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Characteristics of High Protein Snackbar Made of Modified Sweet Potato Flour

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***Abstract*— MOSEP (Modified Sweet Potato) flour that made of sweet potato is potentially used as an emergency food due to its high content of carbohydrate. Snack bar becomes an option of emergency food form because practical in its preparation and serving. Mung beans flour and commercial WPC (whey protein concentrate) were added to produce a new food product that high in protein content of at least 10 – 15% to meet emergency food requirements. The objective of the study was to obtain a proper formulation between MOSEP composite flour and mung beans flour by adding 5% commercial WPC in the making of snack bar emergency food. The method used in the study was Randomized Block Design consisting of four treatments and three repetitions. The treatments were the ratio of MOSEP flour: mung beans flour, 70:30; 65:35; 60:40 and 55:45. Results showed that the best formulation was the treatment of MOSEP flour: Mung beans flour 55:45, having characteristics of 13.96% protein content, 3.45% raw fiber, 120.23 kkal/30 gram calorific value, 2255.93-gF hardness, 94.53% rendement and organoleptic tests of preference, color, flavor, and aroma were accepted.**

***Keywords*— formulation; MOSEP; protein; sweet potato; modified sweet potato.**

I. INTRODUCTION

Fermented flour is a flour product, processed by modifying cells through fermentation that involving bacteria [1]. The growing microbe produces pectinolytic and cellulolytic enzymes that can damage the cell wall of the tuber in such a way that the liberation of starch granules results in a characteristic change in the resulting flour in the form of increased viscosity, gel ability, rehydration and ease of solubility [2]. Fermentation techniques in the flour production generally use lactic acid bacteria or enzymatic, due to its ability to degrade sugars contained in the growth medium into simple sugars and can degrade proteins and peptides to lactic acid. Moreover, lactic acid produced by lactic acid bacteria gives flavor and aroma [1].

MOSEP (modified sweet potato) flour is a kind of fermented flour that uses lactic acid bacteria of *Lactobacillus casei Sp.* as the modifying agent. Physical and chemical changes are expected in order to obtain flour with a better appearance, whiter, softer and having lactic acid aroma compared with unmodified sweet potato. Its high carbohydrate content makes MOSEP potentially used as raw material for emergency food. As it is stated [3], emergency food is a kind of food that produced to fulfill daily need food consumption, of at least 2100 kcal, coming from 10% – 15% protein, 35% – 45% fat and 40% – 60% carbohydrate in an emergency.

A snack bar is a form of food that can become an option of emergency food due to its practical, easy preparing and easy consuming. Commonly, the snack bar is made of soya bean flour, other nutritious or non-nutritious material, dried fruits of bar-shaped, having a dry, and fine of outer texture, and a hard, compact, slightly chewy of inner texture [4].

MOSEP flour can be used in the making of the snack bar, however, due to its low protein content; MOSEP needs to be added by mung beans that are known as a good source of vegetal protein, containing about 20.97% – 31.32% [5]. Protein content in mung beans occurs in the form of essential amino acids such as leucine, isoleucine, phenylalanine, valine, and lysine. Apart from mung beans, the addition of commercial WPC (whey protein concentrate) as much as 5% is expected to produce a final product with a high protein content that meets the requirements of emergency food.

The study on the use of composite flour of MOSEP, mung beans and commercial WPC in the making of the snack bar, has never been carried out previously. Therefore, the study will determine the appropriate ratio between the components to produce a snack bar with the best characteristics by the criteria.

II. Materials and Method

A. Materials

Materials used in this study are white sweet potato with four months old harvesting age obtained from a traditional market, *Lactobacillus casei Sp.*, mung beans, commercial WPC, cooking oil, lecithin, honey, vanilla syrup, salt, raisins, and water. Consumables for analysis consisted of distilled water, hexane solvents, HCL 0.02 N, K_2SO_4 10%, HgO, saturated H_3BO_3 solution, NaOH-NaS_2O_3 solution (60:5), concentrated H2SO4 solution, methyl red and blue indicator, NaOH 0.313 N, and alcohol 95%. Analytical tools used consisted of standard laboratory equipment provided with texture analyzer.

B. Method

The research method used was Randomized Block Design (RBD), consisting of four treatments and three replications. The treatments were a variation of the ratio between MOSEP composite flour and mung beans. The treatment was as follows:

A = MOSEP flour: mung beans flour 70: 30
B = MOSEP flour: mung beans flour 65: 35
C = MOSEP flour: mung beans flour 60: 40
D = MOSEP flour: mung beans flour 55: 45

Test at 5% level was to determine the presence of diversity between treatments, if Fh ≤ F0.05 then there is no diversity between treatments, whereas if Fh > F0.5, then there is a difference between treatment, then followed by Duncan test of Multiple Distance Different Test at 5% level (LSR Test) to determine the difference of influence between treatment. The illustration of the procedure of snack bar making is displayed in Figure 1.

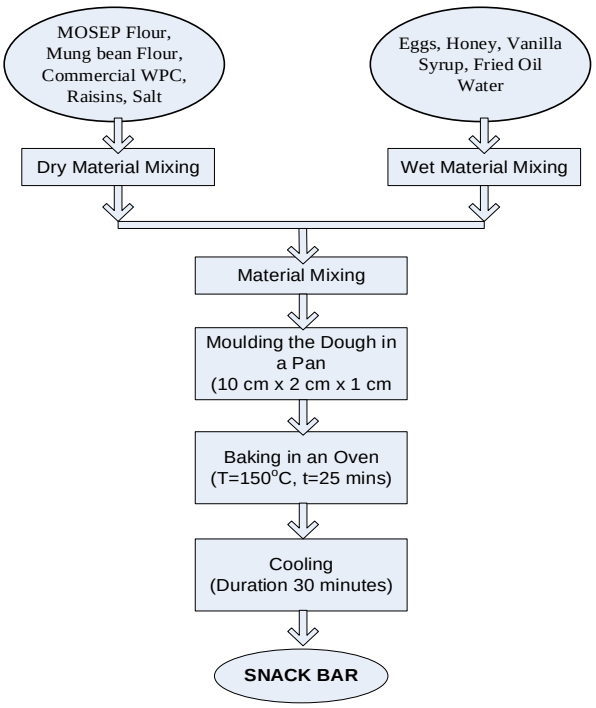

Fig. 1. Snack Bar Making Process

III. Results and Discussion

Characteristics of the resulted snack bar were based on chemical and physical analyses for the parameter of protein content, raw fiber content, calorific value, hardness, and yield. Color, flavor, and aroma preferences also performed the organoleptic test.

A. Protein Content

The following table describes the analytical result of the different formulation between MOSEP flour and Mung bean flour on the protein content of the snack bar produced.

TABLE I
The Influence of Formulation of MOSEP Flour and Mung bean Flour with the Addition of 5% Commercial WPC on Protein Content of Snack Bar.

Treatment	Average Value of Protein Content* (%)	Protein Content of Emergency Food
A: MOSEP Fl.: Mung bean Fl. 70 : 30	12.38 ± 0.045d	10 – 15**
B: MOSEP Fl.: Mung bean Fl. 65: 35	12.92 ± 0.036 c	
C: MOSEP Fl.: Mung bean Fl. 60: 40	13.50 ± 0.007 b	
D: MOSEP Fl.: Mung bean Fl. 55: 45	13.96 ± 0.055 a	

Note: *Average Values ± Standard Deviation
**Zoumas et al. (2002)
The average value marked with the same letter shows no significant difference at 5% level of the Duncan test.

A significant difference of influence occurred between each treatment, where the more mung beans, the higher the protein content of the snack bar will be. The test results showed that treatment D (MOSEP flour: mung bean flour = 55: 45) it has a higher protein content than other treatments. This happens since the mung bean flour has a high protein content of 22.2% [6], and the addition of commercial WPC that has a protein content of 9.70 g in 100 g, based on the protein analysis calculation of micro *Kjeldahl* method.

The protein content of mung bean flour and commercial WPC was higher than MOSEP flour (5.73%), as a result of the calculation analysis with micro *Kjeldahl* method, so that, the mixing process of MOSEP composite and mung beans with the addition of 5% commercial WPC in the dough can increase the protein content of the resulting snack bar. Among other vegetable products, nuts have a relatively high protein content because nuts have a significant role in the fulfillment of protein in the community menu.

Factors that may affect the decrease in protein levels are caused by the deterioration of the functional properties of proteins in the roasting process of Maillard Reaction [6]. Maillard's reaction occurs because of the reaction between aldehyde groups of reducing sugars with amino groups from amino acids [7]. The decrease in protein content is due to lysine and cysteine undergoing damage resulting from reacting with carbonyl and aldehyde compounds, the decrease in the availability of amino acids, and the formation of volatile compounds, which are volatile or lost.

B. Raw Fiber Content

Based on statistical data, between the treatment of composite flour of MOSEP and mung bean flour with 5%

addition of commercial WPC showed a significantly different effect on the fiber content of the snack bar. Resulting data of the analysis is displayed in Table 2.

TABLE II
THE INFLUENCE OF FORMULATION OF MOSEP FLOUR AND MUNG BEAN FLOUR WITH THE ADDITION OF 5% COMMERCIAL WPC TO RAW FIBER CONTENT OF SNACK BAR

Treatment	Average Value of Fiber Content* (%)
A: MOSEP Flour: Mung bean Flour 70: 30	2.17 ± 0.074 c
B: MOSEP Flour: Mung bean Flour 65: 35	2.37 ± 0.070 b
C: MOSEP Flour: Mung bean Flour 60: 40	2.84 ± 0.161 b
D: MOSEP Flour: Mung bean Flour 55: 45	3.45 ± 0.212 a

Note: * Average Values ± Standard Deviation
The average value marked with the same letter shows no significant different at 5% level of the Duncan test.

Treatment A and B did not have any significant different influence as well as between treatment B and C, however there was a significantly different influence between treatment of A,C and D. Raw fiber content ranges from 2.17 to 3.45%, with treatment D being the greatest due to more mung bean flour added than other treatment. Mung bean flour has 4.4% raw fiber content, whereas MOSEP flour contains around 3.42% based on raw fiber analysis so that the more mung bean flour is added, the more raw fiber is contained in the resulted snack bar. Fiber is a component of lignin that belongs to polysaccharide carbohydrate [8]. Raw fiber is composed of cellulose, pectin, hemicellulose, gum and lignin which will be damaged by high temperatures in the roasting process [7]. High temperatures lead to the breakdown of polysaccharide chain bonds into simple sugars; the glycosidic bonds in the fibers are also damaged so that the use of high temperatures will lower the fiber content in the resulting snack bar.

C. Calorific Value

Statistical test between treatments of composite flour of MOSEP and mung beans with commercial WPC addition of 5% showed that there is a significantly different influence on the calorific value of the resulted snack bar. The result can be seen in Table 3.

TABLE III
THE INFLUENCE OF FORMULATION OF MOSEP FLOUR AND MUNG BEAN FLOUR WITH THE ADDITION OF 5% COMMERCIAL WPC TO THE CALORIFIC VALUE OF SNACK BAR

Treatment	Average of Calorific Value* (kcal/30 gr)	Calorific Value of Commercial Snack Bar** (kcal/30 gr)
A: MOSEP Fl.: Mung bean Fl. 70: 30	128.99 + 1.553 a	140**
B: MOSEP Fl.: Mung bean Fl. 65: 35	124.66 ± 1.390 b	
C: MOSEP Fl.: Mung bean Fl. 60: 40.	121.67 ± 0.315 cb	
D: MOSEP Fl.: Mung bean Fl. 55: 45	120.23 ± 1.112 c	

Note: *Average Values ± Standard Deviation
** Otsuka Amerta Indah Company (2012)
The average value marked with the same letter shows no significant difference at 5% level of the Duncan test.

A significant difference effect between each treatment, where the more the addition of mung beans, the lower the calorific value of the resulting snack bar. The analysis results showed that the treatment D (MOSEP flour: mung bean flour = 55: 45) has a lower caloric value compared with other treatments. It is because mung bean flour has a lower calorific value of 345 kcal/100 g [8], compared with the calorific value of MOSEP flour and commercial WPC of 363,6 kcal/100 g and 531.5 kcal/100 g respectively, by using boom calorimeter testing.

Carbohydrates are the main source of calories although the number of calories that can be produced by 1 gram of carbohydrate is only four Kal (kcal) when compared to protein and fat [9]. Formulation with a larger ratio of mung bean flour will result in a lower calorific value of snack bar; this is because the carbohydrate content of mung beans is 62.9% [10], lower than those of MOSEP flour of 90.7514% [11]. The calorific value can also be affected by the amylopectin content of the ingredients. Amylopectin has a branch and the number of monomers more than amylose so that in order to break amylopectin, it requires higher energy [8]. Starch content of mung bean flour is 31.1%, whereas the amylopectin content is 71.2% [11]. The starch content of MOSEP flour is equal to 68,04% with amylopectin content of 45,39% [11], so that the more mung bean flour is added, then the calorific value produced will be lower. Another factor that affects carbohydrate levels is the roasting process. The effect of roasting on carbohydrates is related to the occurrence of hydrolysis that will cause gelatinization of starch, and it will increase the ability of digestion [7].

An increase in the ability of digestion will increase the calorific value. The high calorific value of the resulting snack bar was influenced by ingredients added to the snack bar formulation, including honey that is having a calorific value of 294 kcal/100 g, vanilla syrup has a calorific value of 217 kcal/100 g, coconut oil has a calorific value of 763 kcal/100 g (Directorate of Nutrition, Department of Health of Republic of Indonesia, 2004). [12]

D. Hardness

Based on the statistical test result between treatments of composite flour of MOSEP and mung beans with commercial WPC addition of 5%, there is a significantly different effect occurred on the hardness level of the resulting snack bar (Table 4).

TABLE IV
THE INFLUENCE OF FORMULATION OF MOSEP FLOUR AND MUNG BEAN FLOUR WITH THE ADDITION OF 5% COMMERCIAL WPC TO THE HARDNESS LEVEL OF SNACK BAR

Treatment	Average Value of Hardness Level* (gF)	The hardness of Commercial Snack Bar (gF)
A: MOSEP Fl.: Mung bean Fl. 70: 30	1861.03 ± 22.883 d	3936.39
B: MOSEP Fl.: Mung bean Fl. 65: 35	1961.08 ± 12.318 c	
C: MOSEP Fl.: Mung bean Fl. 60: 40.	2083.24 ± 11.654 b	
D: MOSEP Fl.: Mung bean Fl. 55: 45	2275.16 ± 56.761 a	

Note: *Average Values ± Standard Deviation
The average value marked with the same letter shows no significant different at 5% level of the Duncan test.

A significant different effect between each treatment, where the more mung bean flour is added, the higher the hardness of the resulting snack bar will be. Hardness in bakery products tested by penetration testing with 2000 – 4000 gF values, indicates that the product has a hard texture (Stable Micro System, 2000). The snack bar was a hard texture food but the hardness was lower than the commercial snack bar. This low hardness value indicates that this snack bar was accepted for the children. The hardness of the snack bar also shown in the Figure 2 below.

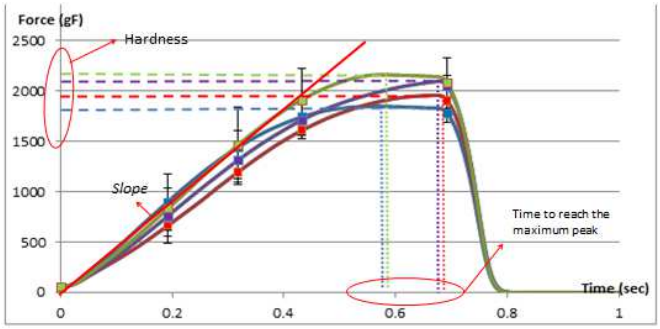

Fig. 2. The Graph of the Snack Bar Texture Analysis

▲ A (MOSEP Flour: Mung bean Flour = 70 : 30)
▲ B (MOSEP Flour: Mung bean Flour = 65 : 35)
▲ C (MOSEP Flour: Mung bean Flour = 60 : 40)
▲ D (MOSEP Flour: Mung bean Flour = 55 : 45)

The texture of a product will be affected by the time to reach the maximum peak of the texture analyzing a process or the highest hardness. The higher hardness needs a longer time to reach the maximum time. Figure 2 showed that treatment A reached the highest peak (highest hardness) in 0.57 seconds; treatment B reached the highest peak (highest hardness) in 0.69 seconds. The snack bar hardness affected by its water content. Treatment C and the D showed a shorter time than B. The baking process, the accuracy, and the precision of the Texture Analyzer can affect this result.

The slope of the graph showed that the lower the slope, the higher the stiffness. The ratios of snack bar formula showed a low slope due to the ratio of mung bean flour. Treatment D showed a higher slope than treatment B and C, due to a higher deformation strength of the treatment D was better than B and C, and the protein content and hardness in treatment D were higher than treatment B and C. Treatment A showed the highest slope due to the higher baking temperature, the harder surface texture, or the accuracy and the precision of the texture analyzer.

The roasting process of the snack bar causes the occurrence of protein denaturation. The texture of hardness is influenced by the protein that undergoing denaturation, this because at the time of the denatured protein, the reactive group will open and then the re-bonding occurred between the reactive groups that are close together so that the number of bonds increases and stronger. The addition of mung bean flour that has a protein content of 20.97 –31.32/100 g [7] and commercial WPC that has a protein content of 79.70/100 g, caused the development is not occurring because the protein binds starch so that the resulting product becomes hard.

The addition of mung bean flour into the formulation can increase the amylose content of the resulting snack bar. Amylose content of mung bean flour of 28.8%, higher than those of MOSEP amylose content of 22.64% [11]. The higher the amylose content, the stronger the inter-molecule bond, because amylose forms a hard texture [6].

E. Yield

According to the statistical analysis, the ratio of MOSEP (Modified Sweet Potato Flour) composite flour to the mung bean flour and 5% of commercial Whey Protein Concentrate was not significantly different in the yield of the snack bar. The statistical analysis of the yield product of the snack bar is shown in Table 5.

TABLE V
THE INFLUENCE OF THE RATIO OF MOSEP (MODIFIED SWEET POTATO FLOUR) TO MUNG BEAN FLOUR AND THE 5% OF COMMERCIAL WHEY PROTEIN CONCENTRATE TO THE YIELD OF THE SNACK BAR

Ratios	Yield* (%)
A (MOSEP Flour : Mung bean Flour = 70:30)	95.20 ± 1.490 a
B (MOSEP Flour : Mung bean Flour = 65:35)	94.28 ± 0.946 a
C (MOSEP Flour : Mung bean Flour = 60:40)	93.75 ± 1.321 a
D (MOSEP Flour : Mung bean Flour = 55:45)	94.53 ± 0.809 a

Note: *Average Values ± Standard Deviation
The average value marked with the same letter shows no significant different at 5% level of the Duncan test.

The mean values of the snack bar's yield ranged from 93.75% to 95.20% showed that the different ratios of the formula did not give a significance difference. This result showed that the same tools prepared the process of snack bar during molding and baking.

The yield was the ratio of snack barnet after the baking process with the snack bar dough before the baking process. The snack bar yield will be affected by the material losses during molding and evaporation during the baking process. The yield percentage is determined by the total solid content and the water content of the ingredients. The low material losses during the process occurred in the snack bar as a portion of emergency food.

F. Organoleptic Characteristics

Organoleptic characteristics were performed by three parameters; color, flavor, and aroma. The test result was statistically calculated, and it was summarized as shown in Table 6.

TABLE VI
THE INFLUENCE OF FORMULATION OF MOSEP FLOUR AND MUNG BEAN FLOUR WITH THE ADDITION OF 5% COMMERCIAL WPC TO COLOR, FLAVOR AND AROMA PREFERENCES OF SNACK BAR

Treatment	Average Value		
	Color*	Flavor*	Aroma*
A: MOSEP Fl. Mung bean Fl. 70 : 30	3.9 ± 0.208 a	3.1 ± 0.148 b	3.2 ± 0.058 b
B: MOSEP Fl.: Mung bean Fl. 65 : 35	3.9 ± 0.100 a	3.3 ± 0.153 ab	3.2 ± 0.058 b
C: MOSEP Fl.: Mung bean Fl. 60 : 40	3.6 ± 0.153 b	3.6 ± 0.153 a	3.5 ± 0.261 ab
D: MOSEP Fl.: Mung bean Fl. 55 : 45	3.6 ± 0.100 b	3.6 ± 0.246 a	3.7 ± 0.190 a

Note: *Average Values ± Standard Deviation
The average value marked with the same letter shows no significant different at 5% level of the Duncan test.

1) Color: The statically calculation between treatments of composite flour of MOSEP and mung bean flour with 5% addition of commercial WPC, showed a significantly different effect on the colour preference of snack bar (Table 6). The average values of color preference ranging from 3.6 to 3.9 indicate that the resulting snack bar was considered to be favored by the panelists. The same formulation of raw material on the different treatments, A and B did not show any significant difference, same with treatment of C and D, did not show any significant difference, but treatment A, B, and C, D showed a significant difference. Snack bar with treatment A (MOSEP flour: mung bean flour = 70: 30) and treatment B (MOSEP flour: mung bean flour = 65: 35) most favored by panelists than other treatments. The more mung bean flour was added, the more brownish color on the snack bar will be. The brown color is formed from the heating process, where the sugar will react with amino acids [9]. Meanwhile, as it is mentioned that [6] brown color is formed due to the process of caramelization and Maillard reaction on the roasting process. The formation of the brown color on the snack bar after the roasting process decreases the panelists' acceptance of the color preferences although it still judged favorably by the panelists. It indicates that the darker brown color decreases the panelist's acceptability or becomes something that less expected. Characteristics of the snack bar color are seen from the resulting brown color; panelists assess the color preferences ranging from 3.6 to 3.9, indicates that the snack bar has a light brown to dark brown.

2) Flavor: Based on the statistical test result between treatments of composite flour of MOSEP and mung beans with commercial WPC addition of 5%, there was a significantly different influence on flavor preferences of the resulting snack bar. The statistical analysis data is shown in Table 6. The average values of flavor preference that is ranging from 3.1 to 3.6 indicate that the resulting snack bar is considered to be favored by the panelists. Flavors can be influenced by several factors: chemical compounds, temperature, concentration, and reaction with other components taste [9]. The same formulation of raw material on the different treatment, C and D, did not show any significant difference, but treatment A and C showed significant differences. Snack bars with treatment C and D have an average value of flavor preferences that more accepted compared with other treatments.

Panelists' preference on the flavor of mung bean flour was caused by protein content in mung bean flour, apart from mung bean flour. The protein content is also derived from commercial WPC. The protein content causes a Maillard Reaction on the roasting process. Maillard's reaction produces melanoidin compounds, which are the main compounds in shaping the color and taste [6]. Chemical compounds will cause taste on the taste senses

Characteristics of the taste on the resulting snack bar were observed from the level of specific peanut flavor, panelists' assessment on the flavor preferences that are ranging from 3.1 to 3.9, showed the resulting snack bar has a slightly specific peanut taste up to specific peanut taste. The panelists' preference on the flavor of mung bean flour was caused by protein content in mung bean flour, apart from mung bean flour, protein content also derived from commercial WPC. Protein content causes a Maillard Reaction to the roasting process. Maillard's reaction produces melanoidin compound in shaping the color and taste. Chemical compounds will cause taste on the taste senses [6]. Characteristics of the taste on the resulting snack bar were observed from the level of specific peanut flavor, panelists' assessment on the flavor preferences that are ranging from 3.1 to 3.9, showed the resulting snack bar has a slightly specific peanut taste up to specific peanut taste.

3) Aroma: Statistics test between treatments of composite flour of MOSEP and mung bean flour with 5% addition of commercial WPC, showed a significantly different effect on aroma preference of snack bar (Table 6). The average value ranges from 3.2 – 3.7 indicates that the resulted snack bar was considered to be rather preferred by panelists. The same formulation of raw material on the different treatments, A, B, and C, did not show any significant difference, same with treatment C and D did not show any significant difference, but treatment A and D showed significant differences. Snack bars with treatment D (the ratio of MOSEP flour to mung bean flour = 55: 45) was the most preferable compared with other treatments. The addition of mung bean flour in each formulation was different, this makes the difference in the effect on the aroma preferences, where the higher the addition of mung bean flour, the more resulting snack bar has an aroma that preferred by the panelist. The panelist can detect the aroma of snack bar through the sense of smell.

The formation of volatile compounds that form flavor is due to the Maillard reaction that causes the formation of compounds melanoidin and polyphenols, which are easily oxidized in the presence of oxygen [7]. Maillard reaction is caused by the presence of protein content in mung beans and commercial WPC flour. Volatile compound is the aroma caused by the roasting process. The aroma arises from the interaction between odorous substances with olfactory epithelial cells in the smell senses [10]. Characteristics of snack bars were determined from the specific aroma of nuts and fruit produced. The panelist assessment on the aroma preferences ranging from 3.2 to 3.7, indicates that the resulting snack bar has a distinctive aroma of peanuts and fruit.

IV. CONCLUSIONS

Formulation of composite flour of MOSEP and mung beans with the addition of commercial WPC 5% in the production of snack bar gave a significantly different influence on the protein content, raw fiber, calorific value, hardness, aroma, color, and flavor preference. Snack bar of D treatment (MOSEP flour : mung bean flour= 55 : 45) yielded the best results with 13.96% protein content, 3.45% raw fiber, 120,23 kcal/30 g calorific value, 2255,93 gF hardness, 3.7 aroma preferences, 3.6 colour preferences, 3.6 flavour preferences, 94.53% yields, 13.49% (b/b) water content, 1.72% ash, 14.93% fat and 56.12% carbohydrate content.

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