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Protein and iron source snack bar made from *Mlanding* Tempeh – A fermented *Lamtoro* (*Leucaena leucocephala*)

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Mlanding tempeh; fermented legumes; non-dairy protein; plant-based protein; supplementary feeding; male adolescents.

Mlanding Tempeh is an Indonesian fermented food made from *Lamtoro* (*Leucaena leucocephala*), a tropical legume that contains complete nutrients. The legume has high productivity and adapts well to dry climates thus serving well as a plant-based protein source in arid areas to improve the local food security. This is especially true for Indonesian male adolescents who often suffer from undernutrition. This study aimed to introduce a process to further improve the nutritional value and potential acceptance of the *Mlanding* Tempeh by developing it into a snack bar. A complete food process development and nutrient analysis were performed. Analysis of anti-nutrient content found a reduction of tannins after 24h fermentation of *Lamtoro*, from 52.11 to 4.20 (mg. tannic acid). Frying and oven-baked method was chosen for processing the Tempeh into the snack bar. Formulation with 60% *Mlanding* Tempeh, 35% red kidney beans, and 5% puffed rice had the highest acceptance and preference score. The energy and nutrients such as protein, fat, and carbohydrates content in 100 g of snack bars were 385.44 kcal, 17.62 g, 3.18 g, and 71.58 g, respectively. A 100 g of snack bar provided around 29% of the daily protein and 22.27% of iron needs for male adolescents. Hence, the *Mlanding* Tempeh snack bar can be considered a good source of protein and iron for this demography. In addition, it also has high dietary fibre.

1. Introduction

Indonesia has various legumes, one of which is *Lamtoro* (*Leucaena leucocephala*). This legume contains high protein and complete nutrients (Palupi et al., 2020; Mahmud et al., 2017; Sayudi et al., 2015). It has high productivity and adaptability to high temperatures and dry climates like the arid area of Gunungkidul, Yogyakarta, Indonesia which is prone to food insecurity (Palupi et al., 2019). However, despite its high nutrient contents *Lamtoro* also contains anti-nutritional substances which can compete with the absorption of important nutrients (Orwa, 2009; Hamid et al., 2017). Previous studies showed that the fermentation process reduces these anti-nutritional substances, increases protein digestibility, optimizes nutritional value, increases the sensory value, and improves the physical properties of the legume-based product (Sayudi et al., 2015; Nkhata et al., 2018).

Acute undernutrition indicated by wasting and severe wasting is prevalent in Indonesia. Adolescent is one of the vulnerable groups at risk of suffering from this type of malnutrition because they need greater nutrition to fulfil their rapid growth and development (Tarwoto et al., 2010). Based on the Indonesian Basic Health Research in 2018, the prevalence of wasting and severe wasting in adolescents aged 13 – 15 years

old was 8.7% while in adolescents aged 16-18 years was 8.1%. For male adolescents, their growth during this period is very rapid and their physical activities including sports are at their peak. They have a more significant peak height velocity (PHV) period (Abaci et al., 2013), twice as much muscle mass gain and a larger skeleton (Buyukgebiz, 2012), a basal metabolic rate about 10% higher than their female counterparts (Traggiai & Stanhope, 2003). Therefore, their nutrition needs as reflected in their Recommended Dietary Allowance (RDA) are greater than that of adolescent girls of the same age (RDA, 2019).

Adequate nutrition intake to fulfil nutritional needs during that accelerated growth and changes in body composition associated with puberty is pivotal (WHO & FAO, 2003). Nutrition deficiency during this phase will lead to growth and development problems (Carrasco-Luna et al., 2018). Easily accessible high-quality supplementary food can help meet the nutritional needs of this vulnerable group. Therefore, this study aimed to develop a supplementary food made from Tempeh *Lamtoro*, a local fermented legume-based food in a form of a snack bar for male adolescents. The drying methods and the ratio combination have been used as the research treatment in this study since those variables has a direct correlation with the sensory quality.

2. Materials and Methods

2.1. The process of making *Mlanding* Tempeh

Mlanding Tempeh was made based on a procedure adopted from *Mlanding* Tempeh craftsmen in Gunungkidul, Yogyakarta. The original process uses wild *Lamtoro* collected from the forest which is then fermented using a traditional yeast derived from cassava flour and dried teak leaf slices (R. oligosporus). Whilst the *Mlanding* Tempeh in this study was produced using *Lamtoro* planted in three regions in Bogor, West Java, and fermented using branded yeast "Raprima". The Tempeh was produced through the following stages: sorting the *Lamtoro* seeds, washing, soaking the seed for 24 hours (water : seed = 2:1; ambient temperature), peeling the epidermis, boiling the peeled seed for three hours, draining to room temperature, inoculating the seed with yeast (seed : yeast = 1:1), packing using teak leaves (6 cm x 7 cm x 4 cm), and incubating at 27-29oC for 48 hours (anaerobic, dark).

2.2. The process of making the snack bar

The main ingredients for the snack bar were *Mlanding* Tempeh, red kidney beans, puffed rice, and binding materials like melted sugar, oil, and water. The Tempeh and red kidney beans were dried prior to the making of the snack bar in order to remove the moisture of Tempeh and prolong its shelf life. Two types of drying methods i.e., deep fat frying (140oC, 7 min, modified from Amalia et al., 2015) and oven baking (900C, 45 min, Nauli et al., 2006) were applied for this process. While the red kidney bean was dried using roasted-puffing methods (90oC, 45 min, Dwijayanti, 2017). The formulation and process were adapted from a modified snack bar recipe from Ahmad et al. (2017). Previous research showed that the use of puffed rice in the snack bar formulation improves its texture and compactness since it has a better density and bonding ability (Jauhariah & Ayustaningwarno, 2013). Thus, we added puffed rice to our formulation. The ingredients and binding materials were mixed evenly distributed and then formed into a bar shape (printed by using a square mould). The formulations were developed through various trials with different types of Tempeh drying methods (b: baked and f: fried) and different ratios of *Mlanding* Tempeh and red kidney beans used. The final formulations for further evaluation were chosen based on the result of the minimum and maximum use of *Mlanding* Tempeh based on the quantity of limiting amino acids (lysine and sulfur amino acids). The four formulations were further evaluated namely, Fb 50:45, Fb 60:35, Ff 50:45, and Ff 60:35, see Table 1.

2.3. Sensory, nutrient, and anti-nutrient evaluation

The sensory evaluation was performed using an acceptance test (ISO 6658). The content of tannin was measured using the spectrophotometric method (Mukhriani, 2014). While the nutrient content was assessed using proximate analysis such as the following: moisture and ash – gravimetric method (AOAC method 925.10 and 923.03), protein - Foss Tecator Kjeltec 200 method (AOAC method 955.04), fat - Soxhlet method (AOAC method 920.39), carbohydrate - by difference, dietary fibre - enzymatic method (AOAC Method 994.13), and iron - Atomic Absorption Spectroscopy (Sulaeman et al., 1995).

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Table 1. Formulations of snack bars made from Mlanding Tempeh and red kidney beans

Ingredients	Unit	Fb 50:45	Fb 60:35	Ff 50:45	Ff 60:35
Mlanding Tempeh (Baked)	gram	50	60	-	-
Mlanding Tempeh (Fried)	gram	-	-	50	60
Dry red kidney beans	gram	45	35	45	35
Puffed rice	gram	5	5	5	5
White sugar	gram	15	15	15	15
Water	gram	1	1	1	1
Coconut oil	gram	1	1	1	1

Note: F: Formulation, Fb 50:45, formulation with baked *Mlanding* Tempeh with ratio 50 to 45 between *Mlanding* Tempeh and red kidney beans; Fb 60:35, formulation with baked *Mlanding* Tempeh with ratio 60 to 35 between *Mlanding* Tempeh and red kidney beans; Ff 50:45, formulation with fried *Mlanding* Tempeh with ratio 50 to 45 between *Mlanding* Tempeh and red kidney beans; and Ff 60:35, formulation with fried *Mlanding* Tempeh with ratio 60 to 35 between *Mlanding* Tempeh and red kidney beans.

2.4. Experimental design

This study was performed using a completely randomized design. The number of replications was three batches of the formulation. There was twice an analysis per batch of samples. The data were processed using Microsoft excel for windows 2010 and analysed using SPSS 16. A parametric test using an independent sample t-test and analysis of variance was conducted to evaluate the treatment effect. The data was interpreted as significantly different if the p-value < 0.05.

3. Results

3.1 Anti-nutritional content of tannins

Poor digestibility and utilization of protein from legumes are often associated with its tannins content. There was a significant difference in tannin content between *Lamtoro* seeds and *Mlanding* Tempeh (p> 0.05) as shown in Table 2. The tannin content in *Lamtoro* legume reduced by 91.94% after fermentation into Tempeh from 52.11 to 4.20 mg tannic acid/g.

3.2. Sensory evaluation

The acceptance test with 9 hedonic scales showed significant differences between formulations based on the snack bars' six attributes (p> 0.05). There were six attributes assessed in this study including colour, texture, flavour, taste, aftertaste, and overall. The details of sensory evaluation results are presented in Table 3. The level of preference for panellists in snack bar products ranges from neither or dislike to like. The acceptability analysis based on different Tempeh drying methods showed that the attributes of taste, aftertaste, and overall attributes in the baked Tempeh were preferred. The baked *Mlanding* Tempeh when combined with dry red kidney beans and puffed rice had the more preferred taste and a neutral aftertaste compared to the taste of the snack bar made from fried *Mlanding* Tempeh because of the oily taste and aftertaste. This was implied from the open question gathered from the respondents during the sensory evaluation.

3.3. Nutrition content of *Mlanding* Tempeh snack bar

Table 4 presents the result of proximate analysis, dietary fibre, and iron content of selected snack bar formulations namely Fb 60:35 and Ff 60:35. The moisture content in the selected snack bars were 4.85 and 5.76 (%wb), respectively. The difference in moisture content occurred due to different types of drying processes used for the *Mlanding* Tempeh preparation. In this study, *Mlanding* Tempeh was dried using a baking or frying technique. The fat content in the fried formulation was higher than in the baked one. Moreover, the protein content of the baked formulation was higher than the fried formulation, i.e., 18.63 and 15.88 (% db).

Table 2. Tannin content of *Lamtoro* legume and *Mlanding* Tempeh

Sample	Anti-Nutritional Substances (mg tannic acid/g)
Lamtoro legume	52.11±1.99[b]
Mlanding Tempeh	4.20±0.37[a]

Note: different superscript indicates significantly different at p <0.05, was evaluated using paired t-test.

Table 3. Sensory acceptance of snack bar products made from Mlanding Tempeh

Attribute	Formulation			
	Fb 50:45	**Fb 60:35**	**Ff 50:45**	**Ff 60:35**
Colour	5.11±1.13[a]	4.91±1.04[a]	5.42±1.09[b]	5.20±1.09[ab]
Texture	5.07±1.34[a]	5.28±1.12[a]	5.53±1.26[ab]	5.85± 0.97[b]
Flavour	5.46±1.06[a]	5.38±1.16[a]	5.45±0.93[a]	5.64±0.95[a]
Taste	5.72±1.10[b]	6.00±0.84[b]	5.43±1.20[a]	5.66±0.83[ab]
Aftertaste	5.26±1.54[b]	5.47±1.23[b]	4.91±1.25[a]	5.38±1.44[a]
Overall	5.74±1.08[b]	6.01±0.80[b]	5.24±1.39[a]	5.62±1.34[a]

Note: F: Formulation, Fb 50:45, formulation with baked *Mlanding* Tempeh with ratio 50 to 45 between *Mlanding* Tempeh and red kidney beans; Fb 60:35, formulation with baked *Mlanding* Tempeh with ratio 60 to 35 between *Mlanding* Tempeh and red kidney beans; Ff 50:45, formulation with fried *Mlanding* Tempeh with ratio 50 to 45 between *Mlanding* Tempeh and red kidney beans; and Ff 60:35, formulation with fried *Mlanding* Tempeh with ratio 60 to 35 between *Mlanding* Tempeh and red kidney beans; different superscript in one line indicates significant difference at p <0.05, evaluated using analysis of variance.

3.4. Contribution of *Mlanding* Tempeh snack bar to Recommended Dietary Allowance (RDA) for male adolescent

The study aimed to develop easy-to-access as well as nutritious supplementary food for male adolescents. Previous stages have shown that the selected formulation was Fb 60:35, thus contribution to RDA in this section refers to this product. The serving size of the snack bar, i.e., 35 g, was determined by assuming the ability to consume it at each meal or at snack time. The contribution of nutrient content in the snack bars per serving compared to the Indonesian RDA for male adolescents was divided into 3 age groups. The nutritional claims based on the comparison to the RDA are presented in Table 5.

In regard to macronutrient contribution based on the RDA for Indonesian male adolescents in the three age groups, one serving, or 35 grams of *Mlanding* Tempeh snack bar contributes to 5.09-6.74% of the total daily energy needs and 8.21-12.32% of daily protein intake. The fat and carbohydrates contribution for one serving ranged from 1.30-1.70% and 6.26-8.34%, respectively. The macronutrient content in 100 g serving size is 385.44 kcal for energy, protein is 17.62 g, fat is 3.18 g, and carbohydrate is 71.58 g. Claims of protein and dietary fibre sources in the *Mlanding* Tempeh snack bar refer to government regulations based on the 2016 nutritional label reference (ALG). According to the percentage of the Nutrition Label Reference Indonesia (ALG), the protein source is not less than 20% ALG per 100 g, the iron source is not less than 15% ALG per 100 g and dietary fibre is not less than 6 g per 100 g (in solid form).

3.5. Comparison of *Mlanding* Tempeh snack bars with other commercial snack bars

The following table presents the comparison of the nutritional content and dietary fibre of the *Mlanding* Tempeh snack bar with other commercial snack bars available in the market. (Table 6)

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Table 4. The content of macro-nutrients, dietary red kidney bean and iron in selected snack bar

Nutrient parameters	Unit	Snack bar (Baked) Fb 60:35	Snack bar (Fried) Ff 60:35
Moisture	(%)	5.42±0.06[b]	4.63±0.03[a]
Ash	(%db)	2.32 ±0.02[a]	2.27±0.02[a]
Fat	(%db)	3.37±0.02[a]	9.58±0.11[b]
Protein	(%db)	18.63±0.05[b]	15.88±0.20[a]
Carbohydrate	(%db)	75.68±0.06[b]	72.27±0.15[a]
Dietary red kidney bean	(%db)	35.68±0.08[a]	35.84±0.01[b]
Iron	(mg)	4.90±0.02[a]	5.65± 0.01[b]
Digestibility protein in-vitro	(%)	99.76[a]	99.70[a]

Note: Different superscript in one line indicates significantly different at p <0.05, was evaluated using paired t-test.

Table 5. Contribution of nutrition content of Mlanding Tempeh snack bar to RDA and nutrition claims

Nutrient	Nutrition content per serving size (35 g)	Nutrition content per 100 g	Contribution of macro nutrients (%) to adolescent male age- (y.o.)			Nutritional Claims
			10-12	13-15	16-19	
Energy (kcal)	134.90	385.44	6.74	5.62	5.09	-
Protein (g)	6.16	17.62	12.32	8.80	8.21	Source of protein
Fat (g)	1.11	3.18	1.70	1.38	1.30	Low fat
Carbohydrate (g)	25.04	71.58	8.34	7.15	6.26	-
Dietary fibre (%)	11.80	22.73	42.14	34.70	31.89	High
Iron (mg)	1.71	4.90	21.37	15.54	15.54	Source of iron

4. Discussion

4.1. Anti-nutritional content of tannins

Tannins are a polyphenol compound commonly found in legumes that can form complex bonds with proteins. The presence of these complex bonds causes the protein to be difficult to break down into amino acids. The presence of tannins also inhibits protease activity (Bakti, 2003). Thus, tannins lower protein digestibility (Suarni, 2012). Our study found that the fermentation process in making the *Mlanding* tempe lowers the tannin content in *Lamtoro* legume by 91.94%, from 52.11 to 4.20 mg tannic acid/g. This result is in line with previous findings from Bakti (2003) on the tannin content in fermented *Lamtoro* legumes. The decrease in tannins could be due to the presence of the enzyme tanase produced by the yeast Rhyzopus oligosporus (Koni et al., 2013). The enzyme tanase or tannin acyl hydrolase (EC, 3.1.1.20) is known as a catalyst in the hydrolysis reaction of gallic acid ester bonds (Aguilar et al., 2007). In addition to fermentation, immersion in water, and alkaline, mechanical means of heating can also reduce the effect of tannins (Ma'ruf, 2005). According to Bakti (2003), the dissolution of tannin components in water can be seen in the brownish colour of the immersed water.

4.2. Sensory evaluation

The results from the hedonic test can be taken into consideration to determine the best formulation for the food product (Munir et al., 2018). According to Lestari et al. (2018), the type of drying can affect the

Table 6. Comparison of nutrients and dietary fibre content of *Mlanding* Tempeh snack bar with Commercial Snack Bars

Snack bar products	Weight (g)	Energy (kkal)	Protein (g)	Fat (g)	Carbohydrate (g)	Dietary fibre (g)	Price (USD)
Zee Cereal Bar	20	90	2	2.50	15	1	0.24
Fitbar	25	110	3	5.00	16	1	0.29
Milo Chocolate Milk Snack Bar	21	86	1	2.70	14	2.1	0.41
Protein Bar L-Men	22	100	3	3.00	15	1	0.39
Heavenly Blush Tummy Yogurt Bar Berries	25	90	2	2.50	15	4	0.54
Granobar Granola Bars	35	160	3	6.00	24	4	0.64
Soyjoy Almond Chocolate	30	160	5	10.00	12	0	0.85
Soyjoy Crispy	30	120	6	6.00	10	3	0.63
Snack Bar Formulation Fb 60:35	35	134.90	6.16	1.11	25.05	11.80	0.10
Snack Bar Formulation Ff 60:35	35	146.48	5.30	3.19	24.12	11.96	0.11

Note: F: Formulation, Fb 60:35, formulation with baked *Mlanding* Tempeh with ratio 60 to 35 between *Mlanding* Tempeh and red kidney beans; Ff 60:35, formulation with fried *Mlanding* Tempeh with ratio 60 to 35 between *Mlanding* Tempeh and red kidney beans

sensory parameters of the product, especially the taste and flavour produced. There were six attributes assessed in this study namely colour, texture, flavour, taste, aftertaste, and overall. A comparison of attributes acceptance for products with a maximum proportion of 60% *Mlanding* Tempeh and 35% kidney beans showed that the fried Tempeh was preferred for colour and texture compared to the baked formulation. The colour of the fried *Mlanding* Tempeh appeared more homogenous (Kateren, 2008; Wihandini et al., 2012) and the texture was crisper (Zahra et al., 2013) than the baked one. However, based on the attributes of taste, aftertaste, and overall attribute the baked formulation was preferable. Therefore, the baked formulation was chosen for further analysis.

In regard to the proportion of *Mlanding* Tempeh and red kidney beans used, our result showed that the more the use of *Mlanding* Tempeh and the less the red kidney beans produced a more preferable texture, taste, aftertaste, and overall attributes quality. According to Dwijayanti (2017), the use of up to 40% dry red kidney bean content in the snack bar formulation produces good characteristics of taste and texture. According to Nurlita et al., (2017) red kidney bean flour has a stronger distinctive taste. Therefore, a higher amount of red kidney beans used causes a more distinctive taste of beans which is often disliked by panellists. In addition, red kidney beans produce an unpleasant odour due to the presence of the lipoxygenase enzyme which naturally gives the nuts their special flavour (Pertiwi et al., 2017). In this study, the red kidney beans used were dried red kidney beans this was in order to reduce the unpleasant taste and flavour. Moreover, dried kidney beans have a hard and crunchy texture (Kurnianingtyas et al., 2014) The starches content in red kidney beans consists of amylose and amylopectin which is important for gelatinisation process, causing the hard and crunchy texture (Rohma, 2013). While the amylopectin content increases the crispness (Santoso et al., 2007).

4.3. Nutritional content of *Mlanding* Tempeh snack bar

Currently, people are more interested in consuming healthier foods to maintain health (Lin et al., 2010). This leads to the development of healthier snack op-

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tions. Snack bars made from legumes are considered a reliable source of high-quality protein, dietary fibre, vitamins, and minerals (da Silva et al., 2014). Champ et al., (2003) reported that an increase in daily dietary fibre consumption is associated with disease prevention, especially digestive diseases, energy balance problems, cancer, heart disease, and diabetes.

Comparison of moisture content from fried and baked methods differed significantly, it was 4.85 (%wb) and 5.76 (%wb) respectively. The difference in moisture content in the snack bar formulation occurs due to different types of processing in *Mlanding* Tempeh. According to Sundari et al., (2015) during frying, there is a mass heat transfer of oil to the surface of the material and propagates inward so that the water content of the material comes out as water vapor and then the material absorbs oil. The presence of water evaporation during heating with the deep-frying method causes the water content to decrease and the concentration of solids increases (Sosa-Morales et al., 2006).

The ash content analysis between the two processing methods was comparable, 2.27 and 2.31 (% db) respectively. Gall et al., (1983) reported no change in mineral composition in fish containing high fat after grilling or frying. According to Jacoeb et al. (2008) the ash content in fried foodstuffs is depending on the time and temperature of the frying pan used. During frying, the increase in ash content in food is mostly attributed to the loss of moisture caused by high temperatures.

The fat content in the fried formulation was higher than the baked one, this was due to cooking oil being absorbed during the frying process (Susanty et al., 2019). Some of the oil occupies the empty space in foodstuffs that were previously filled with water. In the final stage of frying, oil is also absorbed via capillary action as a vacuum form in the material. Further, during the cooling stage after frying the condensation of moisture accelerates the absorption of oil into the product (Thomas, 2007).

The protein content was found significantly higher in the baked formulation compared to the fried one 18.63 vs 15.88 (% db). According to Sundari et al., (2015) during frying, protein levels can decrease due to the higher temperature used. Similar to the protein analysis, the carbohydrate content was significantly higher in the baked formulation. The carbohydrate content for each sample was 72.27 and 75.68 (% db) for the fried and baked formulations respectively. Inocentet al., (2011) stated that different types of heating cause different changes in nutrient content including glucose.

Carbohydrate content in the baked formulation was significantly higher, each sample was 72.27 and 75.68 (% db). According to Inocent et al., (2011) differences in carbohydrate content due to different types of drying. Food processing by heating will affect the levels of nutrients including glucose. The reactions that occur in sugar, either with reactions in the form of changes in carbohydrates themselves without the presence of other compounds or changes in carbohydrates (reducing sugars) as their interactions with amino compounds (Maillard reaction). Especially during heating, the higher temperature (650C) will further accelerate the Maillard reaction, thereby reducing the availability of sugars and proteins (amino acids) and consequently decreasing glucose levels (Indradewi 2016).

The red kidney bean content was significantly lower in the baked formulation, 35.84 vs 35.68 (% db). The structure, physicochemical properties, and effects of diet are easily influenced by food processing (Zhang et al., 2011). When Tempeh is fried, the starch changes. Gelatine starch granules rapidly change upon contact with hot oil. T Structure of the Tempeh changes and becomes soft after 1-2 minutes of frying. Then upon further heating, the texture of the Tempeh becomes crispy and hard on the surface (Boskou & Elmadfa 2010). Compared to the oven baking process, the resistant starch in fried Tempeh significantly increased in part due to the formation of the amylose lipid complex (Asp & Bjorck 1992). At higher temperatures, drying food red kidney beans can reduce some components of soluble dietary fibre (SDF) and change its hydration properties and fat adsorption capacity (Garau et al., 2007). High temperatures break the glucosidic bonds in polysaccharides which can cause the release of oligosaccharides and thereby increase the amount of SDF (Wolf 2010).

The iron content in the fried formulation was significantly higher compared to the baked formulation,

5.65 vs 4.90 (mg) respectively. The difference in iron levels can be associated with cooking factors, namely the temperature and cooking time (Astuti et al., 2014). The decrease in minerals ranged from 5-40%, for iodine, calcium, selenium, zinc, and iron due to these factors. In particular, a decrease in iron was experienced in foods that were heated at a temperature of 1600C (Omoruyi et al., 2007).

The highest protein digestibility in both formulations was comparable with the value for the oven method treatment was 99.76%, while in the fried formulation the protein digestibility value was 99.70%. According to Wolfe et al., (2016) the higher the digestible protein, the better the quality of the protein in the ingredients. The frying and baked method might cause a decrease in digestibility as the cooking time increases. The protein oxidation and the changes of NH2 may greatly affect the protein digestibility of cooked food (Tavares et al., 2019).

4.4. Contribution of *Mlanding* Tempeh snack bar to RDA for male adolescents and the nutrition claims

The snack bar can be consumed along with each mealtime or in between meals. According to the Indonesian guidelines for balanced nutrition, it is recommended to consume healthy snacks, three times a day or in a total of around 95 grams of snack bars per day divided into 2 – 3 pieces of snack bars. The energy, protein, fat, and carbohydrate content of the 100 g snack bar were 385.44 kcal, 17.62 g, 3.18 g, and 71.58 g, respectively. Hence, the protein content per 100 g of the snack bar meets about 29% of the RDA for Indonesian male adolescents in the three age groups. Based on the Indonesian National Food and Drug Agency (2016) it can be claimed as a protein source food because it can meet more than 20% of protein needs reflected in the RDA or 12 g protein / 100 g. In addition, the snack bars can also be considered as high in dietary fibre because based on the National Food and Drug Agency in Indonesia (2016) a product is said to be high in dietary fibre if it contains 6 g of dietary fibre in 100 g of product. Based on the iron analysis, the snack bar was also able to meet about 22.27% of the RDA for iron. Thus, it can also be claimed as a food source for iron.

4.5. Comparison of *Mlanding* Tempeh snack bar with other commercial snack bars

In Indonesia, there are many types of snack bars made from various ingredients. *Lamtoro* is similar to soybeans because it contains almost the same nutritional value. *Lamtoro* legumes and kidney beans have a fairly high protein and carbohydrate content of around 25-30% for protein and 50-60% for carbohydrate respectively. In addition to *Lamtoro* legume, the other main ingredient used was puffed rice which is a cereal ingredient. Based on this similarity, several soybeans-based commercial products were chosen as a comparison, The *Mlanding* Tempeh snack bar products had many similarities with commercial products in terms of physical appearance and texture. However, based on the nutritional value, this *Mlanding* Tempeh snack bar contained higher protein, fibre and iron, but lower price compared to other commercial snack bars.

5. Conclusions

This paper presents a study introducing an effort to process the *Lamtoro* legumes into a snack bar which has better acceptance and nutritional value for male adolescents. A complete food process development and nutrient analysis resulted in the best formulation for development was 60% of *Mlanding* Tempeh and 35% red kidney beans. Analysis of anti-nutrient content showed a reduction of tannin after 24h fermentation of *Lamtoro* into Tempeh from 52.11 to 4/20 (mg tannic acid/g). Based on the flavour, after taste, and overall attributes, the formulation using *Mlanding* Tempeh dried with the oven-baked method was more acceptable. The energy, protein, fat, and carbohydrate content in 100 g of the selected snack bars were 385.44 kcal, 17.62 g. 3.18 g and 71.58 g, respectively. The protein and iron content per 100 g of the snack bar is able to meet around 29% and 22.27% of the RDA of each nutrient for male adolescents respectively. Thus, it can be claimed as a food source of protein and iron. In addition, the *Mlanding* Tempeh snack bar is also high in dietary fibre content which is considered an added health benefit.

Conflict of Interest

The authors declare no conflict of interest. In addition, the funding organization had no role in the design of the study; in the data collection, analyses, or interpretation of data; in the writing of the manuscript, as well as in the decision to publish the results.

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