Malays. Appl. Biol. (2019) 48(4): 101–106

LEB MUE NANG BANANA BARS WITH PROTEIN SUPPLEMENTS FROM SOYBEAN MEAL: NUTRITIONAL AND SENSORIAL QUALITY

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Accepted 12 October 2019, Published online 30 November 2019

ABSTRACT

The objective of this study was to design a value-added product utilizing food industry by-products, specifically dried Leb Mue Nang banana and soybean meal. Five alternative formulations of a fruit bar with different ratios of dehydrated Leb Mue Nang banana and soybean meal (70:30, 60:40, 50:50, 40:60 and 30:70) were compared. The final recipe was judged by 50 panellists using the 9-point hedonic scale. The product was evaluated for chemical properties (carbohydrate, protein, fat, ash and total energy), physical properties (water activity, moisture and texture), consumer acceptance, and quality during storage for three months. The results show that dried Leb Mue Nang banana could be used for up to 45% and soybean meal as protein supplement could contribute up to 30%. The developed product is a good source of carbohydrate (70.51%) and protein (12.97%), giving 189.5 kcal/serving (50 g). The overall product acceptance score from 100 consumers was 7.9/9, indicating high potential for commercial application. The fruit bars were well accepted with desirable sensory quality and met microbiology standards for up to three months of storage in ambient conditions.

Key words: Fruit bars, Leb Mue Nang banana, soybean meal

INTRODUCTION

Fruits are a crucial part of human diet since they are good sources of energy, dietary fiber, vitamins, and minerals that are needed for healthy body function. According to the USDA guidelines, the recommended daily intake of fruits and vegetables for an adult is two cups (USDA, 2015). However, USDA data revealed that adults and children four years of age and older are not achieving the recommended goal. The main obstacles to sufficient fruit consumption level are accessibility to the ingredients, short shelf life, and time required in food preparation. In this regard, fruit bars provide a convenient way to consume fruits regularly. Nowadays, consumer awareness of healthy eating habits continuously increases, so several studies have focused on creating new healthy products to serve that demand. Fruit bars with a variety of main ingredients such as apple (Akhtar *et al.*, 2014), apricot (Sharma *et al.,* 2013), date (Parn *et al.*, 2015), guava (Vijayanand *et al.,* 2000), jackfruit (Bonomo *et al.,* 2011), and papaya (Aruna *et al.,* 1999) have been reported in studies. This type of fruit source diet has become a convenient choice providing the great health benefits of fruits since all the nutrients are concentrated.

Leb Mue Nang banana fruit (*Musa* AA group) is native to South-East Asia, and is grown widely in the Southern Thailand. Its trunk is a pseudostem with a compact mass of circularly arranged leaf sheaths that are 12-15 cm wide and 2-2.5 m long. The bunch contains 5-8 hands with 10-16 fruits each. Special characteristics of this cultivar include small fruit in finger-shaped (2-2.5 cm width and 10-12 cm length), golden yellowish peel and pulp when fully ripe, smooth texture, and sweet taste with a unique flavor. The fruit is a good source of potassium, a mineral necessary for neural electrical activity of the heart and muscles, and regulating the fluid balance in a human body. Moreover, banana pulp was reported to be an excellent source of bioactive phenolics (Bennett *et al.,* 2010). Furthermore, antioxidant activity of 4 μmole TE/g fresh weight and total phenols of 500 μg GA/g fresh weight were reported for Leb Mue Nang cultivar

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(Youryon & Supapvanich, 2017). In general, the fruit is consumed fresh and is distributed more widely in dehydrated form to overcome its short shelf-life. Although food processing technology, especially drying, has been a solution extending the shelf-life and creating value-added products, a large amount of undersized and undergrade by-products are generated. These materials are generally sold at a very low price, and better ways to utilize them are needed.

Soybean meal, a nutritive by-product from soy milk production, is rich in protein, fiber, isoflavones, and phytoestrogen. This material has a superior amino acid profile with high content of essential amino acids, particularly digestible lysine and methionine. Soy milk industry in Thailand is growing fast and valued at 15,000 million baht each year, with continuous 2-3% annual growth rate. As a result, several tons of soybean meals are produced in excess to demand. Despite its various health benefits, most soybean meal by-product has been destined for animal feed products (Chou *et al.*, 2004; Lim & Dominy, 1990; Mohsen & Lovell, 1990; Romarheim *et al.,* 2006; Wang *et al.*, 2006). To accomplish better utilization, this valuable by-product is employed as a protein source for humans in this study.

The present research aimed at creating fruit bars that meet consumer needs, from Leb Mue Nang banana as an alternative source of carbohydrate, with protein supplement from soybean meal. The desired product not only can help increase fruit consumption and protein intake but also is convenient and of high nutritional quality.

MATERIALS AND METHODS

Raw materials

Leb Mue Nang bananas (*Musa* AA group) were hand-harvested from a commercial orchard in Chumphon province, southern Thailand. The sample selection for drying process was based on uniform size, colour, and freedom from apparent damage or disease. The fruit were peeled and racked on trays before dehydration in a hot air oven at 60°C for 16 hr, to obtain water activity (a_w) of 0.6. Soybean meal obtained from local soymilk factory was dried at 55°C for 6 hr until a_w 0.6. Mulberries were procured from a commercial orchard in the Surat Thani province of southern Thailand. These fruits were sorted and washed before dehydration in a hot air oven at 55°C for 8 hr to achieve a_w 0.6. Commercial glucose syrup and honey were used as binders in the fruit bars. Five formulations of the fruit bars were tested, with the ratios of dehydrated banana to soybean meal at 70:30, 60:40, 50:50, 40:60 and 30:70, respectively labelled as formulations I, II, III, IV and V. Fruit bar samples were prepared according to the formulation shown in Table 1.

Preparation of fruit bars

Dehydrated banana and mulberry were cut into small pieces. The ingredients listed in Table 1 were manually mixed in a stainless container until a homogeneous mass was obtained. The mixture was transferred onto aluminium trays, pressed, and baked in an infrared oven at 180°C for 20 min. After cooling, the samples were cut to rectangular shape (3 × 10 × 2 cm), then packed in hot sealed aluminium foil bags. An outline of this study is shown as flowchart in Figure 1.

Sensory evaluation

All formulations of the fruit bars were evaluated by 50 untrained panellists of ages between 15 and 50 years. The fruit bar samples were labelled with three-digit codes and the serving order was random. Sensory evaluation using the 9-point hedonic scale (the minimum for "extremely disliked" and the maximum for "extremely liked") was performed on appearance, color, flavor, texture, taste, sweetness, and overall liking. Sensory evaluations during product storage were performed by 35 untrained panellists from 15 to 50 years old. Scale and attributes evaluated by panellists were the same as above.

Proximate analysis

Fruit bars were subjected to proximate analysis of carbohydrates, protein, fat, ash, and moisture following AOAC (1984) methods. The Kjeldahl method was used for protein determination. Fat content was analyzed using the Soxhlet method, and

Table 1. Formulation of Leb Mue Nang banana bars supplemented with protein

Ingredient	Formulation (g 100 g^{-1})				
	I (70:30)	II (60:40)	III (50:50)	IV (40:60)	V (30:70)
Dehydrated banana	52.5	45	37.5	30	22.5
Soybean meal	22.5	30	37.5	45	52.5
Mulberry	10	10	10	10	10
Glucose syrup	10	10	10	10	10
Honey	5	5	5	5	5

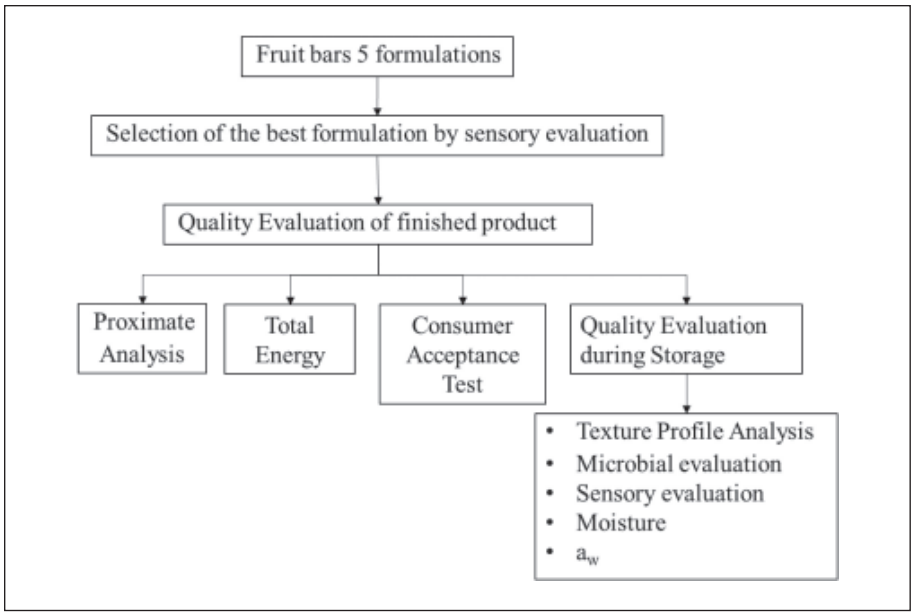

Fig. 1. Overall scheme of the study.

water content was measured using a moisture analyzer. For ash content, the sample was dried in a muffle furnace at 550°C until a white or light grey ash resulted. Total carbohydrate content was calculated using the following equation:

Total carbohydrate (%) = 100-[moisture (%) + crude protein (%) + crude lipid (%) + total ash (%)]

Total energy

Caloric content of the fruit bars was measured using a Bomb Calorimeter (Leco, AC 500, USA), which measure the heat created by a sample burned under an oxygen atmosphere in a closed vessel. The sample was ground and 1 g of it was pressed to a pellet that was analyzed for gross energy in the bomb calorimeter.

Consumer acceptance test

One hundred testers from 15 to 50 years old, including both sexes, were recruited as the panel for consumer acceptance test of the final fruit bar recipe. Sensory evaluation using the 9-point hedonic scale was performed again on appearance, color, flavor, texture, taste, sweetness, and overall liking.

Physicochemical analysis

Texture Profile Analysis (TPA) were done with a texture analyzer (Brookfield Texture Analyzer, CT 3, Germany) with the cylinder probe TA 4/1000 25mm. Texture is reported in terms of hardness, cohesiveness, and chewiness. The moisture content was obtained using a moisture analyzer (Sartorius Moisture Analyzer, MA 37, Göttingen, Germany). The water activity (a_w) was measured using water activity meter (Aqualab, CX3TE, USA).

Microbial evaluation

Total plate count

A 10 g fruit bar sample was homogenized in 90 mL of peptone solution, after which the mixture was diluted by factors 10^{-2}, 10^{-3} and 10^{-4}. An aliquot of each solution (1 mL) was aseptically filled in a petri dish to which 20 mL of sterilized Plate Count Agar (PCA, Himedia, India) was poured and mixed well. After agar solidification, the petri dishes were inverted and incubated for 48 hr at 30°C. Colonies of aerobic bacteria were counted and are reported as CFU/g.

Yeast and mold count

Yeast and mold counts of the fruit bars were examined using Potato Dextrose Agar (PDA, Himedia, India). Sample preparation and dilution were similar to those for total plate counts. Sterilized agar solution (39 g/L) was poured on petri dishes and they were inverted upon solidification. Samples of 0.1 mL were placed and spread thoroughly on prepared media, and then incubated for two days at 30°C. Colony counts are reported as CFU/g.

Statistical analysis

The data from sensorial analysis of the five fruit bar formulations were subjected to Analysis of Variance (ANOVA). The results from other analyses are presented as means of three replications (20 replications for TPA) ± SD. Statistical analysis was carried out using ANOVA and Duncan's multiple range test was applied to compare the means at significance level $p < 0.05$. All the analyses were run in SPSS v6 for windows (IBM, NY, USA).

Table 2. Sensory scores of fruit bar formulations with different ratios of Leb Mue Nang banana to soybean meal

Attribute	Formulation				
	I	II	III	IV	V
Appearance	6.4 ± 0.8^{ab}	6.6 ± 0.7^{a}	6.0 ± 0.9^{bc}	5.7 ± 0.6^{cd}	5.3 ± 0.8^{d}
Color	6.4 ± 0.8^{a}	6.7 ± 0.8^{a}	5.7 ± 0.7^{bc}	5.9 ± 0.7^{b}	5.5 ± 0.6^{c}
Flavor	6.0 ± 0.8^{ab}	6.1 ± 0.8^{a}	5.7 ± 0.6^{bc}	5.4 ± 0.5^{cd}	5.0 ± 0.8^{d}
Texture	6.3 ± 0.7^{a}	6.0 ± 0.8^{ab}	5.8 ± 0.8^{b}	5.4 ± 0.5^{c}	4.8 ± 0.8^{d}
Taste	6.3 ± 1.8^{ab}	6.5 ± 0.8^{a}	5.9 ± 0.8^{c}	5.6 ± 0.6^{c}	4.9 ± 0.7^{d}
Sweetness	6.5 ± 0.7^{a}	6.6 ± 0.7^{a}	5.9 ± 0.7^{b}	5.3 ± 0.5^{c}	4.8 ± 0.6^{d}
Overall liking	6.5 ± 0.7^{a}	6.7 ± 0.8^{a}	6.0 ± 0.5^{b}	5.6 ± 0.5^{c}	5.3 ± 0.5^{c}

Note: Different superscripts within the same row indicates significantly different ($p < 0.05$).

RESULTS AND DISCUSSION

Characterization of the fruit bars from Leb Mue Nang banana with soybean meal

Five fruit bar formulations with different ratios of dehydrated Leb Mue Nang banana to soybean meal were subjected to sensory evaluation, and the hedonic scores are presented in Table 2. The results indicate that formulations 1 and 2 got the highest scores, significantly better than the others for all attributes ($p < 0.05$). Increasing the soybean meal proportion gave strong soybean flavor, crumbly texture and strong soybean taste, that significantly decreasing the scores on appearance, color, flavor, texture, taste, sweetness and overall liking. Thus, soybean meal proportion in a fruit bar should not exceed 40%. The most liked was formulation II. The proximate analysis (Table 3) revealed that this recipe contained 70% carbohydrate, which is similar to earlier reported fruit bars from dates (72.65 g 100^{-1} g) (Parn *et al.,* 2015). The highlight of this formulation is its 13 g 100^{-1} g protein content, which is much higher than in fruit bars from jackfruit and date with protein contents of only 2.7 and 3.2 g 100^{-1} g, respectively (Bonomo *et al.,* 2011; Parn *et al.*, 2015). The soybean meal contains 29.5% protein (Silva *et al.*, 2018), so it effectively increases the protein content of the developed product. The recipe yielded 379 kcal per 100 g, or 189.5 kcal per serving of 50 g.

Consumer acceptance panel

Sensory evaluation is generally carried out to obtain information on the behavior of complex mechanisms on consumer acceptability of a food product (Kemp *et al.,* 2011). In the present study, the consumer acceptance test of fruit bar (formulation II) involved a panel with 100 testers, and the results are summarized in Table 4. Considering the product's visual quality (appearance and color attributes) the testers rated it as moderately liked. Based on the hedonic scores, the fruit bars' flavor, texture, taste and sweetness were acceptable. The mean overall acceptance score was 7.9, which translates into "like very much".

Quality evaluation during storage

Physical, microbiological and sensorial quality of the fruit bars was monitored for 3 months at ambient storage. Table 5 shows texture profile results of the samples. The TPA increased in hardness and chewiness, while cohesiveness did not significantly change over the storage period. The increased hardness and chewiness during storage were consequences of sugar crystallization caused by the proteins absorbing water (Arvanitoyannis *et al.,* 1993). The shelf life of a protein bar tends to be limited by the development of hard texture, which the consumers find unpalatable (Loveday *et al.,* 2009). Moisture content increased significantly,

Table 3. Proximate composition of Leb Mue Nang banana bar (formulation II) with soybean meal

	Proximate centesimal content (% wet base)
Carbohydrate	70.51 ± 0.27
Protein	12.79 ± 1.04
Fat	1.66 ± 0.03
Ash	3.80 ± 0.28
Moisture	11.24 ± 0.52
Caloric value (kcal 100^{-1} g)	379 ± 6.00

Table 4. Hedonic scores from a 100 tester panels on sensorial preferences regarding Leb Mue Nang banana bar with soybean meal (formulation II)

Attribute	Score
Appearance	7.7 ± 0.6
Color	7.4 ± 0.6
Flavor	7.7 ± 0.6
Texture	7.9 ± 0.6
Taste	7.8 ± 0.6
Sweetness	7.5 ± 0.7
Overall acceptance	7.9 ± 0.6

Table 5. Texture profile of Leb Mue Nang banana bar with soybean meal during storage

Storage time (months)	Hardness (g)	Cohesiveness^{ns}	Chewiness (mJ)
0	1147.36± 71.52^{c}	0.35 ± 0.02	9.40 ± 0.47^{c}
1	1223.66 ± 44.60^{c}	0.30 ± 0.07	9.90 ± 0.72^{c}
2	1337.40 ± 47.67^{b}	0.30 ± 0.04	16.92 ± 1.79^{b}
3	1501.20± 41.69^{a}	0.36 ± 0.03	19.10 ± 1.30^{a}

Note: Different superscripts within a column indicates significantly different by storage time ($p < 0.05$).

Table 6. Changes in moisture content (%) and water activity of Leb Mue Nang banana bar with soybean meal during storage

Storage time (months)	Moisture content (%)	a_w ^{ns}
0	7.78 ± 0.00^{d}	0.56 ± 0.00
1	7.81 ± 0.01^{c}	0.56 ± 0.01
2	7.88 ± 0.00^{b}	0.56 ± 0.01
3	7.95 ± 0.00^{a}	0.56 ± 0.00

Note: Different superscripts within a column indicates significantly different by storage time ($p < 0.05$).

Table 7. Microbiology profile of Leb Mue Nang banana bar with soybean meal during storage at ambient temperature

Storage time (months)	Microbial count	
	Aerobic bacteria (CFU/g)	Yeast and Mold (CFU/g)
0	ND	ND
1	ND	ND
2	2.9 x 10^2	ND
3	6.8 x 10^2	<10

ND: not detectable.

Table 8. Sensory scores of Leb Mue Nang banana bar with soybean meal during storage

Attribute	Storage time (months)			
	0	1	2	3
Appearance ^{ns}	7.1 ± 0.9	7.1 ± 0.8	7.0 ± 0.8	6.9 ± 0.7
Color ^{ns}	6.7 ± 0.7	6.8 ± 0.7	6.7 ± 0.7	6.6 ± 0.6
Flavor	7.0 ± 0.9^{a}	6.9 ± 0.8^{ab}	6.8 ± 0.7^{ab}	6.7 ± 0.6^{b}
Texture ^{ns}	7.2 ± 0.7	7.2 ± 0.5	7.2 ± 0.8	7.1 ± 0.8
Taste	7.5 ± 0.7^{a}	7.4 ± 0.6^{a}	7.3 ± 0.6^{ab}	7.2 ± 0.5^{b}
Sweetness	6.9 ± 0.7^{a}	6.9 ± 0.9^{ab}	6.7 ± 0.7^{ab}	6.7 ± 0.6^{b}
Overall acceptance	7.4 ± 0.8^{a}	7.4 ± 0.9^{a}	7.3 ± 0.9^{ab}	7.2 ± 0.7^{b}

Note: Different superscripts within the same row indicates significantly different by storage. Time ($p < 0.05$), ns means no significant difference.

possibly due to uptake from the environment inside the packaging (Table 6). The increasing trend of moisture content is due to relative humidity of air being much higher than the water activity of the product, so moisture is constantly absorbed from air. However, the increase in moisture content is small, with no significant effect seen in the water activity. Water activity plays a vital role in product stability and also affects the overall shelf life. The developed fruit bars had a_w in the range 0.55-0.56 throughout the storage life, indicating low risk of microbial growth or enzymatic activity. The microbial counts confirmed product safety for up to three months storage in ambient temperature (Table 7). The textural changes measured using TPA during storage did not affect the sensory quality (texture) as perceived by the panellists. The scores on appearance and color, provided in Table 8, also did not significantly change during the studied period. The scores for taste, flavor, and sweetness significantly decreased from the initial levels over three months of storage. The testers rated Leb Mue Nang banana bar with soybean meal as overall "moderately liked" until the end of tested storage period.

CONCLUSION

The formulation with the best sensory acceptance had 30% soybean meal protein supplement with 45% dehydrated Leb Mue Nang banana in the prepared fruit bar. The selected formulation had satisfactory nutritional values, with a high 13 g 100^{-1} g protein content and a moderate 189.5 kcal/serving (50 g) caloric value. The nutritional balance of energy, carbohydrates and protein make this bar appropriate as substitute for conventional food, as

an energy snack for the general consumer. The developed product was well accepted by a panel of consumers, with overall product acceptance score of 7.9 out of 9, showing high potential for consideration to target the health product market. The fruit bars were moderately liked in terms of overall acceptance, and satisfied microbiological standards for food safety during ambient storage for up to three months. Considering the changes in moisture content and textural properties, suitable packaging would be the key to prolong the shelf life.

ACKNOWLEDGMENTS

This research was financially supported by Prince of Songkla University, Surat Thani Campus, 2018. The authors would like to thank Seppo Karrila for his kind support. Furthermore, the Food Innovation and Product Development (FIPD) Laboratory is strongly acknowledged here for the provided lab space and equipment support.

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