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ENHANCING NUTRITIONAL VALUE: IRON –RICH CHIPS WITH MORINGA, MOCAF AND MILKFISH FOR ANEMIA PREVENTION

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ABSTRACT

The study aimed to produce functional food products in the form of chips with sufficient iron (Fe) content and macronutrient content (carbohydrate, fat and protein content) which has the potential to prevent anaemia for girl's teenager. This research used a Completely Randomized Design (CRD) method with three replications with several treatments including P1 as control (without moringa and milkfish, 100% wheat); P2 (1% moringa, 20% mocaf, 79% milkfish); P3 (3% moringa, 20% mocaf, 77% milkfish); and P4 (5% moringa, 20% mocaf, 75% milkfish). The resulting product was analyzed for iron (Fe) and macronutrient content such as carbohydrates, fat and protein. The data obtained was analyzed using SPSS for Windows version 25 software using a confidence level of 95% (α<5%) followed by a different test using DMRT (Duncan multiple range test). The results of ANOVA showed that a sig value <5% (0.000<0.05), showed that the substitute materials used have an influence on the levels of iron, protein, fat and carbohydrates. The iron in the product makes it possible to stimulate the prevention of anaemia in girl's teenager. Besides, it was also supported by the presence of protein compounds on the substituted chips. The highest Fe value was 5.75 ppm, protein was 13.21%, fat was 5.21% and carbohydrates were 78.24%. Based on these parameters, P4 was the form of treatment that provides the best results, namely with a formulation of 5 grams of moringa, 20 grams of mocaf, and 75 grams of milkfish.

***Keywords**: Chip; Substitute products; Anaemia, Food Product*

INTRODUCTION

Anaemia is a global health problem in developing countries recently (Kinyoki et al., 2021). Based on data released by the World Health Organization (WHO) in 2021, it is known that anaemia is the 10 biggest health problem in the modern century, the disease mostly attacks women of productive age,

pregnant women and children aged 6-59 months (Biete et al., 2023). In addition, in 2019 It is known that 29.9% of the world's female population aged 15-49 years suffer from anaemia. Daily iron requirements vary depending on age, gender, and physiological conditions. In general, the RDA (Recommended Dietary Allowance) for iron is: Children: 7-11 mg/day, Adolescent girls: 15 mg/day, Adolescent boys: 11 mg/day, Adult women: 18 mg/day , Adult men: 8 mg/day, Pregnant women: 27 mg/day (Gibson-Smith et al., 2020). One effective way to approach prevent and treat anaemia is to consume foods rich in iron and other important nutrients (Foluke & Olufemi, 2013). One alternative solution that needs to be taken as a step to prevent the spread of anaemia is to consume food products that contain high levels of iron (Hayet et al., 2021). This requires a process of developing functional food products in the form of chips by modifying their composition. Chips are a food product in the form of thin sheets that are popular with teenagers as a snack with a crispy texture (Koirala et al., 2023). The development of functional food products primarily in chip form in this research was carried out by modifying the constituent composition.

The composition of the chips in this research includes moringa leaves, mocaf, and milkfish. According to the several literature, the development of food products made from moringa leave (Asfan & Maflahah, 2021), mocaf and milkfish promises an innovative solution in fighting anaemia (Gopalakrishnan et al., 2016). The combination of these three constituent materials is an interesting focus for researchers and health policy makers (Balebu et al., 2023), due to these materials can be used in chip products to improve overall human health (Uzoaga et al., 2020). Moringa leaves (*Moringa oleifera*) are known as a source of iron (Prayitno, 2024) with levels of 17.5 mg/100g, and contain ascorbic acid (vitamin C) (Fouad et al., 2023) which can increase iron absorption in the body (Singh et al., 2020). In addition, Mocaf (*Modified Cassava Flour*) is a cassava flour product that has been modified during the fermentation process with the help of lactic acid bacteria to increase its nutritional value as a source of dietary fiber (Prastiwi et al., 2024) and micro components including iron levels which are important in preventing anaemia (Ekop et al., 2019). The next ingredient is milkfish which has the scientific name *Chanos chanos*. Milkfish is not only rich in protein (Nopiyanti et al., 2023), but also contains iron and vitamin B12 (Jose. & Divya., 2023) which are essential for the formation of red blood cells (Jose & Divya., 2023).

Combining these three ingredients as an appropriate formulation in the form of chips made from moringa, mocaf and milkfish is an important part of highly

nutritious products (Sjamsuddin et al., 2022) especially in fulfilling or increasing iron levels in the body (Oppusunggu et al., 2023) and promises food products that are not only delicious, however helpful in future community-level anaemia prevention initiatives as well (Olena Stabnikova et al., 2021). For customers who need additional iron supplements or are at risk of anaemia, this product can be a useful and pleasurable substitute (Aruna et al., 2021). Apart from the nutritional status, sensory assessment of the product can help to ensure that this product has an attractive taste and is acceptable to consumers from various backgrounds (Prayitno & Rahim, 2021), hence it could also be used as an important part of a comprehensive anaemia prevention strategy (Karim et al., 2013).

It is necessary to find the best formulation in order to develop functional food products in the form of chips with sufficient iron (Fe) content and macronutrient content (carbohydrate, fat and protein content) which has the potential to prevent anaemia in teenagers. In addition to satisfying the demand for iron (Fe) and macronutrients, it is expected that the optimal recipe for making chips will be discovered in order to prevent anaemia and serve as a deliberate attempt to replace food items with ones that are safer, higher-quality, more teen-friendly, and healthier. In addition to being evaluated nutritionally, this product will also be taste, aroma, and texture tested to determine how appealing it is to teenage people and whether or not this functional food product in the form of chips will be accepted.

MATERIALS AND METHODS

Research design

This research uses an experimental design with a Completely Randomized Design (CRD) using the following treatments:

P1: control without moringa and milkfish, 100% wheat

P2: 1 g moringa, 20 g mocaf, 79 g milkfish

P3: 3 g moringa, 20 g mocaf, 77 g milkfish

P4: 5 g moringa, 20 g mocaf, 75 g milkfish

Tools and materials

The equipment of this experiment included; Kjeldahl flask, Bunsen, measuring flask, Nessler tube, AAS (*Atomic Absorption Spectrophotometry*), condenser, extraction tube, Soxhlet distillation, stirrer, bottle, scale, water heater, oven, pipette, 50 mL measuring flask, glass beaker , sieve, blender mixer (Phillips), oven (Advance), sieve, pressure cooker (Miyako), baking sheet, knife, container, spoon, bowl, scale, stove, baking paper, jar, mortar, and plastic gloves. The ingredients are wheat flour, mocaf flour, moringa flour, coconut oil, tapioca flour, cornstarch, salt, pepper, baking powder, garlic, shallots, mineral water, concentrated H_2SO_4, distilled water, NaOH 45%, Nessler's

reagent, petroleum ether solvent, 1 mL of concentrated HNO_3, and Fe 10 ppm.

The chip-making procedure

This is the following step to making process of chip:

a) Preparing the raw materials for milkfish: the fish was fully cleaned and filleted after the scales, gills, and entrails were removed. The fillet fish was marinated in crushed ginger for fifteen minutes, cooked for ten to fifteen minutes under steam, and then allowed to cool. After that, smash it and put it in a sanitised container.

b) Chip processing: After weighing each raw ingredient in accordance with their proportions, the spices garlic, shallots, and pepper are ground and then salted and peppered. Next, combine the egg whites and baking powder and stir until well combined. Add the milkfish, oil, crushed spices, cornflour, mocaf, tapioca, and moringa flour. Smooth out the dough. Shape the dough into round shapes by dividing it into three parts. For two grammes of chips, weigh the chips. Bake the print for 35 minutes at 100°C on a baking sheet. When done, allow it cool before sealing in an airtight container.

Research Parameters

Several parameters that would be analyzed in this research were iron (Fe) content, fat content, carbohydrate content and protein content. The iron (Fe) content was analyzed using spectrophotometry (Ahmed & Roy, 2009), while the fat content, carbohydrate content, and protein content in the chip product were analyzed using procedures based on AOAC (AOAC International. 2005).

Data Analysis

The data obtained were analyzed using SPSS version 25 software using a confidence level of 95% ($\alpha < 5\%$) followed by a different test using DMRT (Duncan multiple range test).

RESULTS AND DISCUSSION

Teenage girls' anaemia is frequently linked to a deficiency in iron and other nutrients. In order to avoid anaemia, food products that are based on nutrients must be developed. Food products can be developed as snacks or nibbles, such as chips made from milkfish, mocaf (modified cassava flour), and moringa leaves. These three elements must be used in order to produce nutritious foods that meet particular dietary needs. Teenage girls' chips are one product invention that makes advantage of these elements. The following are the findings from studies on these nutrients that can be seen in Table 1.

According to Table 1, the addition of moringa flour, mocaf flour and milkfish has an influence on the levels of Fe, protein, fat and carbohydrates.

Table 1. Average test results of chip product

Parameters	Treatments			
	P1	P2	P3	P4
Fe (ppm)	3,28±0,03[a]	4,54±0,02[b]	5,13±0,06[c]	5,75±0,07[d]
Protein (%)	9,36±0,14[a]	11,03±0,56[b]	12,16±0,11[c]	13,21±0,07[d]
Fat (%)	1,88±0,07[a]	2,64±0,01[b]	3,46±0,09[c]	5,12±0,04[d]
Carbohydrate (%)	75,27±0,85[a]	76,46±0,39[b]	77,11±0,46[b]	78,24±0,25[c]
Sig	0.000			

P_1: control without moringa and milkfish (100% wheat); P_2: 1g moringa, 20g mocaf, 79g milkfish; P_3: 3 g moringa, 20g mocaf, 77g milkfish; and P_4: 5 g moringa, 20g mocaf, 75g milkfish

The addition of these ingredients as fortifying ingredients has an influence on increasing the nutritional content in chip products. This chip product is suitable as food or snack for sufferers or to prevent anaemia in teenage girls (women of childbearing age). The explanation of the research results is as follows.

Iron (Fe) Content

Iron is a compound that is associated with anaemia, classified as a micronutrient which plays a role in the formation of haemoglobin in the human body (blood), which is a protein that carries oxygen from the lungs to the rest of the body. Iron deficiency anaemia often occurs in teenagers in particular and also has an impact on groups, especially those with weak (low) socio-economic levels. Iron deficiency is a medical condition that occurs in the body where there is not enough iron to produce haemoglobin, a protein in red blood cells that binds and transports oxygen to all parts of the body. The result of this active transport is iron deficiency. The research results showed that the addition of Moringa leaves, mocaf and milkfish has an influence on the iron levels produced in chip products.

Based on data from Table 1, the iron content of this chip product shows that increasing the proportion of moringa and milkfish has an influence on increasing iron. The increasing of iron levels was caused by several substances mixed in the chip processing, moringa, mocaf and milkfish. The iron-containing leaves of moringa play a significant effect in boosting iron levels (El-Enzi et al., 2018). Moringa contains vitamin C, which contributes to the increase in iron (Manggul et al., 2021). The fact that moringa contains significant amounts of iron, particularly non-heme iron, as well as vitamin C and compounds called beta carotene, which can speed up the absorption process, supports the idea that this plant can be used to fortify food products. The role of iron in human metabolic processes (Mbikay, 2012). (Leone et al., 2015) have provided evidence for this claim by stating that eating specific foods made from Moringa leaves can raise the levels of serum iron and

haemoglobin in those who are iron deficient. Several micronutrients, including iron, calcium, and magnesium, are also found in moringa plants, which help to raise the iron content of chip products (Trigo et al., 2023).

Besides of Moringa, another fortifying ingredient is milkfish which contains quite high protein and is a source of animal protein with the potential for iron levels to increase the absorption of non-heme iron. Consuming animal protein in general can increase iron absorption in the human body (Hurrell & Egli, 2010). Apart from the role of these two ingredients, the addition of 20% moringa also has an influence on the iron contained in the fortified chip product. Mocaf is a form of fermented flour that can increase iron levels. During the fermentation process, lactic acid levels in mocaf can be increased, which can improve the bioavailability of iron in food (Sulistyo et al., 2014).

Protein Content

Protein is a group of macronutrient compounds that have a very essential role in the human body. The main role of protein in body metabolism, especially in the process of forming haemoglobin. Protein can be obtained from vegetable or animal sources (Azka et al., 2023). Proteins provide an important role in iron transport in the human body. A lack of protein or its intake will result in delayed iron transport resulting in a disease known as iron deficiency which will cause anaemia. Apart from that, a lack of protein will have an impact on the body's weakened immunity, such as being susceptible to disease attacks or infections. The application in making chip products from moringa, mocaf and milkfish has an influence on the protein content in the resulting chip products.

Table 1 shows that, in comparison to the control, which provided a lower value than the treatment administered, there was an increase in protein in the treatment that was employed. Chip products protein content can be raised by adding fortifying additives. The inclusion of several proteins in the fortifiers (milkfish, moringa, and mocaf) was the reason for this rise. Human anaemia can be avoided by maintaining an adequate protein intake, particularly in women during their teens. In order to prevent anaemia, women of reproductive age must meet 80% of the RDA, or ±56 g/day (Kanuri et al., 2016).

As an approach of improving the product, moringa is added to chip goods to raise their protein content. It is believed that the reason for this rise in protein levels is that moringa is a rich and complete supply of essential amino acids found in vegetable protein. Protein content in dried Moringa leaves is ± 72% (Foild N. et al., 2001). This protein is made up of several essential amino acids, such as methionine, lysine, and threonine. Chip products' protein content can be greatly raised by fortifying them with moringa leaves (Nambiar & Seshadri, 2001) Utilising milkfish, an animal source of high-

quality protein with beneficial amino acids for health, is another way to boost protein levels (Jang et al., 2008). The addition of fish meat, or milkfish, to chip products can significantly boost the amount of protein they contain since milkfish is high in necessary amino acid components, which are protein compounds (Achyani et al., 2021). The use of mocaf as a type of fermented (modified) flour presents an opportunity to enhance additional nutritional status in the final processed product and add protein to chip products, in addition to moringa and milkfish (Oyeyinka et al., 2020).

Carbohydrate content

Carbohydrate is one of the main groups of organic compounds consisting of C, H and O atoms in a ratio of 1:2:1 which are used to form human energy and as a dietary source (Ebbeling et al., 2022) that consist of monosaccharides, disaccharides and polysaccharides (Urminská et al., 2022). Teenagers' nutritional needs in the form of carbohydrate compounds must be met with great attention, since these compounds play a vital part in the body's daily breakdown of energy for use as fuel and as a source of energy in times of hunger or illness. Carbohydrate needs can be satisfied by a variety of inventive items in addition to rice, wheat, and bean products. Developing products that enhance health using moringa, mocaf, and milkfish is one way this research is innovative.

Table 1 indicates that the amounts of carbohydrates in each therapy have increased. The addition of strengthening elements in the production of chip goods is the cause of this rise in carbohydrates. Milkfish, moringa, and mocaf have the potential to be used in products that raise blood sugar levels. Because it contains nutritional elements, moringa is a vegetable ingredient that is crucial to health. Complex carbohydrates included in moringa, such as dietary fibre and the oligosaccharide group, are beneficial to health. The high fibre content of moringa leaves might raise the amount of carbohydrates in chip products. The addition of fibre and carbohydrates from moringa leaves to processed foods can help support healthy digestion and blood sugar control (Kilany et al., 2020).

The increase in carbohydrates in chip products is also due to the presence of mocaf flour which is produced from fermentation by lactic acid bacteria. Mocaf, or modified cassava flour, generally contains higher levels of complex carbohydrates than regular cassava. The modification process in mocaf can increase the concentration of carbohydrates which are more easily converted into final products such as chip products (Rumiyati et al., 2014). In addition, the fundamental contribution of the milkfish-based fortification components does not raise the amount of carbohydrates in chip products. The main source of protein in milkfish is

amino acids, which explains why. On the other hand, it can contribute a tiny quantity of complex carbohydrates from flour sources or other substances if combined with flour or other binders during the chip fabrication process (Prabawa et al., 2020).

Consuming simple carbohydrates, such as sugar and refined flour, can cause a rapid spike in blood sugar followed by a sharp drop. These changes can affect iron metabolism in the body and influence hemoglobin balance, Despite further research is needed to determine the precise association between these changes and anaemia, they can impact haemoglobin balance and iron metabolism in the body (Sanders et al., 2022). Foods high in carbohydrates may have an impact on the body's ability to absorb iron. High-fiber complex carbohydrates, including those in whole grains, veggies, and nuts, have the ability to bind to non-heme iron (iron derived from plants) and slow down the body's absorption of it. This has the potential to exacerbate iron deficiency, one of the primary causes of anaemia (Hurrell & Egli, 2010).

Fat content

Fat is a hydrophobic organic substance that is difficult to dissolve in water, but can be dissolved in organic solvents such as chloroform, ether and benzene. The constituent elements of fat include Carbon (C), Hydrogen (H), Oxygen (O), and sometimes Phosphorus (P) and Nitrogen (N) (Hilwatullisan et al., 2020). Fat helps the body absorb fat-soluble vitamins, such as vitamin A, D, E, and vitamin K. fat plays a role in protecting internal organs, such as the kidneys, from impact and damage (Riaz & Wahab, 2021). Food fortification can result in fat, which is then used to make new products like chips. Milfish, moringa, and mocaf were added to the chip product on purpose for the study. Table 1 shows that chip products supplemented with mocaf, milkfish, and moringa leaves have an increase in fat content. The final product chip's fat content may increase if strengthening additives are included. The increasing value was due to probably a variety of fatty compound that are found naturally in the subtances. Furthermore, it is supported by addition of oil, which is added to the dough on purpose with the intention of perhaps increasing the fat content of the chip products (Rahayu & Sulistiawati, 2018).

It's potential that using moringa will make the chip items made throughout the study include more fat. Oil and fat, among other ingredients found in moringa, can be transferred to chip products as they are being processed. Furthermore, including moringa leaves in flour or extract form may increase the overall fat content of the finished product (Fernandes et al., 2021). reinforced by the addition of mocaf, a modified flour made by lactic acid bacteria fermentation, as a fortifier. Because fermentation and drying

are steps in the modification process, flour made by this method frequently has a higher fat content than conventional cassava flour. This may result in chip products having a higher fat content (Lindasari et al., 2021). In addition to moringa and mocafe, milkfish is another fortifying ingredient that raises the fat content of chip products. As an animal protein source for chip products, milkfish may raise the overall fat content of the finished good. Fish processing methods like grilling or frying could result in the chip product having more oil or fat in it (Negara et al., 2021). Furthermore, milkfish (Chanos chanos) have a comparatively high lipid content, particularly when it comes to polyunsaturated fatty acids (PUFA), including omega-3 fatty acids. Not only is this fat beneficial to health, but it can also affect the fat content of processed foods that employ milkfish as a primary ingredient (Sergeant et al., 2011). This is also supported by the statement that the milkfish meat used in the dough contains a certain amount of fat is also in favour of this because it transfers extra fat from the raw milkfish material into the finished biscuit product during the roasting (oven) process, which alters the final product's flavour (Ujong et al., 2023).

CONCLUSIONS

Based on the results of research that has been carried out lead us to the conclusion that the alternative ingredients. The study and ANOVA table lead us to the conclusion that the alternative ingredients utilised have an impact on the amounts of iron, protein, fat, and carbs, as indicated by the Sig value <5% (0.000<0.05). All treatments had a significant impact on each test parameter, on Fe, protein, fat and carbohydrates. However, its significance on Fe did not determine other parameters, so it is necessary to add Fe source material which can increase the total Fe on the chip. This product contains iron which can help prevent anaemia in girl's teenager and also contains protein from the substitution of ingredients that has been made. Based on the parameters analyzed, it is known that P4 is the treatment formulation that provides the best results, namely 5 grams of moringa, 20 grams of mocaf, and 75 grams of milkfish. The product resulting from this treatment contains the highest Fe at 5.75 ppm, 13.21% protein, 5.21% fat and 78.24% carbohydrates

RECOMMENDATIONS

In order to improve the final product, more investigation is still required into the proper application of moringa. It is therefore advised to use 5 grammes of moringa flour for every 220 grammes of components. To improve the quality of chip products, you can add other sources of protein and sources of iron or other nutritional compounds that are sufficient to prevent anemia, either natural or

synthetic ingredients that comply with the required health rules and regulations.

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