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Research Article

Development of "Chamcham" Chips Formula for Anemia Made from Tuna (*Thunnus sp.*), Seaweed (*Ulva sp.*), and Pumpkin (*Cucurbita moschata*)

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Abstract

Background: An incidence of anemia in adolescents, especially in developing countries, is still a public health problem. The current nutritional status of adolescents will decide the prosperity of the present as well as the future generations. ***Objective***: The development of Chamcham chips made from tuna (Thunnus sp.), seaweed (Ulva sp.), and pumpkin (Cucurbita moschata) as adolescent girl snacks is considered the solution to avert this situation. ***Methods***: The sensory characteristics, such as appearance, aroma, flavor, and texture, by semi-trained panelists were evaluated by 46 people, and the nutritional analysis (proximate, crude fiber, minerals, and β-carotene content) of Chamcham chips was examined. Chamcham chips contain tuna flour, dry seaweed, pumpkin flour, wheat flour, tapioca flour, and egg. ***Results***: The result of the sensory evaluation showed that the formulation of Chamcham chips had no significant difference between the scores of appearances, aroma, and flavor, but there is a significant difference for texture. The formulation of Chamcham chips also affects nutritional value, in which products containing more seaweed have higher nutritional value than other products containing lower seaweed. Based on this analysis, Chamcham chips F4 with 30% seaweed, tuna 10%, and pumpkin 10% is the best formula. ***Conclusions***: Chamcham chips in 50 g (one portion size) met more than 10% of the RDAs for adolescent girls in terms of protein, carbohydrates, iron, and zinc, so it can be recommended as a potential food to prevent anemia for adolescent girls.

Keywords: Anemia, Iron, Pumpkin, Seaweed, Tuna.

تطوير تركيبة رقائق "Chamcham" لفقر الدم المصنوعة من التونة (*Thunnus sp*) والأعشاب البحرية (*Ulva sp*) واليقطين (*Cucurbita moschata*)

الخلاصة

الخلفية: لا يزال حدوث فقر الدم لدى المراهقين، وخاصة في البلدان النامية، مشكلة صحية عمومية. سيقرر الوضع الغذائي الحالي للمراهقين ازدهار الأجيال الحالية والمستقبلية. **الهدف**: يعتبر تطوير رقائق الشامشام المصنوعة من التونة (Thunnus sp) والأعشاب البحرية (Ulva sp) واليقطين (Cucurbita moschata) كوجبات خفيفة للفتيات المراهقات هو الحل لتجنب هذا الموقف. **الطرائق**: تم تقييم الخصائص الحسية، مثل المظهر والرائحة والنكهة والملمس، من قبل أعضاء اللجنة شبه المدربين من قبل 46 شخصا، وتم فحص التحليل الغذائي (القريب، والألياف الخام، والمعادن، ومحتوى β كاروتين) لرقائق شمشام. تحتوي رقائق الشامشام على دقيق التونة والأعشاب البحرية الجافة ودقيق اليقطين ودقيق القمح ودقيق التابيوكا والبيض. **النتائج**: أظهرت نتيجة التقييم الحسي أن تركيبة رقائق الشمشام لم يكن لها فرق معنوي بين درجات المظاهر والرائحة والنكهة، ولكن هناك فرق كبير في الملمس. تؤثر تركيبة رقائق شمشام أيضا على القيمة الغذائية، حيث تتمتع المنتجات التي تحتوي على المزيد من الأعشاب البحرية بقيمة غذائية أعلى من المنتجات الأخرى التي تحتوي على أعشاب بحرية أقل. بناء على هذا التحليل، فإن رقائق Chamcham F4 مع 30٪ أعشاب بحرية، والتونة 10٪، واليقطين 10٪ هي أفضل صيغة. **الاستنتاجات**: استوفت رقائق شمشام بوزن 50 جم (حجم جزء واحد) أكثر من 10٪ من RDAs للفتيات المراهقات من حيث البروتين والكربوهيدرات والحديد والزنك، لذلك يمكن التوصية بها كغذاء محتمل للوقاية من فقر الدم للمراهقات.

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INTRODUCTION

Anemia is one of the major health problems, which has been linked with an increased risk of maternal mortality and morbidity [1]. Iron deficiency anemia (IDA) is the most common nutritional deficiency-related problem, which is highly prevalent in low- and middle-income countries, and adolescents, particularly females, are prone to this condition [2]. Indonesian health surveys (Riskesdas) conducted in 2007, 2013, and 2018 showed that the reported pooled prevalence of anemia among adolescents increased from 6.9% to 18.4% and 32% [3–5]. Anemia is caused by micronutrient deficiencies, malaria, genetic disorders, blood loss, and infection [6,7]. However, iron deficiency (iron is an integral part of the blood protein, hemoglobin) is considered the primary cause of anemia, which results in insufficient levels of iron needed to produce red blood cells [8,9]. The recommended diet for preventing anemia should be rich in iron, vitamin B12, and folic acid, preferably provided by nature [10,11]. Indonesia has various food sources that have great nutritional functions, including anemia-prevention properties. These food sources are locally available and can be used for Indonesian meals. Tuna (Thunnus sp.) has been widely known to have a high protein content of more than 28%, a low-fat content of <5%, and is rich in unsaturated fatty acids such as EPA and DHA [12,13]. Protein is an essential macronutrient to enhance iron absorption [14]. Pumpkin is a potential food to increase Hb levels in anemic women because of its nutritional content. Pumpkin has a high content of carotenoids, vitamin C, sugar, fiber, protein, and vitamin B [15,16]. Its nutritional content can enhance iron bioavailability. In a mice study, the Hb level in the $FeSO_4$+pumpkin and Bioplex+pumpkin groups was higher than in the $FeSO_4$ and Bioplex-fortified groups [15]. Seaweed is a food source that is rich in macronutrients such as protein, fat, and carbohydrates, and minerals including iron, sodium, calcium, and zinc, as well as vitamins such as vitamins C and A (17). Snacking, such as sweets, chips, and biscuits, contributes to a significant part of people's everyday lives. Chips are popular non-fermented bakery products across the world [18]. Existing research trends are intended to develop an innovative product that can be considered a healthy snack to reduce the prevalence of anemia [18]. The composition of functional chips should be selected through considerate formulation trials and literature studies [19]. Furthermore, it is necessary to identify organoleptic testing of chips to know the characteristics of chips that are preferred by consumers. Since tuna (Thunnus sp.), pumpkin (Cucurbita moschata), and seaweed (Ulva sp.) have anemia-lowering properties, it could be developed as a potential food in the form of chips, which is usually preferred by adolescents. This study aimed to develop food formulation by evaluating the organoleptic properties and nutritional analysis of the functional chips "Chamcham," which are made from tuna (*Thunnus sp.*), pumpkin (*Cucurbita moschata*), and seaweed (*Ulva sp.*) using four different formulations.

METHODS

This study was an experimental study to evaluate the sensory characteristics and organoleptic properties of Chamcham chips as a snack for adolescent girls. The study was conducted in October 2021 in the Laboratory of the Department of Nutrition and Health, Faculty of Medicine, Public Health and Nursing (Universitas Gadjah Mada).

Formulation of Chamcham chips

Four formulations of Chamcham chips were prepared using fresh ingredients that can be found at the local market. The composition of their sample code and formulations in this study are shown in Table 1. The Chamcham chips consisted of tuna fish as a protein and fat source and pumpkin and seaweed as sources of vitamins and minerals. Four formulations were prepared using fresh ingredients obtained from a local market in Yogyakarta. Tapioca flour, wheat flour, garlic, red onion, and egg were used as additional ingredients.

Table 1: "Chamcham" chips formulations used in the study

Sample	Composition (%)					
	Egg	Tapioca flour	Wheat flour	Pumpkin flour	Dry seaweed	Tuna flour
F1	15	10	25	10	15	25
F2	15	10	25	10	20	20
F3	15	10	25	10	25	15
F4	15	10	25	10	30	10

Fresh tuna fish were weighed, deboned, and steam-cooked for 30 minutes before being oven-dried for 30 minutes at 65°C. Fresh seaweed was cleaned and processed using a blender until it was smooth. The ingredients (dried tuna fish, pumpkin flour, blended seaweed, red onion, garlic, and egg) were weighed and mixed together. The dough was homogenously blended and mixed with flour and tapioca flour. Afterward, the mixed dough was rolled out into the same thickness with a rolling pin. Chips were sliced using a food cutter and placed in trays. The dough that had been cut was refrigerated for a day at room temperature before being fried at a high temperature.

Sensory evaluation

An organoleptic test was conducted with numerical scales ranging from 1 to 6. The evaluation scale was 1= dislike extremely, 2= dislike very much, 3= dislike slightly, 4= like, 5= like very much, and 6= like extremely. The purpose of this test was to evaluate the preference level in terms of appearance, aroma, flavor, texture, and general impression for the sample. The organoleptic test in this study was conducted with 46 semi-trained panelists, and the panelist was selected purposively. The panelist was required to sign the informed consent before the test. There were 12 males and 34 females from the 46 semi-trained panelists with 20-25-year-old ages. The panelists were students of the Department of Nutrition and Health, Universitas Gadjah Mada, who have been trained for sensory evaluation in their coursework. The exclusion criteria for the panelists were the presence of disturbances in the sense of smell and taste and having allergies to the food ingredients in Chamcham chips. Each panelist was provided with 10 g of each Chamcham chips formulation.

Nutritional and biochemical evaluation

Analyses of nutrient composition were carried out at the Chemix Pratama Laboratory, Yogyakarta, Indonesia. This research got approval from the Research Ethics Committee Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada No. KE/FK/0771/EC/2021 by 6 July 2021.

Ash content

The ash content was determined using standard analytical methods. The principle of determining the ash content was to weigh the mineral residue produced from the burning of organic matter at a temperature of about 550°C. The materials were burned at a high temperature (500-600°C) for two to eight hours to determine the ash concentration. The residue that was left behind was the weighed and classified ash. There were between two and five grams in each of the samples that had their ash content analyzed. Ash content was calculated by the following formula: amount of ash divided by sample mass (in grams) and multiplied by 100 percent [20].

Crude fiber, protein and amino acids

The crude fiber was estimated by calculating the weight loss of the crucible and its contents on the ignition after ashing. The protein was determined by the Micro Kjeldahl method, which involves calorimetric nitrogen measurement after 0.5 grams of material were digested with sulfuric acid and a catalyst. The value of nitrogen was multiplied by 6.25 to obtain a percentage of crude protein [21]. The amino acid composition was analyzed using the AOAC (2005) method with High-Performance Liquid Chromatography (HPLC) using ophthaldialdehyde-mercaptopropoionic acid (OPA-MPA) as a reagent and amino acid standards [20,22]. Beta-carotene was analyzed by HPLC-reverse phase [21].

Fat and carbohydrate content

Fat content was determined by the Soxhlet extract method. A homogenized sample weighing around 9 grams was put into an extraction thimble and extracted using petroleum ether for 240 minutes. After drying at 103 ± 2°C to a constant weight, the fat content was measured gravimetrically [23]. The different methods between a whole sample and the amount of protein, fat, and ash composition of the sample to analyze carbohydrate content.

Mineral content

Mineral including (Fe, Zn) was determined in atomic absorption spectroscopy (Perkin-Elmer Model 3110., Germany). The content of these elements was measured by atomic absorption spectrometer (AAS) directly in the undiluted filtrate. All the measurements were duplicated twice.

Ethical considerations

The study protocol was approved by the ethical committee of Faculty Medicine, Public Health, and Nursing UGM (KE/FK/0771/EC/2021).

Statistical analysis

Descriptive data were presented as mean and standard deviation. One-way ANOVA with the post-hoc Tukey HSD test was used to compare the nutrient contents and organoleptic characteristics of Chamcham chips formulations. A *p*-value of <0.05 was considered statistically significant.

RESULTS

The four different formulas of Chamcham chips were evaluated for sensory characteristics including appearance/color, aroma, flavor, texture, and general impression. Table 2 shows the sensory characteristics of each formula. Significant differences were shown for texture and general impression ($p<0.05$).

Table 2: Average rating of analyzed features for all samples

Sample	Parameter				
	Appearance	Aroma	Flavor	Texture	General Impression
F1	3.80±0.71[a]	4.15±0.89[a]	3.50±1.24[a]	3.63±1.51[b]	3.89±1.05[b]
F2	3.86±0.77[a]	4.04±0.81[a]	3.63±1.28[a]	2.86±1.40[ab]	3.50±1.09[ab]
F3	3.52±0.88[a]	3.78±0.86[a]	3.58±1.08[a]	2.71±1.22[a]	3.10±1.03[a]
F4	3.76±0.79[a]	3.84±0.98[a]	3.93±1.08[a]	3.47±1.47[ab]	3.67±1.15[ab]
p	0.176	0.171	0.317	0.004	0.006

Values of mean acceptance ± standard deviation (SD) for all involved in this test. ANOVA and *post hoc* Tukey HSD analysis test. [a, b] : the same superscript in the same column shows the results are not significantly different.

There was no statistically significant difference between 4 formulas in appearance, aroma, and flavor ($p>0.05$). In terms of appearance, the least preferred was F2, Chamcham chips with 20% seaweed, tuna fish 20%, and pumpkin 10%. The highest tuna fish content in F1 had the highest level of aroma, texture, and general impression. The result of the nutrient content for each treatment can be seen in Tables 3 and 4. The highest calorie content was found in F3 (341.1 kcal), which was significantly different from F2 (340.52 kcal), followed by F1 (324.32 kcal) and F4 (320.17 kcal). The highest protein content was seen in F3 (14.12 g), followed by F2 (14.09 g), F4 (14.03 g), and F1 (11 g). The highest crude fiber, iron, lysine, and histidine content was seen in F4, Chamcham chips with 30% seaweed, 10% tuna, and 10% pumpkin. F2 had the highest β-carotene content (32,625.66 g kg^{-1}).

DISCUSSION

Functional food is defined as foods that give dietary benefits beyond their macronutrient or macronutrient content. Seaweed, tuna fish, and pumpkin have many beneficial effects on biological activity and could be developed to produce therapeutic products [24–26]. This study aimed to examine the nutritional content and to assess sensory acceptability to find the best formula for Chamcham chips. Sensory properties of food products are important to provide an understanding of the key attributes for consumer satisfaction [27–29]. The result obtained from this study showed that there was a significant difference in terms of texture and general impression of the four formulas of Chamcham chips, indicating that different attributes were perceived by the panelists among the formulas.

Table 3: Proximate content of *Chamcham* chips formulas per 100 grams

Sample	Ash (%)	Water (%)	Calories (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Crude fiber (g)
F1	3.93±0.50^{a}	20.80±0.01^{c}	324.32±1.03^{b}	11±0.02^{a}	14.35±0.24^{b}	38.31±0.26^{a}	11.61±0.01^{b}
F2	3.54±0.19^{a}	16.26±0.07^{a}	340.52±0.33^{a}	14.09±0.04^{a}	14.23±0.01^{b}	40.52±0.33^{b}	11.35±0.15^{b}
F3	3.63±0.17^{a}	17.65±1.42^{ab}	341.1±4.53^{c}	14.12±0.025^{a}	13.73±0.22^{b}	40.66±0.68^{b}	10.2±0.05^{a}
F4	3.35±0.14^{a}	19.27±0.05^{bc}	320.17±0.44^{b}	14.03±0.02^{a}	13.07±0.015^{a}	36.86±0.06^{a}	13.40±0.01^{c}

Data are presented in mean±SD, the different superscripts in one column stand for significant differences (p<0.05).

Table 4: Lysine, Histidine, Fe, Zn, and □-carotene content of Chamcham chips per 100 grams

Formulas	Lysine (%)	Histidine (%)	Fe (mg)	Zn (mg)	β-carotene (g kg^{-1})
F1	0.1±0.0^{a}	0.1±0.0	10.06±0.4^{b}	645.53±14.38^{c}	20,498.14±32.9^{c}
F2	0.18±0.0^{b}	0.13±0.0	9.52±0.03^{a}	778.91±2.27^{d}	32,625.66±42.76^{d}
F3	0.22±0.0^{c}	0.16±0.0	11.2±0.01^{c}	214.31±0.91^{a}	19,527.97±17.87^{b}
F4	0.26±0.0^{d}	0.19±0.0	13.2±0.02^{d}	300.1±4.68^{b}	18,801.77±17.89^{a}

Data are presented in mean±SD, the different superscripts in one column stand for significant differences (p<0.05).

In contrast, there was no significant difference in appearance, aroma, and flavor. Based on the result of sensory characteristics, each formula had a brown color. This color appears as a result of the oven process in the manufacture of Chamcham chips. High temperatures can result in the extinction of the pigment and result in discoloration. This result can be associated with a previous study in which yellow materials, namely bananas, potatoes, and apples, had an increase in brownish-red color after high-temperature processing [30,31]. In this study, the mean scores of aroma increased with the ratios of tuna fish content in the product. The aroma of tuna fish is the formation of volatile compounds through the process of processing. Aroma attributes are an important factor that helps determine the acceptability of a food product [32]. Table 2 showed that F4 (30% seaweed, 10% tuna, 10% pumpkin) has the highest value of flavor attribute. The flavor of Chamcham chips is an important factor in the acceptance of a food product. Even though a product has a good appearance, aroma, and texture, without a good flavor, a food product will not be accepted commercially. Among the other formulas, F1 (15% seaweed, 25% tuna fish, 10% pumpkin) has the highest score for texture attributes. The gelatinization process during heating affected the texture of Chamcham chips. This is because seaweed contains carrageenan, which serves as a form of elasticity [33]. Flavor components of chips are released in the mouth, providing lubricating effects, a desirable mouthfeel, and an important role in satiation. Fat droplets trigger sensations of creamy, smooth, or rich texture and flavor. A medium heat transfer at high temperatures generates food textures that are crispy, brittle, and crunchy [34]. The addition of tuna fish, seaweed, and pumpkin affected the nutritional composition of Chamcham chips (Tables 3 and 4). Based on the results of the sensory test conducted by panelists, the formula F1 of Chamcham chips has the highest score for general impression. F1 Chamcham chips contain 15% seaweed, 25% tuna fish, and 10% pumpkin and contain proteins, fats, carbohydrates, and iron of 11 g, 14.35 g, 38.31 g, and 10.06 mg, respectively. F4, the formula with the highest nutritional content (higher protein, highest Fe), has good acceptability among panelists despite having slightly lower results compared to F1 for general impression. This may be due to seaweed having a fishy aroma, which can negatively affect the score of acceptance [35,36]. Water content in food provides crucial information about the quality of the product. The water activity (a_w) provides information on the possibility of microbial activity growing on the surface of the product [37,38]. Drying treatment could reduce up to 87.7% of the water content of a food product [39]. The ash content of material indicates the total amount of mineral contained in a vegetable, whereas the mineral content is a measure of the amount of specific inorganic components in food, namely iron (Fe), zinc (Zn), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), and copper (Cu) [40–43]. The highest ash content was in F1 (3.93%), which is lower than the ash content of unprocessed seaweed. The presence of fiber in seaweed contributes positively to the ash and crude fiber content of Chamcham chips. Winarni *et al*. (2021) reported that the unprocessed seaweed contains 3.048% protein, 0.617% fat, and 7.112% ash [44]. The highest micronutrient content, such as iron, lysine, and histidine, of 13.2 mg, 0.26 mg, and 0.19 mg was in F4. Analysis of the content of b-carotene showed that the Chamcham chips F2 had the highest value, while the Chamcham chips F4 had the lowest value. The previous study found that more than half of the lutein and β-carotene content could be degraded during the process of drying [45]. Despite this, the four formulas (100 g) met the requirements for β-carotene, which is 600 mg [45,46]. According to nutrient content analysis and organoleptic evaluation, the best formula in this study was the F4 formula for its relatively acceptable preference level and high nutritional content over other formulas. Based on the Recommended Daily Allowances (RDAs) for adolescent girls, one portion size (50 g) of the Chamcham chips product (F4) could meet the requirement for 10.79% of protein, 6.14% of carbohydrates, 44% of iron, and 1.66% of zinc [47]. Chamcham chips were developed to be a supplemental food for adolescent girls to prevent the incidence of anemia. It utilized low-cost food resources and promoted prolonged shelf life by drying the ingredients. Animal studies followed by clinical trials are required to determine the effect of Chamcham chips consumption on biochemical biomarkers, especially of iron metabolism. This study has certain limitations that need to be addressed in future research. One notable limitation is the absence of information regarding the shelf life, packaging, and storage stability of the Chamcham chips. These factors are critical for maintaining product quality and ensuring the chips remain safe and appealing to consumers over time. To address this gap, future research should focus on evaluating the shelf life, packaging, and storage stability of "Chamcham" chips. Such studies will help determine optimal packaging materials and storage conditions to preserve the chips' quality and nutritional value during distribution and storage, ultimately enhancing their marketability and effectiveness as a nutritional intervention.

Conclusion

The use of seaweed, tuna fish, and pumpkin in producing Chamcham chips affected the nutritional content and sensory acceptability. This research points out that Chamcham chips contain a substantial amount of protein and essential micronutrients such as iron, zinc, lysine, and histidine. Chamcham chips (30% seaweed, 10% tuna, 10% pumpkin) might be a promising product to help adolescent girls accomplish their RDAs for protein, iron, and zinc in the form of a snack with good acceptability to prevent iron deficiency.

Conflict of interests

No conflict of interest was declared by the authors.

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Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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