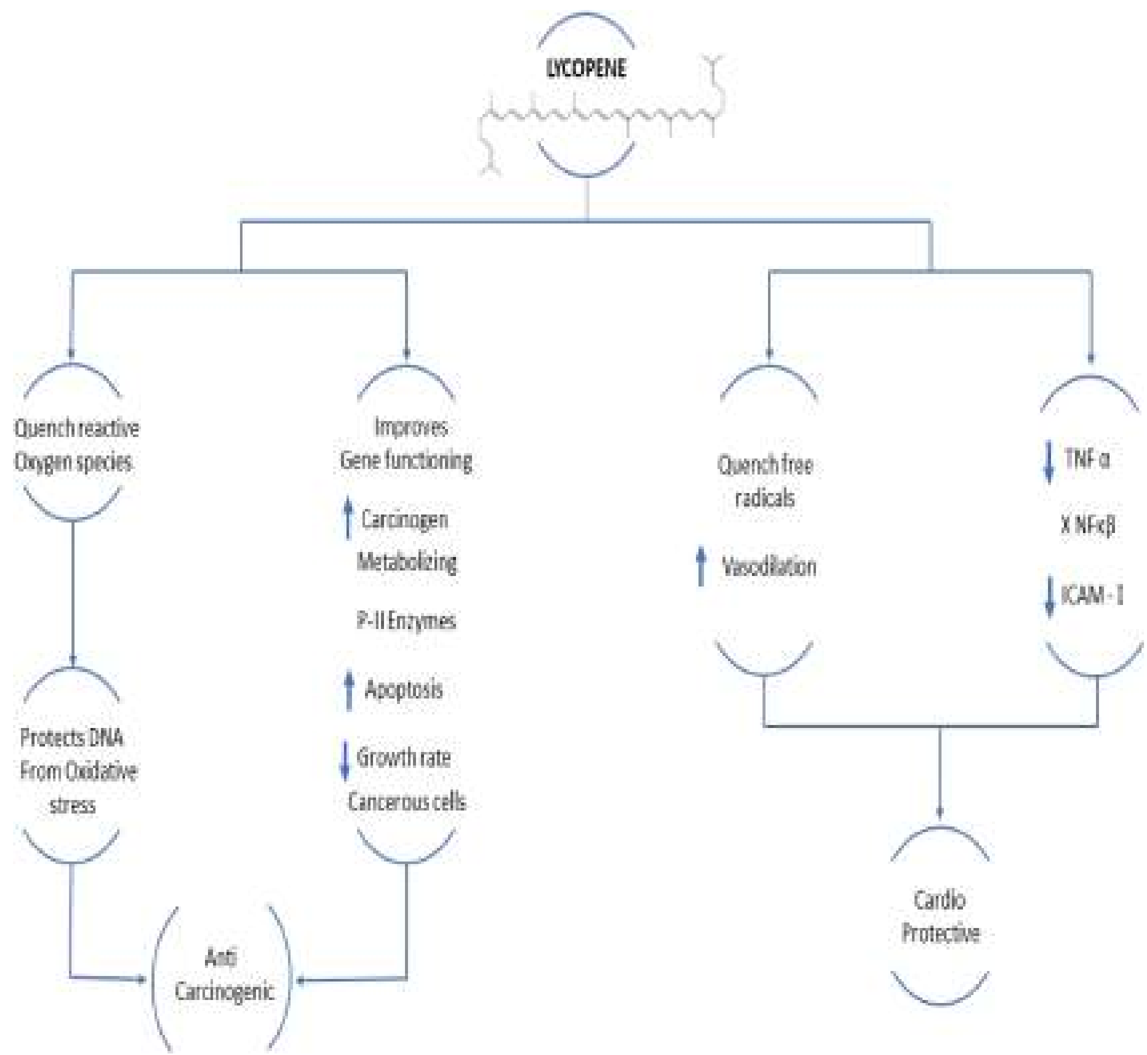


Fig. 2 Lycopene present in tomato is a potent antioxidant which provides several health benefits

minerals like Na, K, Ca, Mg, Cl, P and S. Dietary consumption of cruciferous vegetables is highly beneficial in preventing stomach, colon, thyroid, skin and prostate cancers. Anti—cancer property of broccoli is associated with sulforaphane, indoles, polyphenols, vitamins and minerals. It has been reported that sulforaphane prevents carcinogen induced tumorogenesis. It reduced incidence, multiplication and growth of breast cancer in dimethylbenzanthracene (DMBA)-treated rats. Moreover, sulforaphane or 4-methylsulfinylbutyl isothiocyanate induces phase 2 detoxification enzymes such as glutathione transferases, epoxide hydrolase, NAD(P)H: quinone reductase, and glucuronosyltransferases through inhibiting Nrf2-Keap 1 interactions and MAP Kinase activation (Bai Y et al. 2015)). In a clinical study where subjects consumed 250 gm/day (9 oz/day) of broccoli, it was found that broccoli consumption increased the urinary excretion of a potential carcinogen—2- amino-1-methyl-6-phenylimidazo [4, 5-b] pyridine (PhIP), which is commonly found in meat (Walters et al. 2004). Broccoli has also been reported to alter gut microbiome in humans.

Several studies have reported the cardioprotective properties of broccoli. Broccoli sprouts are rich in glucoraphanin which is a metabolic product of sulforaphane. It has been reported that glucoraphanin can induce phase II proteins which in turn decreases oxidative stress and inflammation in both kidneys and the cardiovascular system. Thus, it lowers the risk of hypertension and atherosclerosis in spontaneously hypertensive stroke prone rats (Wu et al. 2004). In a clinical study where the subjects consumed broccoli sprouts (100 gm/day) for a week it was found that total cholesterol levels and escalated HDL cholesterol levels declined (Murashima et al. 2004). Broccoli reduces mRNA and protein levels of thioredoxin super family members which are commonly found following ischemic reperfusion injury, thus broccoli improves the cardiac function, reduces the risk of myocardial infraction, and cardiomyocyte apoptosis (Mukherjee et al. 2008).

Sulforaphane, bioactive compound of broccoli has been found to be beneficial in neurodegenerative diseases. Broccoli inhibits glial cell activation and improves the expression of GABA, AMPA, and NMDA receptors in hippocampus region of rats. Broccoli consumption inhibits NF-κB signaling cascade and proinflammatory cytokines which are responsible for neuroinflammation. Broccoli also upregulates the expression of Nrf2 pathway, inhibits neuronal apoptosis and enhances memory consolidation in mice (Subedi et al. 2019). Broccoli protects from Aβ-induced neurotoxicity in cell line model by mediating mitochondrial functioning, increased Hsp70 mRNA levels and improving the expression of Nrf2-ARE signalling (Masci et al. 2015).

Soya bean

Soya beans (*Glycine max*) are a legume species originated in Southeast Asia and it was first grown by Chinese farmers around 1100 BC. Soya beans consist of protein (35–40%), lipids (20%), and fiber (9%). The major bioactive fractions of soya beans include peptides, isoflavones, saponins, and protease inhibitors. The prominent protein fractions of soya beans are β-conglycinin (βCG, 7S) and glycinin (11S) which constitute around 80–90% of the whole proteins in the soya bean. Moreover, soya beans are also rich in isoflavones which have potent estrogenic and anti-estrogenic properties and saponins which are proven to have significant anti-inflammatory, anti-carcinogenic and cardioprotective properties (Guang et al. 2014).

The majority of the scientific studies have been focused on the hypolipidemic properties of soya beans. Yoshikawa et al. in 2000 have discovered the bioactive peptide LPYPR from the glycine fraction of soya beans. They found that administration of LPYPR (50 mg/kg) significantly reduced the total cholesterol and LDL cholesterol levels in rats (Yoshikawa et al. 2000). Further studies revealed that LPYP functions by inhibiting 3-hydroxy-3-methylglutaryl CoA reductase (HMGR) enzyme, which is the prominent rate limiting enzyme in cholesterol biosynthesis. In addition, other glycine derived peptides like IAVPGEVA and IAVPTGVA had shown potent inhibitory effects on HMGR enzyme, thus promoting hypolipidemic activity. Moreover, peptides derived from βCG like KNPQLR, EITPEKNPQLR, and RKQEEDEDEEQQRE had found to effective in inhibiting fatty acid synthase activity and thereby decreased serum triglyceride levels in rodents (Singh et al. 2014).

Bioactive peptides that are available in food products are well studied for their anti-hypertensive properties (Singh et al. 2014). The bioactive peptides isolated include: valyl-prolyl-proline (Val-Pro-Pro), isoleucyl- prolyl-proline (Ile-Pro-Pro) and (Tyr-Pro). These peptides elicit their action by inhibiting angiotensin-converting enzyme (ACE), which is a key enzyme in the regulation the blood pressure (Cam and de Mejia 2012). The marketed fermented soya bean food products like soya sauce, natto and tempeh are abundant in ACE inhibitory peptides (Hernández-Ledesma et al. 2004). Fermented Korean soya bean contain anti-hypertensive peptide HHL, also soya bean fermented with *Bacillus natto* or *Bacillus subtilis* contains two anti-hypertensive peptides VAHINVGZK and YVWK (Singh et al. 2014).

Soybean supplementation improve cholinergic transmission by increasing the levels of acetylcholine in cortex and hippocampus region of rats (Pan et al. 1999). Soybeans also promote the release of neurotrophic factors which have a critical role in brain development and functioning.

Soyabean upregulates the expression of brain derived neurotrophic factor in cortical region of rats, nerve growth factor in cortex and hippocampus of rats (Pan et al. 1999) and improve memory performance in mice which is corroborated to decrease in high blood lipid levels and increased activity of neurotransmitters in mice. Clinical studies have also found that intake of soya improves both short term and long-term memory. Soybeans have also been found to improve the motor functions in Parkinson's disease by inhibiting the levodopa metabolism in humans (Liu et al. 2007).

Spinach

Spinach (*Spinacia oleracea*) is a leafy green vegetable belonging to the family *Amaranthaceae* and originated from Persia in the 7thcentury. Spinach is consumed in both raw and cooked form. Primarily the major chemical constituents are water (91.4), carbohydrates (3.6%), proteins (2.9%) and fat (0.4%). The lipid fraction mainly consists of poly unsaturated fatty acids (PUFA) (Park 1966). In addition, spinach is an abundant source of the carotenoid leutin, which is highly beneficial for patients with macular degeneration and cataracts (Olmedilla et al. 2003). Compared to other leafy vegetables spinach is rich in flavonoids which includes patuletin, spinacetin, spinatoside, jaceidin, and flavone (Koh et al. 2012). These compounds are responsible for the potent antioxidant and anti-inflammatory properties of spinach.

Antioxidant properties of spinach are well established. Studies have reported that spinach scavenges 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid; ABTS) radical, superoxide anion (O2-), Fe^{2+}, peroxyl radical, hydroxyl radical, and peroxynitrite thereby protecting cells from oxidative damages (Jaiswal et al. 2011). A water-soluble natural antioxidant (NAO) mixture extracted from spinach contains polyphenols and flavonoids. NAO was found to be effective in preventing malonaldehyde (MDA) formation (Bergman et al. 2001). The ant-inflammatory properties of spinach are also well established. Animals treated with spinach derived NAO and then challenged with lipopolysaccharide have shown reduced severity of lesions and alleviated the COX2 mediated inflammation (Bergman et al. 2001). In addition, leutin has potential free radical scavenging property and thereby decreased the levels of PGE2, TNF-α, and IL-1β in the LPS induced inflammatory model. Spinach intake reduces infarct volume, lowers caspase activity in cerebral cortex and increased locomotor activity in focal ischemic rat brain (Lingappan 2018).

Clinical studies have also proven the potential cardioprotective properties of spinach. In a A Randomized, Controlled Trial Jovanovski et al. (2015) had hypothesized that short term consumption of spinach, which is high nitrate content, this can affect arterial stiffness as well as central and peripheral blood pressure. The patients were supplemented with spinach (845 mg nitrate/day). They found postprandial reduction in augmentation index and concluded that spinach consumption contributes to hemodynamic properties, decreased arterial stiffness and central blood pressure.

Brown rice

Brown rice is a whole grain rice with the outer inedible husk removed. Green revolution in 1960's and 1970's has improved the crop yield and economy of the Asian countries like Japan and Korea. Since then, these countries focused on improving the taste, appearance and the texture of rice. A meta-analysis study from (Itani et al. 2002) has shown that increased consumption of sugar rich rice such as processed rice and sedentary life style raised the incidence of type 2 diabetes. This happened due to rice milling, which discards the micronutrients, proteins and fiber rich outer aleurone layer. Brown rice possesses prominent health benefits when compared to white rice. One cup of boiled brown rice has 216.4 cal of energy, monosaturated and polysaturated fat (0.64 g and 0.63 g respectively), 44.8 g of carbohydrates and 5.3 g of proteins. In addition, brown rice is also a rich source of fiber (3.5 g), thiamine (12%), riboflavin (15%), nicotinic acid, zinc (8%), iron (5%), magnesium (21%), phospherous (16%) and pantothenic acid (6%). The vitamin E component of brown rice consists of eight lipid homologues α, β, γ and δ tocopherol or tocotrienol these are having potent lipid peroxy radical scavenging properties thus preventing cellular ageing (Kim et al. 2015).

Lee et al., conducted a randomized 12-week clinical study where the type 2 diabetes patients were assigned to follow brown rice-based vegan diet. They found that brown rice-based vegan diet is more effective for glycaemic control in type 2 diabetic patients than conventional diet. In addition, they also found a reduction in the HbA1C levels among the vegan diet followed patients (Lee et al. 2016). Kozuka et al., have elucidated the underlying mechanism on how brown rice improves the glucose intolerance and impede the onset of diabetes. They investigated the effect of γ-oryzanol (orz) which is a major chemical constituent of brown rice on the feeding behavior and glucose homeostasis. They found that orz significantly improved the glucose intolerance and this was achieved by attenuating endoplasmic reticulum stress in mice fed with high fat diet. Using HEK293 cell line the revealed that orz prominently inhibits the transcriptional activity in the endoplasmic reticulum stress responsive element. In addition, they also found that orz significantly down-regulated the gene expression of endoplasmic reticulum stress related molecules in fetal mouse brain derived neuronal cells. Moreover, orz also has shown to improve glucolipotoxicity induced pancreatic islets disruption via enhancing glucose-stimulated insulin secretion and inhibiting excessive secretion of glucan (Kozuka et al. 2015).

Buckwheat

Buckwheat (BW) is a gluten free commonly eaten functional food belonging to family *Polygonaceae* genus *Fagopyrum*. It is considered as a food of high nutritional value due to the presence of protein, lipid, dietary fiber, minerals, phenolic compounds, and sterols. Buckwheat contains flavonoids such as rutin and polyphenolic compounds like hyperin, quercitrin, and studies showed that quercetin could be responsible for the beneficial effects. BW is also rich in amino acid lysine, arginine and vitamins (Giménez-Bastida and Zieliński 2015). Recently it has been found that buckwheat also contains γ-aminobutyric acid (GABA) and 2″-hydroxynicotianamine. BW has shown to possess strong antioxidant activity and prevents the DNA damage induced by oxidative stress (Zhou et al. 2012). Phenolic compunds and flavonoids present in BW exert anti-inflammatory effect by reducing the expression of IL-6, IL-1β, and TNF-α and inhibit NF-κB (Hole et al. 2009). BW consumption reduces body fat, low density lipids (LDL) and increases the content of high density lipids (HDL) and lowers cholesterol and triglycerides (TG) in rats (Kayashita et al. 1996), thus inhibiting the development and progression of cardiovascular diseases. BW intake also affects the mRNA expression of enzymes responsible for lipid metabolism. BW decreases the expression of glucose-6-phosphate dehydrogenase and fatty acid synthase and downregulates expression of PPAR -γ, peroxisome proliferator activated receptor-γ, CCAAT/enhancer-binding protein-α, sterol regulatory element-binding protein 1c, and carbohydrate responsive element-binding protein and of lipogenic genes acetyl-coenzyme a carboxylase 1 or 2 (ACC1 and 2), stearyl-coenzyme A oxidase, and FA synthase (Choi et al. 2007). Preclinical studies have shown that BW reduces the blood glucose levels in diabetic rats (Yao et al. 2008), inhibited α-amylase and α-glucosidase activity (Lee et al., 2015) and also modulates satiety, improve insulin sensitivity and glucose tolerance in hyperglycaemia patients (Qiu et al. 2016). Polyphenols present in buckwheat exert neuroprotection because of its free radical scavenging activity. Buckwheat has shown to improve spatial memory by inhibiting glutamate release and inhibiting production of nitric oxide in cerebral ischemia induced rat (Giménez-Bastida and Zieliński 2015). Buckwheat also improved the memory in *in vivo* model of AD by reducing oxidative stress in mice (Choi et al. 2007) (Fig. 3).

Several clinical studies have also shown potential health benefits of BW. He et al. (1995) has shown that daily intake of 100 g of lowered both total and LDL cholesterol in 850 people of ethnic minority in china. In a doube blind crossover study from Wieslander et al. (2011) samples were supplemented with normal BW (16.5 mg rutin/day) and tartary BW cookies (359.7 mg rutin/day) for two weeks. They found that tartary BW cookies consumption reduced the serum myeloperoxidase, total serum cholesterol and HDL-cholesterol. Moreover, they also found that tartary BW consumption improved the lung vital capacity. Hence, consumption of BW reduces the inflammatory markers and cardiovascular events in human beings.

Fruits as a source of functional food

Fruits are a rich source of fiber, vitamins and polyphenolic and anthocyanin compounds. These compounds have many physiological functions and delays the onset of ageing related changes, helps in fighting infections and chronic diseases, impedes cancer, osteoporosis and neurological disease progression. Some of the fruits which act as functional food discussed below.

Blueberries

Blueberries were known as 'super fruit' because of their strong antioxidant activity and rich content of polyphenolic compounds. Blueberries contain flavonoid and non-flavonoid. Anthocyanins (60%) are the major components. Malvidin 3-galactoside, delphinidin 3-galactoside, delphinidin 3-arabinoside, petunidin 3-galactoside, petunidin 3-arabinoside, malvidin 3-arabino-side, cyanidin 3-glucoside, cyanidin 3-galactoside, cyanidin 3-arabinoside and delphinidin 3-glucoside are the major anthocyanins present in blueberries. Proanthocyanidins, flavonols and chlorogenic acid are also present in blueberries. The commercially available blueberries species are *Vaccinium corymbosum* L., *V. virgatum* Aiton, *V. angustifolium*, *V. myrtillus* L. The association between the higher intake of anthocyanin and health benefits have been well studied. Higher intake of anthocyanin was associated with a decrease in hypertension risk in women, improved vascular function and helps in weight maintenance (Bertoia et al. 2016).Blueberries are also found to be beneficial in diabetes. Higher intake of anthocyanins improved insulin sensitivity, reduced inflammation and oxidative stress in diabetic patients (Li et al. 2015). Anthocyanin intake also reduced the risk of Alzheimer's disease, dementia and PD (Gao et al. 2012). *In vitro* studies have shown that anthocyanins improved viability and differentiation of human corneal epithelial cells (Song et al. 2010) and improve

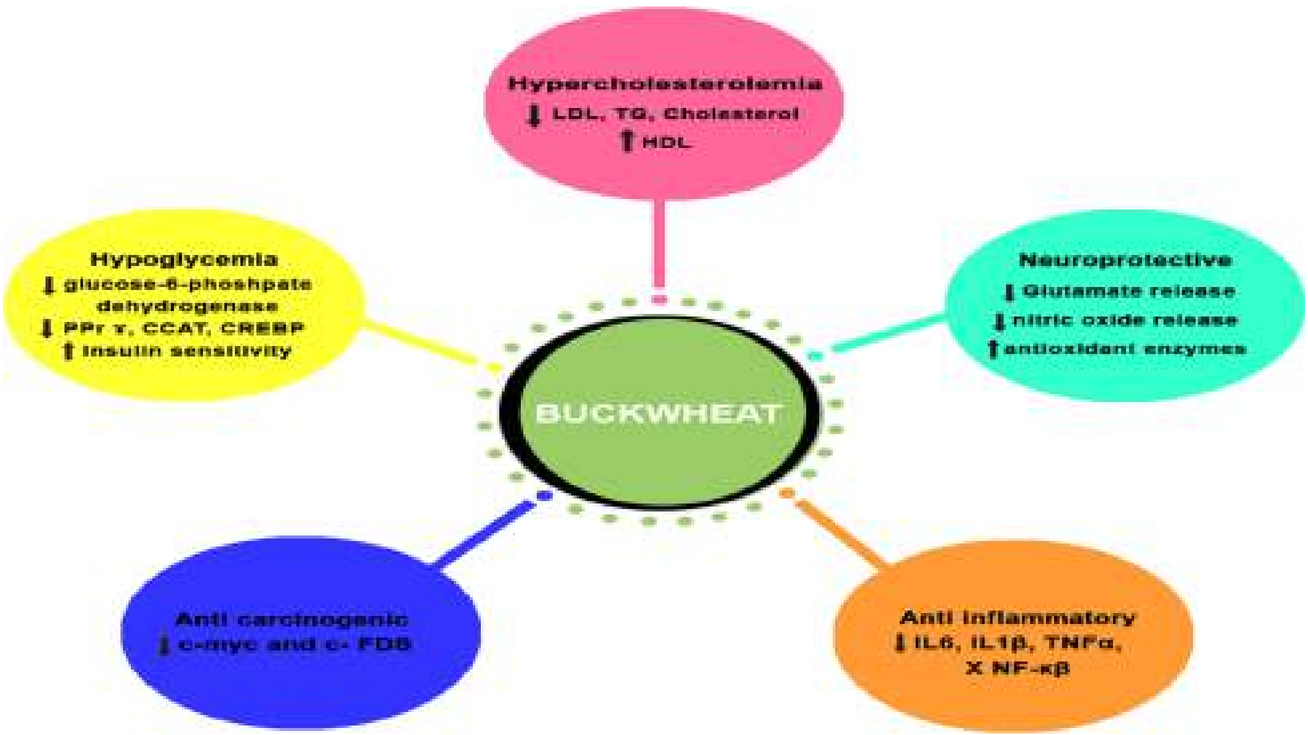


Fig. 3 Mechanism by which buckwheat intake provides benefits in different disease conditions

retinal photoreceptor sensitivity. Blueberries have been shown to reduce cancer progression by inhibiting production of pro-inflammatory molecules, oxidative stress and products of oxidative stress such as DNA damage, inhibition of cancer cell proliferation and increased apoptosis (Johnson and Arjmandi 2013).

Pomegranate

Pomegranate (*Punica granatum* L) fruits are rich source of phytochemical such as polyphenols, anthocyanins, tannins, flavonoids, lignans, terpenoids, and sterols. Ellagitannin which is broken down to ellagic acid is the main active constituent of pomegranate which is responsible for its strong antioxidant activity (Akbar et al. 2015). Punicalagin and punicalin are the two other ellagitannins having antioxidant and anti-inflammatory activity (Vučić et al. 2019). Numerous studies have claimed health benefits of pomegranates in preventing chronic diseases such as hypertension, arthritis, cancer, hyperglycaemia, reducing oxidative stress and maintaining cholesterol levels (Zarfeshany et al. 2014).

Khan et al. (2007) has revealed that pomegranate juice inhibits cell growth, induces pro-apoptotic proteins and downregulates anti-apoptotic proteins and suppresses the progression of prostate cancer and breast cancer as well as lung and colon cancer (Khan et al. 2007). The pomegranate fruit extract (PFE) used in this study was rich in six anthocyanins (pelargonidin 3-glucoside, cyanidine 3-glucoside, delphinidin 3-glucoside, pelargonidin 3,5-diglucoside, cyanidine 3,5-diglucoside and delphinidin 3,5-diglucoside), ellagitannins and hydrolysable tannins. Invitro data has shown decreased cell viability in A549 following PFE administration. They found that PFE upregulates the cell cycle regulatory molecules like WAF1/p21 and KIP1/p27. WAF1/p21 and KIP1/p27 are regarded as the universal molecules of inhibitor of cyclin–cdk complexes. PFE administration has also significantly downregulated the cyclin–cdk associated molecules. In addition, the PFE administration declined progression of A549 human lung carcinoma cells in athymic mice. The potent anti-oxidant property aid to the chemoprotective nature of PFE.

Studies have showed the role of pomegranate juice in preventing hypertension and congestive heart disease (Esmaillzadeh et al. 2006). Pomegranate juice also promotes the expression of transcription factors such as CREB, and BDNF which play a critical role in brain development. Pomegranate juice reduces cerebral amyloid beta deposits by increasing the expression of CREB and synaptic proteins which were also found to be involved in the cleavage of amyloid precursor protein in transgenic mice model of Alzheimer's disease (Braidy et al. 2016). Decreased expression of amyloid beta in hippocampus due to pomegranate intake improves cognitive functions in mice. Pomegranate juice also enhances neuronal survival, protects from oxidative stress, reduces α-synuclein aggregation and could be able to increase mitochondrial activity in rotenone model of Parkinson's disease. Pomegranate administration also reduces the neuroinflammation and improved motor functions in mice (Kujawska et al. 2019).

Mango

Mango (*Mangifera indica* L.) is rich in polyphenols and other micronutrients which exert several health benefits. Mangiferin, gallic acid, gallotannins, quercetin, isoquercetin, ellagic acid, and β-glucogallin are the polyphenols present in mango. Mango parts have been used in traditional system in the management of various diseases. Mango extracts counteract the oxidative damage induced by the excessive production of free radicals and exert anti-inflammatory activity in mice model of colitis by reducing the expression of inflammatory mediators via IGF1R/AKT/mTOR pathway (Kim et al. 2016). Mango extract has beneficial effects in hypoglycaemia by inhibiting α-amylase and α-glucosidase activities (Gondi and Prasada Rao 2015). Bioactive compounds of mango have also shown to possess anticancer activity which is mediated by down-regulating the anti-apoptotic factor Bcl-2 and activating caspase proteases. Mango intake reduces the risk of obesity and promotes endothelial function. Phytochemicals present in mango improve the lipid profile and reduced blood pressure surge in hypertensive rats (Liu et al. 2003). Mango intake also reduces the development of neurological diseases such as Alzheimer's disease. *In vitro* and *in vivo* studies have confirmed that magniferin protects the neurons by scavenges the ROS and restores mitochondrial membrane potential and improved cognitive performance (Bhatia et al. 2008).

Nuts as a source of functional food

Almond

Almonds are the most popular nut consumed by humans. They have a high nutritional value and are rich in poylphenols, vitamins, carbohydrates and polyphenols. Almonds are also rich in monounsaturated fatty acids such as oleic, linoleic and palmitic acids. Intake of almonds reduce chronic disease such as diabetes, hypertension and help in weight maintenance. Invitro and animal studies have reported that almonds reduce oxidative stress and DNA damage. Epidemiological studies have shown that higher intake of almonds in Mediterranean countries contributes to lower incidences of coronary heart disease, reduce inflammatory diseases and improve endothelial functions (Kamil and Chen 2012). Dietary elements present in almonds improve memory consolidation in rodent models of amnesia (Batool et al. 2016).

Walnut

Walnuts are one of the most nutritive nuts belonging to family *Juglandaceae*. They are rich in proteins, fats, vitamins, minerals, and polyphenols. The major triacylglycerols; free fatty acids found in the walnut kernel are oleic, linoleic, linolenic acids (Poulose et al. 2014). They also contain high quantity of omega-3 fat [alpha-linolenic acid] which has been linked with numerous health benefits. Walnuts also contain amino acids such as lysine and arginine which are converted to nitric oxide, which acts as a potent vasodilator, inhibiting platelet adhesion and aggregation, and reducing the progression of atherosclerosis. Ellagic acid present in the walnut reduces the risk of congestive heart disease and suppresses cancer progression. Melatonin present in walnut is a powerful antioxidant and regulates circadian rhythm. Dietary supplement of walnut improves memory consolidation and has been reported to delay the progression of neurological disorders. Moreover, walnut supplementation provided neuroprotection and improved motor functions in rodent model of Parkinson's disease (Choi et al. 2016). Taken together, evidences suggest that integration of nuts in a healthy diet could be an effective measure to maintain a health state and delay the onset of diseases.

Functional foods of animal origin

Fish

The chief bioactive component present in fish products are polyunsaturated fatty acids. Eicosapentaenoic acid and docosahexaenoic acid (DHA) form the major components of polyunsaturated fatty acids. DHA forms an essential component of cellular membranes in brain and retina. DHA is critical for normal functioning and development of organs in children. Preclinical and clinical studies have shown the beneficial effects of fatty acids in inflammatory diseases such as arthritis, psoriasis, Crohn's disease, and chronic diseases such as cancer and cardiovascular diseases. DHA have also been found to provide protective effect in neurological diseases (Wergeland et al. 2012).

Probiotics

Probiotics are the viable microorganisms that improve the intestine functions in the host organisms. Probiotics are known for their anti-carcinogenic, hypocholesterolemic and antagonistic action against enteric pathogen in the intestines. Dairy products are the best source of calcium. Probiotics have been incorporated in milk products, mayonnaise, edible spreads (Begum et al. 2017). Probiotics constitute around 65% of functional food market. Probiotics inhibit pathogen growth by synthesizing biochemical compounds which possess antimicrobial activity, altering the pH, receptor binding of pathogens, and initiating immune response. Probiotics have also been found to be useful in the management of neurological disorders. Alteration in gut microbiome have been reported in autistic children. Lower levels of *Bifidobacterium* have been found in autism. Similarly, fecal matter of autistic children has higher levels of *Clostridium spp.* In case of Alzheimer's disease *Oscillospira* were found to be reduced while as *Enterobacter*, *Shigella* and *Roseburia* increased. Various clinical and animal studies have confirmed the beneficial effects of probiotics in autism. The key mechanism by which probiotics have an impact on the gut microbiome are by competing for dietary ingredients production of end products having inhibitory property increased innate immunity reduced inflammatory response. Some of the commonly used microorganisms in probiotics are *Lactobacillus rhamnosus, Lactobacillus reuteri, Bifidobacteria, Lactobacillus casei Lactobacillus acidophilus, Bacillus coagulans, Escherichia coli, Saccharomyces boulardii.* Probiotics may contain a single strain or mixture of these microorganisms.

FDA perspective on functional foods

The Federal Food Drug and Cosmetic Act (FFDCA) does not provide a specific definition for the functional food. Hence, FDA does not have an established regulation for the functional foods. Therefore, marketing functional foods come under the existing regulatory options. There is a rising concern to develop regulations to document the safety of the dietary ingredients and dietary supplements. Nutrition Labeling and Education Act which was developed (NLEA) in 1990 introduced food labels, this explains the relationship between food or a food component with disease or health conditions. These potential health benefit claims should be approved by FDA before marketing. In 1997, the FDA Modernization Act (FDAMA) had been implemented. This act smoothened the FDA preapproval process by implementing the "authoritative statements" on food labels as health claims. These statements should be published by US government bodies which are responsible for the public health like National Institute of Health (NIH). Manufacturers who intend to use the authoritative statement should notify the FDA 120 days prior to the marketing (Affairs 2019 p. 1).

The most significant change in the food regulation was implemented by Dietary Supplement Health and Education Act of 1994 (DSHEA). This act considered the food additives as vitamins, minerals, amino acids used by man to improve the health conditions. They introduced "significant Scientific agreement" which includes the reports of the safety and efficacy of these compounds in living system. This includes the role of the bioactive compound that affects the functioning of living systems and the mechanism by which the compound induces pharmacological effect. In addition, if the compound claims to treat any conventional nutrient deficiency diseases then the prevalence of the disease in the United States should be produced. Manufacturers who are using structural and functional claims on the label should notify the FDA within 30 days of marketing and the following statement should be kept as a disclaimer ("Dietary Supplement Health and Education Act of 1994," n.d.).

Conclusion

Functional foods have been receiving considerable global attention because of their nutritional value and the presence of constituents which are critical in regulation of physiological processes. Functional foods have all the ingredients necessary for a healthy diet and have been found to possess health benefits. Recommendation of functional foods is evolving and will be an essential strategy for maintenance of healthy sate and delaying or preventing the onset of diseases.

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Author contributions MB, and AB performed literature research, gathered and analyzed information, and generated short preliminary write-ups. SBC, BB, HH and NG provided research insight, content examination and supported wide ranging aspects of the manuscript development process. MME, RPF and MWQ conceptual work, framework, final draft write-up, critical reading and editing. All authors read and approved the final manuscript.

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Declarations

Conflict of interest Authors declare no conflict of interest.

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Paini Sri Widyawati <paini@ukwms.ac.id>

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FOOD RESEARCH

MINI REVIEW

Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

*Widyawati, P.S., Darmoatmodjo, L.M.Y.D., Wibisono, D.A.S., Putra, E.W. and Dharma, A.W.

Department of Food Technology, Faculty of Agricultural Technology, Widya Mandala Catholic University Surabaya, Dinoyo Street Number 42-44, Surabaya, 60265, East Java, Indonesia

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Abstract

Wet noodles lack functional nutrients that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as a source of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Thus, the addition of pluchea leaves has potential to increase the functional value of wet noodles including the phytochemical content and functional properties.

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles have water content of about 50-52% (Nuraida *et al*., 2009), 52.10-52.85% (Billina *et al*., 2014) 58-70% (Zhou *et al*., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina *et al*., 2014). According to Nuraida *et al*. (2009), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42 hrs at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa *et al*., 2021). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. The raw materials of noodles generally include wheat flour, eggs, and water. However, noodles are known to be low in functional nutrients that are beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). Therefore, various efforts have been made to overcome the shortcomings of wet noodles. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds, one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols, that act as sources of natural antioxidants (Widyawati *et al*., 2015). In addition, pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah *et al*., 2003). The use of pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodle's product.

Currently, the use of pluchea leaves is only limited to fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), pluchea-black

*Corresponding author.
Email: *paini@ukwms.ac.id*

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tea salted eggs (Adventi *et al*., 2015), effervescent powder based on pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati *et al*., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Pluchea leaves as functional supplement

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic *et al*., 2013; Sari, 2014). Marsono (2008) also declared that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa *et al*., 2021). According to Essa *et al*. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil *et al*. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed, making the noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are relatively low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili *et al*., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim *et al*., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil *et al*., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). Research conducted by Widyawati *et al*. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Pengelly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and

Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding	Magatra (2013)
Pluchea-black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the	Adventi *et al*. (2015)
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih (2015)
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat	Firdausi (2017)
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang (2018)
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati *et al*. (2019)
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea	Wijaya (2019)
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono (2021)

soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman *et al*., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari *et al*., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo *et al*., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian *et al*., 2010; Vichapong *et al*., 2010; Chen, 2013). Flavonoids act as antioxidants by chelating metals and donating hydrogen atoms, thus provide certain physiological effects on the human body (Erlidawati *et al*., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

The research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012; Koirewoa *et al*., 2012; Mahasuari *et al*., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3',4',5,5',6,7,8-heptametioxyflavones (Lakshmanashetty *et al*., 2010; Ullah *et al*., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). The TFC value of wet noodles with the addition of 5%

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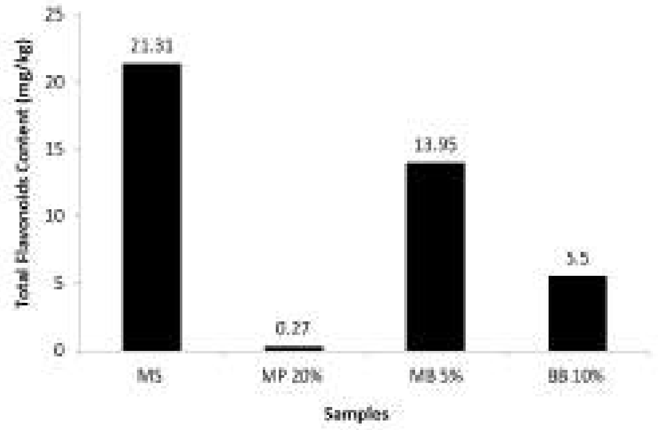

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB 5% (Wibisono, 2021)) compared to sidondo wet noodles (MS (Syahirah and Rabeta, 2018)), pegagan wet noodles 60% (MP 60% (Fadzil *et al*., 2020)), and pluchea bun 10% (BB 10% (Chiang, 2018)). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP 20%, MB 5%, and BB 10% were expressed by the values that have been subtracted with the TFC of control from each study.

concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta's research (2018), while pluchea wet noodles dough in Wibisono's study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, a study conducted by Saikia and Mahanta (2013) showed that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also mentioned that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in

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various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati *et al*., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny *et al*., 2001). According to Widyawati *et al*. (2014), iron ion is one of the pro-oxidants that have the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

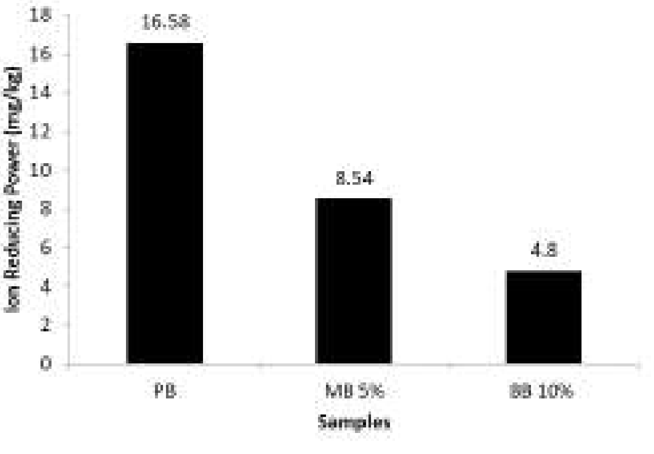

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB 5% (Wibisono, 2021)) compared to rice flour paste (PB (Nitha *et al.,* 2013)) and pluchea bun 10% (BB 10% (Chiang, 2018)). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB 5% and BB 10% are expressed by the value that has been reduced by the RP value of control from each study.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya *et al*. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1, can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati *et al*., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea bun, can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati *et al*. (2014), white rice has total phenolic content (TPC) of 4.12±0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan *et al*. (2010), which was 0.831±0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be

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provided by pluchea leaves in food products include activities as anti-warmed-over flavor, anti-inflammatory, antidiabetic (Widyawati *et al*., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah *et al*., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati *et al*., 2014; Widyawati *et al*., 2015). According to Li *et al*. (2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari *et al*. (2009) also proved that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

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FOOD RESEARCH

MINI REVIEW

Potency of pluchea (*Pluchea indica* Less) leaves to increase functional value of wet noodles: a review

*Widyawati, P.S., Darmoatmodjo, L.M.Y.D., Wibisono, D.A.S., Putra, E.W. and Dharma, A.W.

Department of Food Technology, Faculty of Agricultural Technology, Widya Mandala Catholic University Surabaya, Dinoyo Street Number 42-44, Surabaya, 60265, East Java, Indonesia

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Abstract

Wet noodles lack functional nutrients that are beneficial for health, thus it is necessary to add other food ingredients that can increase the functional value of wet noodles. One of the food ingredients that can be added in wet noodles formulation is *Pluchea indica* Less leaves, which have been known as a source of antioxidants and used by the community as a traditional medicine to treat various health problems. The use of *Pluchea indica* Less leaves in making wet noodles is expected to increase the functional value of wet noodles. For this reason, this review paper discussed the potency of *Pluchea indica* Less leaves in affecting the phytochemical compounds content and functional properties of wet noodles. The use of *Pluchea indica* Less leaves showed potential to increase the phytochemical compounds contents of wet noodles, such as alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides, which play an important role in the health of human body and maintaining the quality of wet noodles, such as antioxidant, anti-warmed over flavor, anti-inflammatory, antidiabetic, and antimicrobial activities. Thus, the addition of pluchea leaves has potential to increase the functional value of wet noodles including the phytochemical content and functional properties.

1. Introduction

Noodles as one of the wheat flour-based product are quiet popular among various levels of society in Indonesia. Noodles can be classified into five forms based on processing stage and water content of the noodles product, including raw noodles, wet noodles, dry noodles, fried noodles, and instant noodles. Wet noodles have water content of about 50-52% (Nuraida *et al*., 2009), 52.10-52.85% (Billina *et al*., 2014) 58-70% (Zhou *et al*., 2021), and is produced through the cooking stage of raw noodles before being marketed (Billina *et al*., 2014). According to Nuraida *et al*. (2009), the high moisture content of wet noodles causes the shelf life of wet noodles to only reach 42 hrs at room temperature storage.

Increased awareness and interest in functional food supports the development of various food products with high functional value (Essa *et al*., 2021). The functional value of a food product depends on the nutrients contained in the food ingredients that make up the food product. The raw materials of noodles generally include wheat flour, eggs, and water. However, noodles are known to be low in functional nutrients that are beneficial to health (Akbar, 2018; Khasanah and Astuti, 2019). Therefore, various efforts have been made to overcome the shortcomings of wet noodles. Increasing the functional value of wet noodles can be done by adding other food ingredients that contain bioactive compounds, one of which is the addition of pluchea leaves.

Pluchea (*Pluchea indica* Less) is an herbaceous plant that contains phytochemical compounds, including alkaloids, saponins, tannins, phenol hydroquinone, flavonoids, cardiac glycosides, and sterols, that act as sources of natural antioxidants (Widyawati *et al*., 2015). In addition, pluchea leaves also have antimicrobial activity that has the potency to prevent food damage (Ardiansyah *et al*., 2003). The use of pluchea leaves in the manufacture of wet noodles is expected to produce wet noodles that are able to provide antioxidant effects that are good for health, and have an impact on increasing the shelf life of the wet noodle's product.

Currently, the use of pluchea leaves is only limited to fresh vegetables and drinks, but there have been many studies on the use of pluchea leaves in the food sector that continue to be developed, including making tempeh with pluchea leaf extract (Magatra, 2013), pluchea-black

*Corresponding author.
Email: *paini@ukwms.ac.id*

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tea salted eggs (Adventi *et al*., 2015), effervescent powder based on pluchea leaf extract (Hudha and Widyaningsih, 2015), pluchea bun products (Chiang, 2018), pluchea soy milk (Widyawati *et al*., 2019), pluchea-green tea jelly drink (Wijaya, 2019), and pluchea wet noodles (Wibisono, 2021). The use of pluchea leaves in the manufacture of wet noodles was studied further as an effort to develop functional food products that were beneficial to the health of the consumer's body.

2. Pluchea leaves as functional supplement

Several factors such as individual education, household standards and level of knowledge about food products with health claims, as well as perceptions of some existing functional food product attributes affect the development of public interest in functional food products (Stojanovic *et al*., 2013; Sari, 2014). Marsono (2008) also declared that increasing awareness of the importance of food in preventing or curing disease, consumer demands for foods with more properties (containing functional ingredients), experiences with alternative medicines, and studies on the prevalence of certain diseases that are influenced by diet have also become the basis for the rapid development of functional food products in various countries.

Functional food is defined as a food product that is able to provide benefits to the health of the body, one of which is through the presence of bioactive components contained in a functional food product (Suter, 2013; Essa *et al*., 2021). According to Essa *et al*. (2021), there are five categories of functional food, i.e. foodstuffs with a reduction or increase in the basic nutritional content, products that naturally do not have certain nutrients and are added to them, milk-based products fermented with probiotics, products that are specially formulated to fulfill certain needs, and foodstuffs containing herbal ingredients to help overcome various health problems.

Herbal plants are a source of functional food, i.e. a source of natural antioxidants that can be used in the food sector to improve the functional properties of processed food products, one of which is the use of herbal plants to increase the content of bioactive components in wheat flour-based products such as noodles. According to Fadzil *et al*. (2020), noodles are known to be low in nutritional components that are beneficial to health, while noodles with functional properties such as high antioxidants are in high demand at this time.

2.1 Utilization of pluchea leaves in making wet noodles

The main ingredients in making noodles are generally wheat flour, eggs, water, and other additives as needed, making the noodles products only contain carbohydrates, proteins, fats, and minerals. The content of carbohydrates, several minerals, and energy in noodles are very high, but the content of protein, fat, and vitamins in noodles products are relatively low (Akbar, 2018; Khasanah and Astuti, 2019). Several studies have been carried out in an effort to improve the functional properties of noodles products, one of which is by using the leaves of plants that have been known as traditional medicines to be added to the manufacture of noodles, such as making herbal noodles with cosmos (*Cosmos caudatus* Kunth.) leaf extract (Norlaili *et al*., 2014), manufacture of herbal noodles with leaves of the Indian bael plant (*Aegle marmelos*) (Shamim *et al*., 2016), manufacture of sidondo (*Vitex negundo* Linn.) noodles (Syahirah and Rabeta, 2018), addition of moringa (*Moringa oleifera*) leaf extract to wet noodles (Khasanah and Astuti, 2019), making herbal noodles with pegagan (*Centella asiatica*) extract (Fadzil *et al*., 2020), and using pluchea (*Pluchea indica* Less) leaf powder steeped water to make pluchea wet noodles (Wibisono, 2021).

The content and activity of phytochemical compounds in pluchea leaves, both in the form of fresh leaves and water steeped in powdered pluchea leaves have been identified. Pluchea is classified as plant that has high polyphenol content and relatively large antioxidant capacity compared to other herbaceous plants (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). Research conducted by Widyawati *et al*. (2016) showed that the phytochemical compounds contained in the brewed water of pluchea leaf powder include alkaloids, flavonoids, phenolics, saponins, tannins, and cardiac glycosides. According to Pengelly (2004), each phytochemical compound has physiological effects including alkaloids as analgesic, mydriatic, miotic, hypertensive, hypotensive, bronchodilator, stimulant, antimicrobial, and antileukemic, flavonoids as antioxidant, antiviral, hepatoprotective, antiatheromatous, anti-inflammatory, and antihypertensive, phenolic as antioxidant, antimicrobial, anti-inflammatory, antiplatelet, and antiallergic, saponins as anticancer, anti-inflammatory, immunomodulatory, antihepatotoxic, and antidiabetic, tannins as antioxidant, antitumor, antihemorrhagic, and antiatherogenic, as well as cardiac glycosides that can increase strength and speed of systolic contraction. Flavonoids are one of the important constituents that can provide real benefits for the health of the human body.

The use of pluchea leaves in food products continues to be developed through various studies as shown in Table 1. Using pluchea leaves in many food products (tempeh, beverage, salted egg, bun, jelly drink, and

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Table 1. The use of Pluchea leaves in food product

Type of food product	Pluchea leaf form	Stages of use	References
Tempeh	Pluchea leaf water extract	Soak soybeans before adding	Magatra (2013)
Pluchea-black tea salted egg	Pluchea leaf flour	Mixed in salt solution for the	Adventi *et al*. (2015)
Effervescent powder	Water extract (infusion) and ethanol extract (maceration)	Evaporated and mixed according to the formulation	Hudha and Widyaningsih (2015)
Dry method salted egg	Fresh pluchea leaves	Added to pasta dough to coat	Firdausi (2017)
Bun	Pluchea leaf powder steeping water	Added during dough making	Chiang (2018)
Soy milk	Pluchea leaf powder steeping water	Added to soy milk	Widyawati *et al*. (2019)
Pluchea- green tea jelly drink	Pluchea leaf powder	Brewed with green tea	Wijaya (2019)
Wet noodles	Pluchea leaf powder steeping water	Added during dough making	Wibisono (2021)

soymilk) to increase their functional value can be added in the form of extract, powder/flour, or fresh with different stages of processing each food product. However, the use of pluchea leaves to increase the functional value of wheat flour-based food products has not been widely studied. So far the research that has been carried out regarding the use of pluchea leaves in the formulation of wheat flour-based food products is in the manufacture of pluchea bun (Chiang, 2018) and pluchea wet noodles (Wibisono, 2021), both of which use pluchea leaf powder steeping water which is added to the product formulation.

2.2 The effect of pluchea leaves on the content of phytochemical compounds of wet noodles

The largest group of phytochemical compounds in plants includes alkaloids, terpenes, and phenolic compounds. Phenolic compounds are a group of phytochemical compounds that are widely distributed in various plants, where this group of compounds can be used as the main source of natural antioxidants and are able to act as antimicrobial, anticarcinogenic, and other biological activities (Kennedy and Wightman, 2011; Aziman *et al*., 2012). Pluchea leaves contain phenolic compounds in the form of flavonoids, 1,3,4,5-tetra-O-cafeoilquinic acid, 3,4,5-tri-O-cafeoilquinic acid, chlorogenic acid, and ferulic acid (Mahasuari *et al*., 2020).

Flavonoids as secondary metabolites as well as the main and largest compounds in the group of phenolic compounds are commonly found in plant tissues in free form or glycosides (Aberoumand and Deokule, 2008; Sulaiman and Balachandran, 2012; Agbo *et al*., 2015). In plants, flavonoids are found in the form of flavonoid glycosides, flavonols, flavan-3-ol, flavones, flavanones, chalcones, anthocyanins, and proanthocyanidins (Dehkharghanian *et al*., 2010; Vichapong *et al*., 2010; Chen, 2013). Flavonoids act as antioxidants by chelating metals and donating hydrogen atoms, thus provide certain physiological effects on the human body (Erlidawati *et al*., 2018). This has become one of the basis for the use of herbal plants for traditional medicine and supports various functional food product innovations such as pluchea wet noodles.

The research by Wibisono (2021) showed that the use of pluchea leaf powder steeped water was able to contribute in increasing the content of phytochemical compounds (especially flavonoids) in wet noodles, that the lowest (5%) and the highest (30%) concentration of pluchea leaf powder in steeping water were able to increase the total flavonoid content (TFC) of wet noodles as much as 1.43 times and 4.07 times compared to the control wet noodles (without the use of pluchea leaf powder steeping water), respectively. The potential use of pluchea leaves in the manufacture of wet noodles can be seen by comparing the TFC of pluchea wet noodles in Wibisono's study (2021) with other herbal noodles and pluchea bun as another form of wheat flour-based product. Comparison of the total flavonoids of pluchea wet noodles with sidondo wet noodles, pegagan wet noodles, and pluchea bun from existing studies can be seen in Figure 1.

The group of flavonoids found in pluchea leaves are flavonols and flavones, including quercetin, myrisetin, kaempferol, apigenin, luteolin, and chrysoeriol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012; Koirewoa *et al*., 2012; Mahasuari *et al*., 2020), sidondo flavonoids consist of castikin, orientin, isoorientin, luteolin, lutekin-7-O-glucoside, corimbosin, gardenins A and B, 3-Odesmethylartemethin, 5-O-desmethylnobiletin, and 3',4',5,5',6,7,8-heptametioxyflavones (Lakshmanashetty *et al*., 2010; Ullah *et al*., 2012), while the flavonoids of pegagan include quercetin, myrisetin, and kaempferol (Andarwulan *et al*., 2010; Andarwulan *et al*., 2012). The TFC value of wet noodles with the addition of 5%

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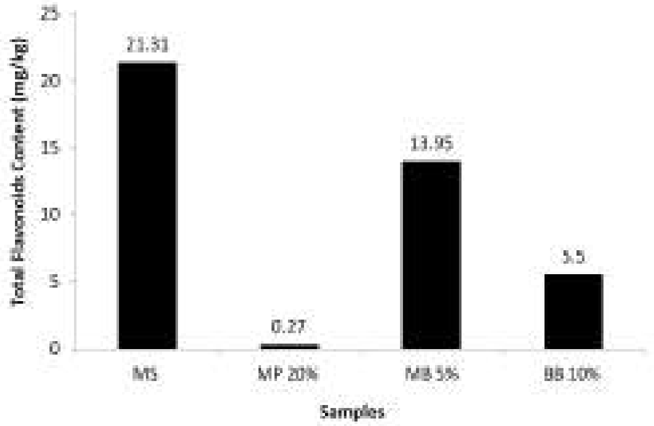

Figure 1. Total flavonoid content (TFC) of pluchea wet noodles 5% (MB 5% (Wibisono, 2021)) compared to sidondo wet noodles (MS (Syahirah and Rabeta, 2018)), pegagan wet noodles 60% (MP 60% (Fadzil *et al*., 2020)), and pluchea bun 10% (BB 10% (Chiang, 2018)). The TFC of sidondo and pegagan wet noodles were respectively expressed in terms of quercetin equivalent per weight of wet noodles and rutin equivalent per weight of wet noodles extract, while the TFC of pluchea noodles and pluchea bun were expressed in terms of catechin equivalents per dried weight of freeze-dried results. TFC of MP 20%, MB 5%, and BB 10% were expressed by the values that have been subtracted with the TFC of control from each study.

concentration of pluchea leaf powder in steeping water was greater than the TFC of wet noodles with the addition of 20% pegagan extract, but the TFC of pluchea wet noodles 5% was lower than the TFC of sidondo wet noodles which used 0.66% sidondo leaf powder from the total weight of the noodles ingredients. Based on this comparison, it can be indicated that the use of pluchea leaf powder steeping water with a concentration of 5% can increase the flavonoids content of wet noodles far exceeding the flavonoids content that can be given by 20% pegagan extract solution in wet noodles (total flavonoids of pluchea wet noodles 5% is 51.67 times compared to pegagan noodles 20%). The total flavonoids of the pluchea wet noodles 5% is 1.53 times lower than the total flavonoids of sidondo wet noodles. The flavonoids content of sidondo wet noodles which was higher than pluchea wet noodles 5% could be caused by the addition of sidondo leaf powder directly to the making of wet noodles dough in Syahirah and Rabeta's research (2018), while pluchea wet noodles dough in Wibisono's study (2021) was made with using pluchea leaf powder steeping water in the formulation of wet noodles. In addition, several factors such as differences in formulation, sequence of processing and analysis stages, as well as stated standards and product sample forms analyzed in each study also affect the difference in TFC values compared between types of herbal wet noodles.

The TFC of wet noodles with the addition of 5% concentration of pluchea leaf powder in steeping water was higher than the TFC of bun with the addition of 10% concentration of pluchea leaf powder in steeping water. This shows that the flavonoids content of pluchea wet noodles is higher than the flavonoids content of pluchea bun even though the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea wet noodles is lower than the concentration of pluchea leaf powder in steeping water in the manufacture of pluchea bun (the TFC of pluchea wet noodles 5% is 2.54 times compared to pluchea bun 10%). According to Li *et al*. (2015), antioxidant compounds, one of which is flavonoids, are easily degraded in the heating process, and are lost during the process of mixing and kneading the dough. The degradation of flavonoids during heating and the extraction of glycosides by water vapor can be the cause of the low TFC value of pluchea bun. On the other hand, a study conducted by Saikia and Mahanta (2013) showed that the high flavonoids content can be caused by breaking the glycosidic bond of flavonoids with sugar by heating treatment. The wet noodles cooking process is thought to have an effect on breaking the glycosidic bond so that aglycones are formed which can improve the detection results of flavonoids compounds in the analysis. Various factors can affect the TFC value in different food products, including differences in ingredient formulations, specifications of the methods used, and the stages of the process in the manufacture of food products.

The TFC of pluchea wet noodles 5% showed that pluchea leaves have the potency to increase the content of phytochemical compounds (in this case flavonoids) in wet noodles as a wheat flour-based food product. Wibisono (2021) also mentioned that the use of higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles is able to provide a significant increase in the TFC of wet noodles. There has been no research on the effect of adding pluchea leaf powder steeping water on the type and amount of phytochemical compounds other than flavonoids in pluchea wet noodles products, so the use of pluchea leaves in the manufacture of wet noodles still needs to be developed and further investigated its effect on the phytochemical component content of wet noodles.

2.3 The effect of pluchea leaves on the functional properties of wet noodles

The functional properties of functional food products mainly focus on the ability of bioactive components in food products to help maintain the health of the human body. One of the properties possessed by bioactive components is that they can act as antioxidants. Carotenoids, flavonoids, and phenolic compounds are classified as natural antioxidants that can be found in various foodstuffs (Marsono, 2008). Antioxidant activity can be in the form of DPPH free radical scavenging ability, iron ion reducing power, reactive oxygen species scavenging activity, and β-carotene-linoleic acid system inhibitory activity (Widyawati *et al*., 2017).

Iron ion reducing power (RP) is one of the parameters of antioxidant potential which is measured as secondary antioxidant activity based on the ability of antioxidant compounds to reduce Fe^{3+} to Fe^{2+}. Secondary antioxidants play a role in the mechanism of binding metal ions, scavenging oxygen, converting hydrogen peroxide into non-radical compounds, absorbing UV radiation, or deactivating singlet oxygen (Pokorny *et al*., 2001). According to Widyawati *et al*. (2014), iron ion is one of the pro-oxidants that have the potency to generate new free radicals. Antioxidant components are able to neutralize iron ions by acting as a substrate that will be oxidized first. Based on the research of Wibisono (2021), the use of the lowest (5%) and the highest (30%) concentration of pluchea leaf powder were able to increase the RP value of wet noodles by 1.33 times and 3.27 times compared to control wet noodles, respectively. The potency of pluchea leaves in increasing the antioxidant activity of wet noodles products can be described by comparing the RP value of pluchea wet noodles with other products such as rice flour paste and pluchea bun. The comparison of secondary antioxidant activity in the form of the iron ion reducing power of pluchea wet noodles with rice flour paste and pluchea bun can be seen in Figure 2.

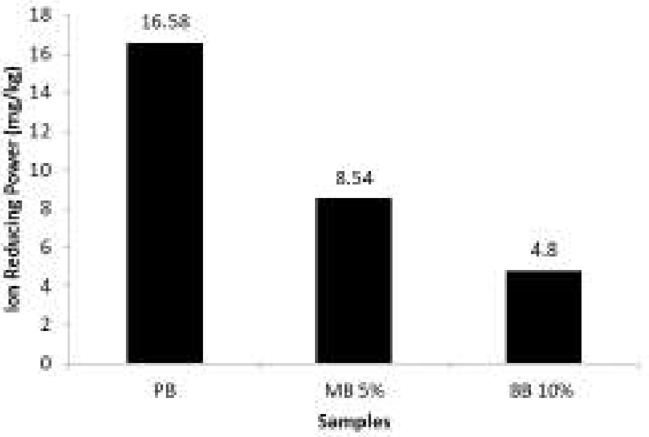

Figure 2. Iron ion reducing power (RP) of pluchea wet noodles 5% (MB 5% (Wibisono, 2021)) compared to rice flour paste (PB (Nitha *et al.,* 2013)) and pluchea bun 10% (BB 10% (Chiang, 2018)). RP value of rice flour paste was stated to be equivalent to BHT per weight of pasta, while the RP value of pluchea wet noodles and pluchea bun was expressed in gallic acid equivalent per dried weight of freeze-dried results. Iron ion reducing power of MB 5% and BB 10% are expressed by the value that has been reduced by the RP value of control from each study.

Pluchea wet noodles 5% in the Wibisono's study (2021) had the RP value 1.78 times higher than the RP value of pluchea bun 10% in Chiang's research (2018), but 1.94 times lower than the RP value of paste made from rice flour in the research of Nithya *et al*. (2013). The RP value indicates that the use of pluchea leaf powder steeping water with 5% concentration of pluchea leaf powder in steeping water has potency to provide greater secondary antioxidant activity in wet noodles than in bun products. The TFC of pluchea wet noodles 5% which is greater than the TFC of pluchea bun 10%, as shown in Figure 1, can contribute to the large iron ion reducing power of pluchea wet noodles 5% and pluchea bun 10%, that the phenolic group compounds, one of which is flavonoids, capable of donating hydrogen atoms/electrons so that they can reduce iron ions (Widyawati *et al*., 2014). The flavonoids content of pluchea wet noodles which is higher than the flavonoids content of pluchea bun, can cause the iron ion reducing power of wet noodles is higher compared to pluchea bun.

RP value of pluchea wet noodles 5% which is lower than the RP value of rice flour paste can be due to the use of different types of raw materials (related to the number and types of bioactive components in the ingredients) and the shape of the product samples analyzed in each study. Based on the research of Widyawati *et al*. (2014), white rice has total phenolic content (TPC) of 4.12±0.05 mg gallic acid equivalent/g dry basis which is greater than the TPC of pluchea leaves in the study of Andarwulan *et al*. (2010), which was 0.831±0.129 mg gallic acid equivalent/g fresh leaf weight. According to Wibisono (2021), the iron ion reducing power of pluchea wet noodles can be increased by using higher concentration of pluchea leaf powder in steeping water in the formulation of wet noodles.

RP value of pluchea wet noodles 5% shows the potency of pluchea leaves to increase the antioxidant activity of wet noodles products as an effort to increase the functional value of wheat flour-based food products such as wet noodles. The effect of adding pluchea leaf powder steeping water on the antioxidant activity of pluchea wet noodles using a type of analysis other than the iron ion reducing power has not been studied further, so it is necessary to measure other antioxidant parameters to support the potency of pluchea leaves in making wet noodles.

Research on the potency of pluchea leaves in improving the functional properties of wet noodles is still limited to being studied on product antioxidants, while pluchea leaves have been known to have various other functional properties that are beneficial to health and are able to maintain the quality of food products. Several other functional properties that have the potency to be

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provided by pluchea leaves in food products include activities as anti-warmed-over flavor, anti-inflammatory, antidiabetic (Widyawati *et al*., 2017), and antimicrobial properties that have the potency to prevent food spoilage (Ardiansyah *et al*., 2003). This ability is inseparable from the presence of bioactive compounds in pluchea leaves which have the capacity as antioxidant and antihyperglycemic agents (Widyawati *et al*., 2014; Widyawati *et al*., 2015). According to Li *et al*. (2014), herbal plant extracts are potential preservatives that are currently being developed to be applied to bread, pasta, and noodles products due to the presence of phenolic components that have high antimicrobial activity. Tiwari *et al*. (2009) also proved that the antimicrobial activity of phenolic compounds is related to the ability of phenolics to affect the permeability of microbial cells which causes the release of important macromolecules from the microbial cell, as well as the ability of phenolics to interact with membrane proteins that cause deformation of the structure and function of microbial cell membranes.

3. Conclusion

Pluchea (*Pluchea indica* Less) leaves have the potency to increase the functional value of wet noodles in terms of the phytochemical content and functional properties of the wet noodles. The use of pluchea leaves increases the content of phytochemical compounds, in this case flavonoids, in wet noodles. The increase in the content of phytochemical compounds with the use of pluchea leaves affects the increase in the functional properties of wet noodles products, especially antioxidant activity in the form of the iron ion reducing power of wet noodles.

Conflict of interest

The authors declare no conflict of interest.

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