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Nutritional Value Analysis of Carrot-Fortified *Pempek* Prepared with a Low-Cost Hybrid Temperature Treatment Method as an Alternative Food to Prevent Stunting in Indonesia

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ABSTRACT

The problem of nutritional adequacy remains a major concern in Indonesia. Various measures to reduce stunting rates (one of the effects of malnutrition) have been implemented, including fortifying food products such as iodised salt. This method is considered quite effective in reducing malnutrition problems in Indonesia. Pempek is chosen as a food fortification with a vegetable addition to enhance its nutritional value from a vitamin perspective. The sample was combined with the low cost hybrid temperature method to maintain the nutritional value of pempek. The study used a one-way factorial design to examine how carrot concentration affects the nutritional value of pempek fortified with carrots. The analysis carried out were proximate analysis, dietary fiber analysis, and beta-carotene analysis. One-way ANOVA was used for data analysis in SPSS 21.0.0.0; $p < 0.05$ was considered statistically significant. The fortification of carrot using a combination of an economical, low-cost hybrid temperature treatment method was successfully incorporated into the pempek. The protein and carotene are the main factor to distinguish the best outcome. The best outcome in this research was achieved with sample P2, which included 300 g of carrot in the pempek dough. The results show the significance of the percentages in the proximate and carotenoid perspectives (5.69% and 0.34%, respectively).

Contribution to Sustainable Development Goals (SDGs):

SDG2: Zero Hunger

SDG3: Health and Well-being

1. INTRODUCTION

1.1. Research Background

The National Development Planning Agency (Bappenas) and the Ministry of Health (Menkes) conducted a nutrition capacity assessment to examine the institutional arrangements and capacities of provincial and district governments for legislating, planning, and managing nutrition programs. The assessment concluded that the stunting rate in 2022 was 21,6%. However, great efforts are still needed to achieve the stunting reduction

target of 14%. Stunting is a chronic form of malnutrition caused by prolonged inadequate nutrition from food that does not meet nutritional needs. Stunting can appear in the womb and be detected after 2 years of age [1]. The effects of stunting can be severe if not balanced by adequate nutrition. Stunting is characterised by growth faltering and inadequate catch-up growth, reflecting the inability to achieve optimal growth. This reveals that groups of toddlers who are born with normal weight can experience stunting if the fulfilment of subsequent needs is not met properly. Conditions can make children more susceptible to disease and reduce future productivity. Broadly



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speaking, stunting can inhibit economic growth, increasing poverty, and widening inequality. To reduce the number of stunting in Indonesia, many experts are interested in studying the quality of food consumed before consumption. Social and cultural factors have a significant influence on diet and health practices in society, which in turn influence efforts to reduce stunting [2]. Food that provides nutrients that give our bodies energy, support health, and promote a sense of fullness is considered healthy. But not every kind of food can meet the body's nutritional requirements. Food fortification is one of the best treatments that can be applied to overcome the issues. By definition, food fortification or enrichment is the process of adding micronutrients (vitamins and essential trace elements) to food fortification can be used as a treatment to reduce micronutrient deficiency problems[3].

Fortification provides a practical way to enhance the nutritional composition of staple foods. Home fortification is one of these strategies that could gain greater acceptance globally. This decision was made because of its apparent sustainability and affordability, which appeal particularly to socioeconomically underdeveloped areas where micronutrient deficiencies are prevalent. Adding vitamins and minerals to cooked, ready-to-eat food is known as point-of-use fortification. In order to reflect the variety of settings in which this type of intervention can occur, including schools and refugee camps, the WHO recommended point-of-use fortification of complementary foods with micronutrient powders (MNPs) as a crucial intervention for improving micronutrient intake (to improve iron status and reduce anemia in particular) in children aged 6-24 months [4]. Freeze drying method. This method has the advantage of shorter drying time. The products produced are of higher quality, with smaller colour differences and higher retention of antioxidant components [5]. However, all previous studies focused on high-cost methodologies that are unaffordable for small-scale industry.

1.2. Literature Review

1.2.1. Pempek

Pempek is a traditional dish from Palembang City, Sumatera Selatan, Indonesia. The dish can be served either as a main course or a complementary dish. The study of *Pempek* with fortification is still limited. The innovation in this study was the combination of fortification and low-cost freeze-drying methods to maintain the chemical composition of *Pempek*. The principle of this method is to transform the physical properties of water to a sublimation state without passing through the thawing stage. The objective of drying is to prolong the shelf life of food products by preserving food with microbial degradation and enzyme activity. Samples dried using the freeze-drying method are reported to have higher resistance to beta-carotene degradation because the method enlarges the pore structure and protects the carotene compounds from degradation. The freeze-drying method is costly and energy-intensive. Thus, it has to be combined with another method, namely the microwave assisted *Pempek* is a traditional dish from Palembang City, Sumatera Selatan, Indonesia. The dish can be served either as a main course or a complementary dish [6]. The freeze-drying method is costly and energy-intensive. Thus, it has to be combined with another method, namely microwave-assisted drying. This method has the advantage of a shorter drying time. The products

produced are of higher quality, with smaller colour differences and higher retention of antioxidant components [7]. However, all previous studies were focused on the utilisation of high-cost methodologies, which are not affordable for small-scale industry.

1.3. Research Objective

This study aims to analyze the effect of carrot-fortified pempek to prevent stunting.

2. MATERIALS AND METHODS

2.1 Materials

The main materials used in this study were ground fish (snakehead fish), carrot, tapioca flour, monosodium glutamate, salt, and water. All ingredients were purchased at the local market in Padang Selasa, Kota Palembang.

2.2 Methods

Four formulations were used to determine the nutritional value of the *pempek* fortification. Percentages of ground fish (snakehead fish), tapioca flour, salt, monosodium glutamate, and water in every formulation remained the same. In contrast, the percentages of carrots varied depending on the substitution level at 150 g, 300 g, and 500 g. Based on that, there were *pempek* without additional carrots that would be labeled as "P0 (0 g)," *pempek* with 150 g of carrots as "P1 (150 g)," *pempek* with 300g of carrots as "P2 (300 g)," and *pempek* with 500g of carrots as "P3 (500 g)."

2.2.1 Preparation of carrot

Carrots were prepared by weighing the desired concentration (150 g, 300 g, or 500 g) and blending with 500 ml of water. Adding carrots cannot exceed the water limit, as it can make the pempek dough mushy and fall apart when boiled [8].

2.2.2 Preparation of Pempek Fortification

The basic ingredients of pempek are 1 kg ground snakehead fish, carrots blended with water, 20 g monosodium glutamate, 40 g salt, and 800 g tapioca, which were mixed until evenly combined and formed pempek dough. The pempek dough can be shaped into many forms depending on the type of pempek itself [8.] From this study, we used pempek Lenjer Kecil. Pempek Lenjer Kecil is oblong and small. Tapioca was used as a medium to prevent the pempek dough from sticking to the hands during the process. Next, the pempek dough was boiled until it floated, then drained and freeze-dried.

2.2.4 Hybrid Thermal Drying Method

The sample was cooled to room temperature using a low-cost hybrid temperature-treatment method. The sample was put in the freezer (-5 °C) for 1 day. The process was continued using an oven at 100 °C for 20 minutes. The method had been applied to a traditional Palembang dish called Burgo [9].

2.2.5 Chemical Composition Analysis and Beta-carotene

The chemical analysis was conducted at PT Saraswanti Indo Genetech. The analysis carried out was proximate analysis, dietary fiber analysis, and beta-carotene analysis. Water and ash content was determined using SNI 01-2891-1992, while the

analysis of total fat content was determined using gravimetric method (18-8-5/MU/SMM-SIG), protein content analysis using titrimetric (18-8-31/MU/SMM-SIG), Dietary fiber content was analyzed using the enzymatic gravimetric method (18-8-6-2/MU/SMM-SIG), and Calculation of carbohydrates by different methods using the AOAC procedure.

2.3 Analysis Data

All measurements were conducted three times. One-way ANOVA was used for data analysis by the SPSS 21.0.0.0 software, $p < 0.05$ was considered statistically significant.

3. RESULT AND DISCUSSION

3.1 The Effect of Fortification on Moisture Content

Water content is a critical proximate characteristic for product stability and shelf-life extension. Water content refers to the amount of water present in food materials, both in free and bound forms. In this study, the water content ranged from 60.23% to 64.53% (**Figure 1**). The highest water content was found in Sample P1 (150 g), which had an addition of carrot at 64.53%, while the lowest was in Sample P3 (500 g), which contained 500 g of carrot, with a water content of 60.23%. The data indicate that an increase in carrot juice addition correlates with a decrease in water content. According to the Indonesian National Standard (SNI) for pempek

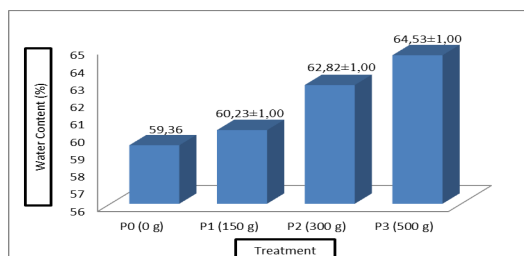


Figure 1. Water content of pempek

According to product No. 7661:2019, the maximum water content for pempek is 70%. This suggests that all samples met the SNI requirements for pempek.

The tapioca flour used in the preparation of pempek contains 17% amylose and 83% amylopectin [9]. The amylose content of tapioca starch processed by freeze-drying is 20.34%. The increase in amylose concentration is attributed to the disintegration of starch molecules. The freeze-drying process disrupts the crystalline structure formed during heating, allowing the amorphous regions to bind water preferentially rather than the crystalline portions within the starch granule. The accumulation of amylose enhances water absorption capacity due to its higher affinity for water [10]. This is supported by the observation that higher tapioca flour additions increase water content. During freeze-drying, the swelling of starch granules creates pores on their surfaces, facilitating greater water absorption during the rehydration of pempek produced by this method.

Additionally, water content is influenced by the fiber present in the added carrot juice. Fibre can bind water in proportion to its quantity and structural characteristics. The hydroxyl (OH-) groups in the fibre contribute to its water-absorption capacity.

As more fibre is incorporated, its capacity to absorb water increases, thereby reducing the overall water content of the food material. For example, in carrot puree, the crude fibre content was reported to be 10.54% [11].

3.2 Ash Content of Fortified Pempek

Ash content refers to the amount of minerals present in a food material. In this study, the ash content ranged from 1.23% to 1.53%. The sample with the lowest ash content was Sample P1 (150 g), which had an addition of 150 g of carrot, while the sample with the highest ash content was Sample P3 (500 g), which included 500 g of carrot. The research data indicate that an increasing quantity of carrot addition correlates with a higher ash content (**Figure 2**).

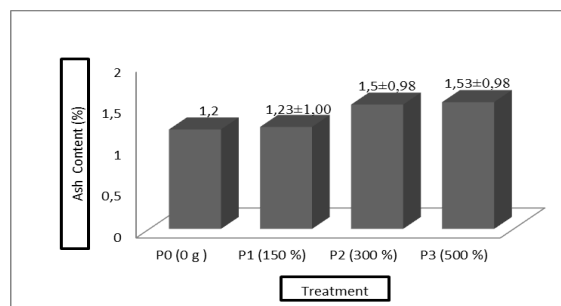


Figure 2. Ash content of pempek

This is attributed to the presence of various minerals in carrots, which include calcium (Ca) at 34.4 mg/100 g, magnesium (Mg) at 13.1 mg/100 g, potassium (K) at 321 mg/100 g, nitrogen (N) at 101 mg/100 g, phosphorus (P) at 34.0 mg/100 g, copper (Cu) at 56 µg/100 g, zinc (Zn) at 387 µg/100 g, iron (Fe) at 408 µg/100 g, manganese (Mn) at 245 µg/100 g, and nitrate (NO₃) at 413 ppm [12].

3.3 The Effect of Fortification to Protein Content

Proteins consist of the elements carbon (C), hydrogen (H), oxygen (O), and nitrogen (N), which are linked by peptide bonds. In addition to serving as an energy source, proteins also function as building blocks. In this study, the protein content ranged from 5.22% to 5.69% (**Figure 3**). The protein content of the control sample was 5.23%. The highest protein content was found in Sample P2 (300 g), which contained an additional 300 g of carrot juice, resulting in a protein level of 5.69%, representing an increase over the control sample (**Figure 3**).

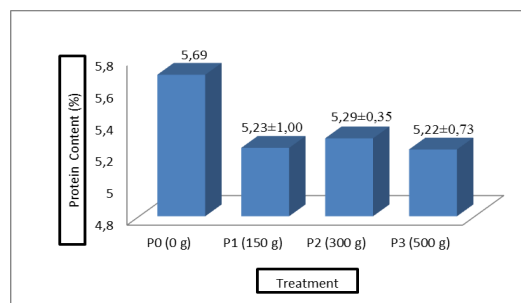


Figure 3. Protein content of pempek

Adding 300 g of carrot juice increased protein content. It can be explained that proteins and beta-carotene can form aggregates when combined in proportional amounts. During cooking,

proteins are better protected, helping prevent excessive hydrolysis and degradation. However, with a higher amount of carrot juice added, the protein and beta-carotene aggregates can become disproportionate. This increases the protein's susceptibility to hydrolysis during processing. Thus, adding more carrot juice, specifically 500 g, decreases protein content.

3.4 Carbohydrate Content of Fortified Pempek

Carbohydrates are composed of hydrogen, carbon, and oxygen molecules. The primary role of carbohydrates is to serve as a source of energy. The results of this study indicate that the carbohydrate content of carrot-fortified pempek ranges from 28.19% to 30.21%. The lowest carbohydrate content was found in Sample P1, which had an addition of 150 g of carrot, while the highest carbohydrate content was observed in Sample F3, which contained 500 g of carrot.

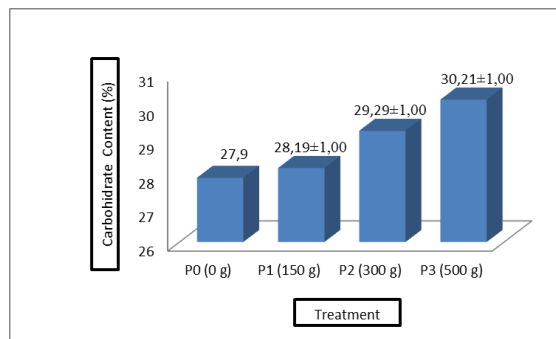


Figure 4. Carbohydrate content of pempek

The carbohydrates originate from the tapioca flour used, which consists of 13% amylose and 83% amylopectin [13]. Additionally, carbohydrates are also contributed by the carrot juice. Carrots contain 9 grams of carbohydrates per 100 grams, providing 173 kJ (41 kcal) of energy with 5 grams of sugar per 100 grams. The research findings demonstrated that an increase in carrot juice addition correlates with an increase in carbohydrate content (Figure 4). However, the economical freeze-drying method does not significantly affect the carbohydrate content in fortified pempek products. Compared with the control group, the carbohydrate content can be maintained or even increased by adding carrot. The carbohydrate content is also influenced by the levels of other components in the food, such as water, protein, ash, and fat.

3.5 Total Energy (kcal)

Calories are needed for energy and metabolic energy needs. Calorie sources are met first with carbohydrates, then with protein and fat. The total calories needed by adults are 2100 kcal for women and 2500 kcal for men. For children, it ranges from 1000-2000 kcal per day. The control pempek product contains 140.09 kcal. The total calories in the carrot-fortified pempek product range from 140.47 kcal to 148.68 kcal, as shown in (Figure 5).

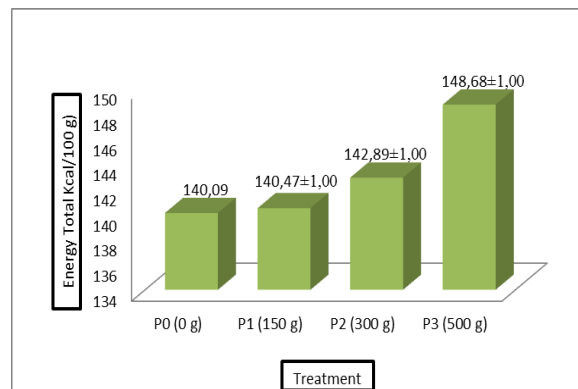


Figure 5. Total energy of pempek

This shows that the more carrots are added, the more the total calories will increase. The calorie content of carrot-fortified pempek is derived from the nutrients in its ingredients. Among them is the ground fish used [14], which is reported to contain 69 calories per 100 grams. Meanwhile, carrots have 36 calories per 100 grams. Carrots have a higher carbohydrate content than snakehead fish. Snakehead fish has a carbohydrate content of 2.6 grams/100 grams of fish meat (Silaban and Nurjanah, 2024), while carrots have a carbohydrate content of 7.9 grams/100 grams [1]. This means that the more carrot juice added, the higher the calories produced.

3.6 Fat Content

Factors influencing the fat content in pempek primarily include the type of fish used. Fish are rich in unsaturated fatty acids, and unlike other animal fats, fish fat contains relatively low levels of cholesterol. One advantage of fish over other meats is its high content of unsaturated fatty acids, which are typically long-chain fatty acids with double bonds. This includes omega-3 fatty acids, specifically EPA and DHA, which are vital for growth and brain development. Omega-3 fatty acids are also associated with reduced triglyceride levels in the blood and reduced cholesterol levels in the liver and heart. Fish have very high protein digestibility, making them easier to digest than other animal meats, and they also provide fat-soluble vitamins.

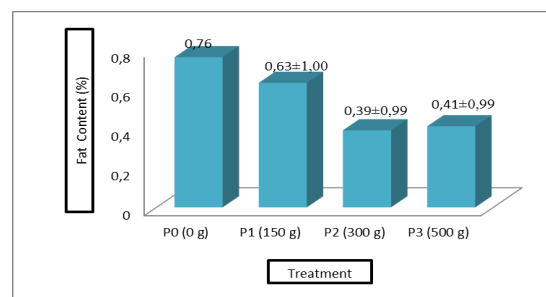


Figure 6. Fat content of pempek

It can be concluded that the amount of carrot juice affected the fat content. The lowest value was P2 (0.39%). Additionally, from the results in the previous section on total calories, we see that the largest contributor to total calories in fortified pempek is carbohydrates, not fat.

3.7 Carotene Content

Carotene are compounds that can be found in yellow to orange fruits and green vegetables. Carotene consists of beta carotene which is a precursor of vitamin A. The results of the study (Figure 7) showed that carotene levels ranged from 0.03% to 0.67%.

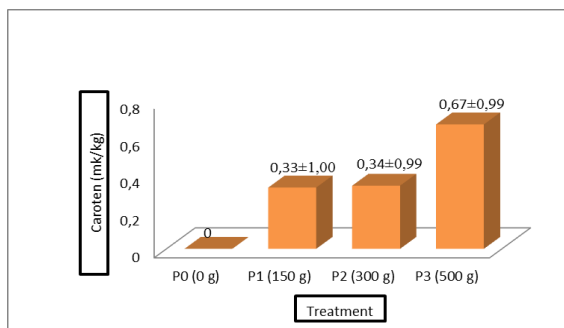


Figure 7. Carotene content of pempek

The lowest carotene levels were in sample P1, namely the addition of 150g of carrot juice, and the highest carotene levels were in sample P3, namely the addition of 500g of carrot juice. [15] reported that the freeze drying method causes the structure to collapse so that oxygen will diffuse and oxidize carotene. In addition, there is porosity in the product which causes the oxidation rate to increase. However, vacuum packaging can reduce oxidation rates. In this study, pempek with carrot fortification was packaged under vacuum to minimise carotene loss.

3.8 Dietary Fiber

Dietary fiber consists of water-soluble and insoluble fiber. Fiber has health benefits to maintain the digestive tract. The need for dietary fiber for adults ranges from 20-35 g/day. The main sources of fibre are almost all from vegetables, wheat, and nuts [16]. The results of the study showed that the amount of fiber content ranged from 3.20% - 6.50% (Figure 8).

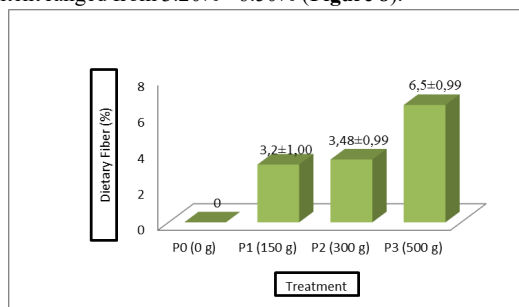


Figure 8. Dietary fiber of pempek

The more carrot juice added, the higher the fiber content. The highest fiber content was contributed by the added carrot juice. Carrots have a fiber content of 1.1 grams/100 grams. Another source of fiber comes from tapioca flour of 1.9 g/100 g.

4. CONCLUSION

The results of the study showed that the best sample was sample P2, namely the addition of 300 g of carrot juice with a water content of 62.82%; ash content of 1.50%, fat content of 0.39%, protein content of 5.69%, carotene content of 0.34%, dietary

fiber of 3.48%, carbohydrate content of 29.29% and calories of 142.89 kcal.

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