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Original article

Development and sensory test of eel cookies for pregnant women with chronic energy deficiency using many facet Rasch model: a preliminary study

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Summary: *Study objectives:* This study aimed to assess the respond of pregnant women with chronic energy deficiency by giving them cookies that contain eel's bone flour. *Methods:* The study was conducted in three stages. First, a functional food formula based on *Anguilla bicolor* was created. Second, the qualities of the food products were examined. Lastly, a sensory assessment was performed with 30 pregnant women. The sensory assessment data were analyzed using many-facet rasch model. *Results:* Three cookies formulae were made. Among the parameters for the sensory assessment with the consumers, texture was the most difficult criterion to be fulfilled (1.13 logit), followed by taste (0.18 logit), aroma (-0.34 logit), and color (-0.97 logit). The peanut-flavored cookie (0.62 logit) was preferred over cheese or chocolate-flavored. *Conclusion:* Cookies made from fish bone flour of *Anguilla bicolor* and local corn may be a better functional food option for addressing chronic energy deficiency in pregnant women.

Keywords: development; sensory test; eel cookies, pregnant women; many-facet Rasch model

Introduction

Chronic energy deficiency in pregnancy increases the occurrence of infectious diseases and anemia, and is a risk factor for maternal mortality (1). The condition also affects the fetus, and may lead to intrauterine growth retardation, low birth weight, or even death (2,3). Low birth weight infants may be exposed to the risks of malnutrition, with the effects even passed down the generations (4). The prevalence of chronic energy deficiency in pregnant women in the regency of Sukabumi is among the highest in West Java province, Indonesia. One of the solution for this is providing functional foods.

Functional foods are food products with physiological benefits for the human body (5), and may function to reduce the risk of disease (6). As part of a nutrition program, the Indonesian government provides functional food supplementation for pregnant women with chronic energy deficiency in the form of a sandwich biscuit that contains 208 to 312 calories, and 6 to 9 grams of protein per 100 grams. The nutritional content, however, falls below the Indonesia Ministry of Health's (MoH) requirements of 500 calories of energy, and 17 grams of protein per 100 grams.

Nevertheless, these functional foods can also be derived from traditional foods that are locally available while still meeting the nutritional intake requirement (5,7). Among other food sources, local eel (*Anguilla bicolor*) can be a good source of protein, vitamins, and minerals. Indonesia has 12 of the 19 species of *Anguilla* in the world. According to Seo et al., the *Anguilla* eel has higher nutritional contents, such as protein, fat, vitamins, and minerals, compared to other fish species

(8). In particular, the *Anguilla bicolor* is endemic to the Sukabumi regency. Its parts, such as the head, bone, and viscera also contain high nutritional value, especially fatty acids, with the bone being superior compared to other body parts. The dominant fatty acid components in *Anguilla* bone are palmitic acid, oleic acid, EPA, and DHA (9). According to Sales-Campos et al., *Anguilla bicolor* bone also contains a high amount of oleic acid, potentially developed as a source of omega-9 fatty acid [10]. Oleic acid is used in products to maintain healthy skin, and is also known to have physiological effects that help to prevent cancer, autoimmunity and inflammatory diseases, and to facilitate wound healing (10). So, it is predicted that these qualities could be a potential commodity to be utilized as an ingredient in a functional food product (9).

Another local food ingredient that can be used is corn, as a source of carbohydrate. The nutrient content of corn starch can be utilized as a functional food ingredient (11). According to Suarni, every 100 grams of yellow corn starch has a carbohydrate content of 73.3 grams, protein content of 9.2 grams, and a fat content of 3.9 grams (12). A study on cookies based on the *Anguilla japonica* ingredient has also been done by Giango in the Philippines, the result was that the addition of *Anguilla* powder to the cookies as much as 90 grams were accepted by consumers (13).

The aimed of study was to assess the respond of pregnant women with chronic energy deficiency on created functional food. Formula which based on *A. bicolor* and corn were developed and examined through several tests to determine the most acceptable one.

Materials and Methods

Study Design

The design of this study was exploratory, and was conducted in three stages. The first stage was intended to produce formulae of functional food in the form of cookies using *A. bicolor* bone powder, and local corn flour as its main ingredients. In the second stage, the product's qualities were tested using proximate, microbiology, and metal contamination tests. Lastly, a sensory or acceptance test was conducted among 30 pregnant women. The study was conducted in Sukabumi regency, Indonesia, from October to December 2017.

Development of New Functional Food

A new functional food was made in the form of cookies, and the basic ingredient used was *Anguilla bicolor,* which was preprocessed into powder. Other ingredients used for the cookies were corn flour, wheat flour, butter, margarine, refined sugar, and eggs, all weighed according to the formula. Butter, margarine, and refined sugar were stirred using a mixer at a low speed to make a homogeneous mixture of a pale color. Subsequently, eggs were added, and the mixture was stirred again before the bone powder was added. Next, sifted wheat flour and corn starch were slowly added into the dough while stirring until the mixture was well blended. Food flavoring additives (cheese, chocolate, and peanut) were added to the dough before it was baked for 15 minutes at 160 degrees Celsius until it was golden or yellow in color, and ready for consumption.

Quality Test of Functional Food

Quality tests were performed on the cookies, which included a proximate test, metal contamination test, and microbiology test. The proximate test aimed to measure the contents of water, protein, fat, carbohydrate, energy, and color, while the metal contamination test aimed to detect traces of tin (Sn), lead (Pb), mercury, and arsenic. Lastly, microbiology tests were run for coliform, *E. coli*, *Salmonella sp.*, and *Staphylococcus aureus*. The tests were conducted at Saraswanti Indo Genetech Laboratory.

Sensory Assessment

Thirty pregnant women with chronic energy deficiency were selected and agreed voluntarily as consumers for a sensory assessment. Pregnant women with a mid-upper arm circumference of less than 23.5

Table 1. Sensory Assessment Consumers Characteristics

Consumers	Frequency	%
Age Group		
20 – 35 years	21	70
> 35 years	9	30
Gestational Age		
Trimester 1	10	33
Trimester 2	4	13
Trimester 3	16	53

cm were eligible to participate. However, those suffering from constant nausea, infectious diseases such as tuberculosis and malaria, or allergies to nuts and fish were excluded from participating. The majority of consumers were pregnant women aged between 20 to 25 years old, who had a gestational age in the third trimester. Table 1 below summarizes the characteristics of the sensory assessment consumers.

Sensory assessment was then carried out with the 30 consumers who were pregnant. The consumers were asked to taste all three types of cookie flavors and rate their color, taste, texture, and smell on a three-point scale, namely "dislike" (scored as one), "like" (scored as two) and "really like" (scored as three). The consumers assessment results were entered into a Microsoft Excel 2016 document, resulting in a 30 (consumers) x 3 (types of cookies) x 4 (assessment parameters) data array. Each subject was coded A1 to A30.

Multi-Rater Analysis

Consumers assessment data were treated as multi-rater data, where one rater assessed the three types of cookie flavors independently. The data were analyzed using the many-facet Rasch model (MFRM) that treated ordinal data as odd probability based on its frequency of occurrence. The odd probability was then logarithm-transformed to establish an equal-interval scale (14,15). Hence, the model resulted in a logit interval data with a value and unit that showed the quality measurement of the sensory assessment of the cookies (16,17). Analysis of multi-rater data is commonly done based on the classical test theory, on the other hand MFRM provides more precise information, and gives valuable results regarding what is assessed, the severity/leniency of the consumers, and the quality of the instrument used simultaneously (14,16,17). The analysis for this study was done using the Facets software version 3.71; total responses analyzed with three cookies assessed by 30 pregnant women on four parameters were 360, and there were no missing data. In addition, use of the Facets software informed about unexpected responses, which are a correction method for the consumers when rating the cookies according to their preferences.

Ethics Approval

This study fulfilled Helsinski's declaration, and received ethical clearance from the Ethics Committee of the Faculty of Medicine Universitas Padjadjaran No. 106/UN6.C.10/PN.2017. Informed consent was obtained from all subjects before participating in this study.

Results

The cookies were examined using proximate, microbiology, and metal contamination tests (refer Table 2). Results from the proximate tests demonstrated that both the cookies based on *A. bicolor*, and the biscuits used by the MoH met the Indonesian National Standard (*Standar Nasional Indonesia*/SNI) requirements. Both the contents of protein and fat in *A. bicolor* cookies and the MoH biscuits were higher than the SNI standard. Microbiology tests, on the other hand, indicated that coliform, *E. coli*, salmonella, and staphylococcus were not found in the specimens, while the total plate number was still far below the maximum standard of 10^4. Metal contamination was absent, or detected below the SNI maximum level of contamination. A summary of the results from the tests are shown below in Table 2.

Table 2. Results from Proximate, Microbiology, and Metal Contamination Tests of *A. Bicolor* Cookies, Compared to Indonesian National Standard (SNI) Requirements

	INS	***A. Bicolor* Cookies**	**MoH Biscuits**
Proximate tests			
Maximum level of water (%)	5	1.88	1.8
Minimum level of protein (%)	9	15.7	15
Minimum level of fat (%)	9.5	34.96	42
Maximum level of carbohydrate (%)	70	34	16
Level of energy (cal)	400	507	500
Color	Normal	Normal	Normal
Microbiology tests			
Total plate number	Max. 1.0×10^4	4.0×10^1	N/A
APM coliform	-	-	N/A
APM *E. coli*	-	-	N/A
Salmonella sp	-	-	N/A
Staphylococcus aureus	Maximum 1.0×10^2	-	N/A
Metal contamination tests			
Tin (Sn)	0.3	0.2	N/A
Lead (Pb)	40	0.29	N/A
Mercury	0.3	-	N/A
Arsenic	0.1	-	N/A

A three-facet model was constructed for three cookies, ratings for four cookie criteria and 30 pregnant women whose role was as raters. The cookies and rating criteria were centered at zero, which consequently allowed for the severity/leniency of the raters to be calibrated accordingly. Table 3 shows a summary of the statistics for the many-facet Rasch model (MFRM) analysis of the multi-rater sensory assessment performed.

As shown in Table 3, the mean measure (logit) of both the cookies and the rating criteria was 0.00 logit. However, while the standard deviation for the cookie measures was relatively low (0.45 logit), suggesting that there was not a wide dispersion of measures across the logit scale of cookies, the standard deviation for rating criteria was slightly higher (0.77 logit), indicating they were a little more widely dispersed. The average outfit mean square statistics were close to the expected value of 1. The standard deviations for the cookies, rating criteria, and rater facets indicated a uniform fit to the model, with all homogeneity indices at a significant level (14,16). The strata and reliability statistics of the cookies, rating criteria, and raters were good, whereby all facets showed that its strata can be reliably separated into three distinct levels.

These same statistics also suggest that raters were not a homogeneous group, with high reliability and strata indices. Nevertheless, raters were shown to have the same level of inter-rater agreement, which was at a good level (16,17). Table 3 is shown below.

The results of the multi-rater assessment of the cookies by the consumers can be seen in figure 1, which was generated by the Facets software.

Among the consumers, the peanut-flavored cookies were the most preferred with a value of 0.62 logit, followed by chocolate-flavored cookies with a value of -0.23 logit, and cheese-flavored ones with a value of -0.40 logit. A scale difference of greater than 0.5 logit indicates that the consumers favored the peanut-flavored formula the most in comparison to other cookie formulations.

Table 3. Summary of Statistics for the MFRM Analysis

	Cookies	Criteria	Raters
N	3	4	30
Measures			
Mean	0.00	0.00	-0.37
Standard Deviation, SD	0.45	0.77	0.95
Standard Error, SE	0.15	0.17	0.48
Outfit Mean Square			
Mean	1.05	1.05	1.05
SD	0.22	0.38	0.56
Homogeneity Index (χ^2)	25.5*	76.0*	99.1*
Df	2	3	29
Strata	4.07	6.11	2.59
Reliability	0.89	0.95	0.74
Inter-rater Reliability			
Observed Exact Agreements			41.4%
Expected %			40.4%

* $p < 0.01$

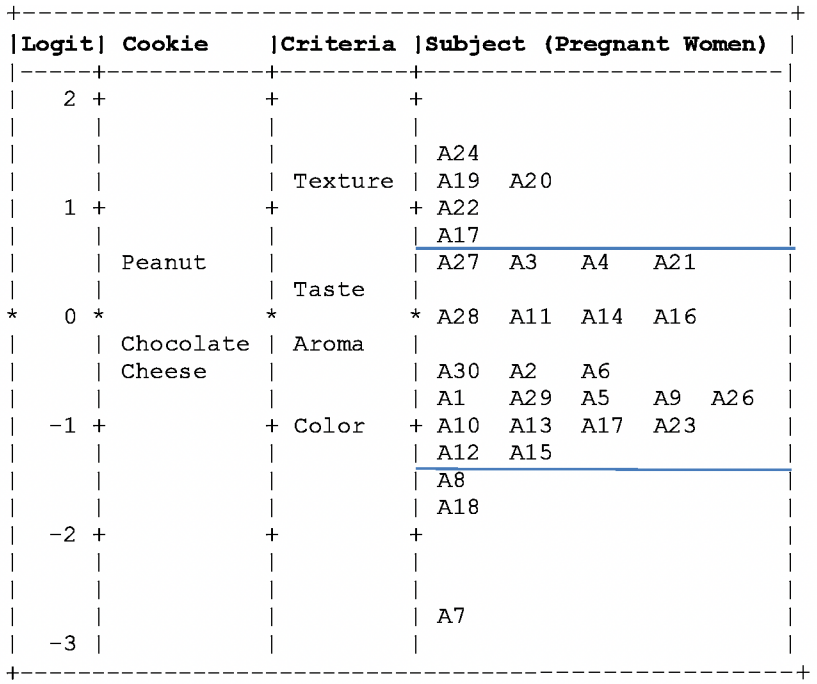

Figure 1. Results of *A. bicolor* Cookie Assessment by Pregnant Women Using MFRM Analysis

For the parameter of the cookie qualities, the cookie's texture (1.13 logit) was the most difficult criterion to be fulfilled by all three cookie formulations. All consumers reported that, with regards to the texture aspect, no cookie formulation met their preference, including the most favored peanut-flavored cookies. Nevertheless, the peanut-flavored cookies met the three other parameter requirements, namely taste (0.18 logit), aroma (-0.34 logit), and color (-0.97 logit). In the flavor aspect, chocolate and cheese cookies were deemed unfavorable by the consumers. However, the chocolate-flavored cookies fulfilled the color and aroma parameters, while the cheese-flavored cookies only fulfilled the color criterion.

Based on the logit mean and standard deviation of the consumers, there were three groups of pregnant women. There were five (17%) pregnant women (A17 up to A24 in Figure 1 above) who could be considered severe raters (higher logit than mean, plus standard deviation, more than 0.58 logit), while the majority of the pregnant women (22 persons, or 73%) fell under the category of moderate raters, and three consumers (10%) were lenient raters (A8, A18 and A7) whereby they gave a passing rate to all three cookies easily.

Another interesting finding was where the consumers made a judgment on the cookies referred to as an "unexpected response" in the MFRM. There were 15 judgments that were considered unexpected responses, which informed about the raters' consistency as well as the quality of the cookies and their parameters (refer Table 4).

The first line informs that rater A12, when assessing the peanut cookie in aroma, gave a score of 1, but the expected score was 2.8. This means that A12 had provided an under-value in this occasion. In another case, on the other hand, in line 7, rater A28 provided an over-value, where she gave a score of 3 for the chocolate cookie in terms of texture instead of 1.4. In total, there were four overvalue scores (lines 7, 9, 10 and 15), while the rest were undervalue scores.

From the 30 pregnant women, there were 13 of them who gave unexpected responses, which is less than half; peanut cookies had the highest number of instances of unexpected bias at seven times, compared to chocolate (six times), and cheese (twice). Interestingly, for the parameters, there were no unexpected responses when the subjects gave judgment on taste, while there were many for aroma (seven times), color (five times), and texture (three times)

Table 4. Fifteen Unexpected Responses of Sensory Assessment

No	Subject	Cookie	Criteria	Given Score	Expected Score
1	A12	Peanut	Aroma	1	2.8
2	A7	Chocolate	Color	2	2.9
3	A10	Peanut	Aroma	1	2.8
4	A13	Peanut	Aroma	1	2.8
5	A24	Peanut	Aroma	1	2.8
6	A26	Peanut	Aroma	1	2.7
7	A28	Chocolate	Texture	3	1.4
8	A8	Peanut	Aroma	2	2.9
9	A27	Peanut	Texture	3	1.6
10	A25	Chocolate	Color	3	1.6
11	A8	Chocolate	Color	2	2.8
12	A9	Cheese	Aroma	1	2.4
13	A11	Chocolate	Color	1	2.4
14	A16	Chocolate	Color	1	2.4
15	A26	Cheese	Texture	3	1.6

Discussion

Cookies are widely accepted and consumed in many countries as they have a variety of choices, and are enjoyed as snacks with longer expiration dates and crispiness, and low-budget prices (18). Cookies are, in general, baked products containing three main ingredients: flour, sugar, and fat (19). In this study, *Anguilla bicolor* bone powder was added to enhance the nutritional value of the cookies (13, 20,21). *A. bicolor* bone powder has a high nutritional value, being rich in proteins and minerals, and can be used as a raw ingredient for the diversification of food, additives, and functional food like cookies (13).

The main ingredients used in the cookie formula are *A. bicolor* bone powder, corn flour, wheat flour, butter, margarine, refined sugar, and eggs, with the addition of cheese, chocolate, and peanuts as flavoring to reduce the fishiness of the *A. bicolor*. Additionally, those added flavoring ingredients have nutritional benefits in their own right. Cheese is a source of protein, fat, lactose, calcium, magnesium, riboflavin, and vitamin B12 (22), while chocolate is a source of flavonoids, and may improve endothelial function, and lower blood pressure in overweight adults (23). On the other hand, peanuts, too, are a source of fat, protein, and fiber (24). Because they are considered a great source of nutrients, and are easily affordable, they are often recommended to malnourished patients for consumption (25).

Ready-to-use therapeutic foods (RUTFs) are energy-dense foods fortified with macronutrients such as vitamins and minerals (26). Most RUTFs are made from peanuts, sugar, oil, milk powder, vitamins, and minerals. In utilizing the benefits of RUTFs, Bechman conducted a research in Mali, and produced a recommendation of a RUTF with a composition of peanuts, cowpeas, and millet as well as rice or barley-koji, which are sources of a-amylase. It was claimed to be able to meet the energy, protein, fat, and fiber requirements of malnourished pregnant mothers (27). The results of the present study differed from a research by Ali et al., who found that 78% of pregnant and lactating women could not receive RUTF-Plumpy' nut, and that 5% rejected it, although 85% were aware that the therapeutic effects of the RUTF were good (28).

The quality test of the cookies in this study comprised the proximate test (energy, protein, fat, carbohydrate, water, and ash levels), microbiology test, and metal contamination test. *A. bicolor* cookies had an energy content of 507 kcal/100 g, compared to the MoH's biscuits that contained 500 kcal/100 g. This was derived from the carbohydrates, fats, and proteins in the cookies. Furthermore, fish is a source of energy, protein, and essential amino acids (29). Since the *A. bicolor* bone powder cookies had a high energy content of 507.37 kcal/100 g, this demonstrates that the addition of the *A. bicolor* bone powder in the cookies can increase their energy content.

Pregnant women require an increase in caloric intake of 300 kcal per day during pregnancy (30). Nevertheless, the energy needs of pregnant women are also very dependent on age, body mass index, and the types of physical activities engaged in during pregnancy. During pregnancy, there will be a 30% decrease in total protein and albumin. Therefore, to compensate for this loss, the recommended intake of protein during pregnancy is a higher 60 g/day or 1.1 g/kg body weight/day, as compared to 0.8 g/kg body weight/day for non-pregnant women (30). It was found that the protein content of the *A. bicolor* cookies was 15.7%, which is much higher than the protein in the MoH's biscuits (9.4%). Hence, the protein in the *A. bicolor* cookies can serve to increase the total intake of protein and albumin in pregnant women.

Besides that, fish consumption during pregnancy is a good choice, because fish, especially *A. bicolor*, is rich in omega-3 (31,32), which is beneficial for fetal brain development, and is associated with better vision in premature infants, as well as better cardiovascular health later in life. Aside from that, the EPA and DHA levels in *A. bicolor* bone powder were very high. The laboratory test result showed that the EPA level was 1810.6 mg/100 g, and the DHA was 7704.9 mg/100 g. These EPA and DHA levels of the *A. bicolor* cookies were much higher than the MoH's biscuits although the fat content in the *A. bicolor* cookies was lower than the MoH's biscuits.

On the other hand, many fish were also reported to have high mercury levels that is contraindicated for consumption by pregnant women (32). This is because mercury can penetrate the placental and

blood-brain barrier, and may cause an impairment in central nervous development, resulting in irreversible damages (33,34). Based on the laboratory test results, the *A. bicolor* cookies had zero mercury content. Therefore, the cookies are safe for consumption, and can be a functional food for pregnant women with chronic energy deficiency. The results of this study are in line with Giango's research in the Philippines (13), and Farzana and Mohajan's research in Bangladesh on soy flour biscuits and mushroom powders which can be used to overcome chronic energy deficiency (35).

The main parameters used in the sensory assessment of the cookies were texture, taste, aroma, and appearance of color (36). First and foremost, taste parameters are significant as they determine the acceptance of food products, and they have a high impact on a product's marketing success (35). Based on the assessment of the taste parameter of the cookies, according to the consumers of pregnant women, only cookies with the peanut formula were considered favorable. Chocolate and cheese-flavored cookies were not preferred by the pregnant women in this study. This finding was different from what was discovered in the research study by Ali et al. in Bangladesh, where 60% of the pregnant and lactating mothers rejected the taste of the peanut-based RUTF-Plumpy'nut which they considered bad (28). The acceptance of the taste of peanuts in the cookies by pregnant women in Sukabumi regency, Indonesia can be explained by the fact that peanuts are typically consumed daily as a source of vegetable protein.

The aroma assessment was also an important measure of food acceptance as it determines how good the food is (13). Based on the assessment of the consumers of pregnant women, only cheese-flavored *A. bicolor* cookies were considered fairly off-putting in aroma compared to other cookies, while peanut and chocolate-flavored cookies were well accepted. However, the results for this functional food differed from the findings of Ali et al., in which 40% of the pregnant and lactating women did not like the aroma of the RUTF-Plumpy' nut (29). Due to hormonal influences, pregnant women have a more sensitive sense of smell, and therefore, this becomes an important parameter for consideration.

The assessment of color indicated that all cookies were favored by all consumers. The addition of the *A. bicolor* bone powder and corn flour contributed to the color change favored by the consumers. The color change was influenced by the high protein content of the *A. bicolor* bone powder. The Maillard reaction, and the heating process gave the cookies their brown color when baked at high temperatures (37). The appeal in color is crucial as it is the parameter that attracts interest in food selection (13).

The sensory assessment with a multi-rater approach indicated that there was a strict preference of the pregnant women in assessing the texture of the cookies made from *A. bicolor* bone powder. Almost all consumers considered the texture aspect not fulfilled. The *A. bicolor* bone powder has a fairly distinctive texture, which brittles easily. Texture is one of the important characteristics of biscuits, and it is also one of the most important parameters that greatly affects the dough machinability, and the quality of the final product [38]. Hence, fat is often ensured to maintain the texture, softness, and quality of the biscuits (39). The combination with corn flour improved the smoothness of the cookies. Therefore, the texture of the cookies can then be accepted. The results of this study, however, differed from the Giango research, where the texture of the Bakasi (*Anguilla japonica*) cookies were accepted by the respondents because they were very crunchy (13).

Jacob and Leelavathi found that cakes containing liquid oil were relatively more dense in texture compared to bread and hydrogenated fats (40). A very important component to the density of the cookies is the ratio of the solid fat used; a low density rate means increased crispiness, and higher texture value (35). Cookies containing more *A. bicolor* bone powder could result in a positive change in texture.

The unexpected response findings informed on the meaning behind the judgments of pregnant women. However, there were only 15 unexpected responses detected, which is a very small number—only 4% from the total of 360 responses given. This means that the pregnant women in the study were very careful when judging the cookies' qualities. Another interesting finding was that there was no unexpected response about the taste parameter compared to aro-

ma, color and texture; this indicates that all the cookies were accepted well by the subjects, and they liked the taste of the cookies from *Anguilla bicolor* bone powder regardless of the flavor.

At present, research on sensory assessment has been carried out by researcher using variety of methods, but the use of multi-facet Rasch model in the assessment analysis has not been done yet. Other researcher s using CATA (check-all-that-apply) technique and the results can improve the prediction of consumer's actual foods (41).

The study has certain limitation. The sample size was small, requires further statistical analysis that can guide the formulations to measuring the impact of taste on preference. The efficacy of these prototypical formulae should also be examined through field trials. At present, the new supplementation formula is ready, safe and acceptable to be tested in advanced and large-scale experimentation to assess its effectiveness in addressing chronic energy deficiency in pregnant women in Indonesia. The advantages of this study using facet's multi-rater analysis improved the sensitivity and performance quality of the cookies with very precise information such as the logit measure, and unexpected response of judgment. The peanut cookie formula was the one which was well accepted at the research site, and all the pregnant women did not have issues with the taste parameter as shown in the unexpected response analysis.

Conclusions

Cookies which were intended to tackle chronic energy deficiency in pregnant women, using local raw ingredients, have been formulated. The utilization of *Anguilla bicolor* bone powder increased the nutritional content of the cookies. It possessed a good quality, where protein, fat, and calcium content were higher than those already on the market for pregnant women, which are approved by the government and meet the national standard. In addition, microbiology test results on the cookies showed negative in metal contamination. Hence, the cookies are feasible and safe as a functional food for pregnant women with chronic energy deficiency.

The combination of *A. bicolor* and local corn improved the quality of the cookies. The most preferred formula of *A. bicolor* cookies is the one with the additional ingredient of peanuts. Based on the results of the sensory assessments, the taste, the color, and the aroma of the cookies generated good responses.

Author Contributions

Conceptualization: DKS and DMDH; methodology: DPP; validation: DKS and BS; formal analysis: DPP and BS; writing—original draft preparation: DMDH and DPP; writing—review and editing: DKS and BS. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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