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Effect of Osmotically Process on Bastard Oleaster (*Elaeagnus latifolia* L.) Fruit Bar

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Abstract

This presented study aims to develop a fruit bar from bastard oleaster fruit. The osmotically dehydrated process was studied by soaking a whole fruit in sucrose syrup at the concentration of 20, 30 and 40 °Brix and adjusting pH at 2.5 and 2.8 by citric acid. The results indicated that the optimal process of bastard oleaster fruit bar was the fruit immersion in 40 °Brix sucrose syrup and controlling pH of syrup at 2.8 for 20-24 h. Then, the infused fruits were dried at 50-55 °C for 20-24 h. Thereafter, the osmotically dehydrated fruit were mixed with fructose syrup in the ratio of 5:1 weight by weight (w/w), formed into a rectangular shape, and dried at 50-55 °C for 12 h. Sensory evaluation showed that the finished product had the high acceptability scores in terms of appearance, color, taste, flavor, texture, and overall liking corresponding to like slightly to like moderately. It contained total soluble solid of 74.40 °Brix, 1.13 % total acidity, 1.78 mg ascorbic acid/100 g, and 1.27 mg gallic acid equivalent/g. This product also exhibited a high antioxidant activity as DPPH assay. Therefore, the bastard oleaster fruit bar can be used as an alternative health products for consumption.

Keywords: Bastard oleaster fruit, *Elaeagnus latifolia* L., Fruit bar, Osmotically dehydrated fruit

1. Introduction

Globally, with the changing of consumer attitude, health conscious consumers take to interest the natural health-developed food products known as functional food. The functional foods can be those foods made up of distinct, fortified, and enriched elements that provide health benefits on human body functions such as providing antioxidant, improving the general physical state, decreasing the risk of disease evolution, etc. (1). Moreover, consumers have less time for cooking or food consumption which is one reason for the consumer behavior changing. Fruit bar is a dehydrated fruit-based product, one kind of popular snack foods in the foreign countries because of a suitable ready-to-eat product and can be used as a meal part or a meal replacement (2, 3). Presently, these products are complemented with nutrients that has more health benefits, focusing on an energy source and natural nutrients from a variety of fruits such as apple, papaya, guava, mango, jackfruit, etc. (1, 2, 4). Food Intelligence Center Thailand (2020) (5) reported that the Thailand snack bar and fruit-based snack market showed values of 105.9 and 1,341.2 million Baht, respectively in 2019. The market is segmented in several categories with high competition. Regarding the increased health awareness, the consumers demand the snack with healthy, energy boosting, and enhanced nutritional value, such as fruits and vegetables (5).

Bastard oleaster (*Elaeagnus latifolia* L.) is one of an endemic fruit plat cultivated in the upper-north and north-eastern part of Thailand. The fruits is attractive in fresh color, with a sourness taste, and is also reported to be a source of vitamins, minerals, essential fatty acids and other bioactive compounds, especially phenolic acids and flavonoids (6, 7). Seal (2012) (10) found the high quantity in its fruit by potassium 13580 mg/kg and calcium 5860 mg/kg, and sodium 965 mg/kg. Most of minerals are necessary for muscle and body improvement. Yingthongchai and Sirikhum (2008) (9) reported that fruit size was varied from small to large. Mature fruits had dark red, red, orange-red and yellow colors with sourness and sweetness taste. Fruit contained vitamin A, C, and total phenolic acid 621.37-626.17 mg/100 g, 2.37-17.26 mg/100 g, and 2.32-3.81 mg/g, respectively. The bastard oleaster fruit can be utilized for the value-added food and drink products, such as jam, salsa, wine, drink, including fruit leather (6). The perishable nature of fruits causes hindrance in its optimum utilization. Hence, the processing of fruit bar can be effective way for preserving its taste and other

nutrients (10). Therefore, this study aims to develop the healthy fruit bar by using a new fruit source-bastard oleaster (*Elaeagnus latifolia* L.) fruits focusing on less sugar and naturally decent taste. These developed products are expected to create opportunities for Thai entrepreneurs.

2. Materials and Experiment

2.1 Materials and prototype

The mature fresh bastard oleaster (*Elaeagnus latifolia* L.) fruits were purchased from the orchard in Nong Khai province, Thailand during November, 2018. Then they were washed with tap water, dried using a double-layers cotton cloth, and frozen at -18 °C to -20 °C. After that, they were kept into plastic bag in a freezer until using.

One of commercially fruit bar products which comprised 33% concentrated apple juices and 64% fruits: apple, strawberry, black currant, raspberry, and blueberry, was selected to be as the prototype.

2.2 The bastard oleaster fruit bar process

A bastard oleaster fruit bar process was composed of the raw material preparation, the osmotically dehydrated process, and the hot air drying process, respectively. Frozen bastard oleaster fruits were thawed and punched with needle on fruit surface. Whole fruit was soaked in sucrose syrup in the portion of 1:1 (w/v) at the different concentration: 20, 30, 40 °Brix and controlled different pH of syrup at 2.5 and 2.8. The osmotically dehydrated process was done for 20-24 hours. Then, the seed of infused bastard oleaster fruit was removed and the infused fruit was dried in a hot air oven at 50-55 °C for 20-24 hours. Thereafter, the osmotically dehydrated fruit were mixed with fructose syrup in the ratio of 5:1 w/w, formed into a rectangular shape (3x10x1 cm^3), and dried at 50-55 °C for 12 hours, respectively.

2.3 The physico-chemical analysis

All samples were chopped and blended to measured moisture content and water activity (a_w) using an infrared moisture analyzer (IR-35, Denver instrument, USA) and a water activity analyzer (4 TE, Agua lab, UK), respectively. The 5 g of sample was mixed with distilled water (20 mL) and homogenized at 5000 rpm for 30 seconds using a homogenizer. Then the clear sample solution was taken to analyses. The content of total soluble solids (TSS) and pH value were determined using a digital hand-held refractometer (PAL-3, Atago, Japan) and pH meter (Seven easy, Mettler Toledo, Switzerland), respectively, as described by AOAC (11). Total titratable acidity (TTA) was conducted by the titrimetric method of AOAC (11) using an auto-titrator (DL53, Mettler-Toledo, Switzerland), in which of titration against 0.1N NaOH solution using phenolphthalein as an indicator. The result was computed as the percentage of ascorbic acid content (TAA).

Color measurement was conducted for the developed fruit bar using a Minolta chromameter (CR-400, Konica Minolta, Japan). The chromameter was calibrated by a white color standard (Illuminant D_{65} 2 degree observer, Y=92.50, x=0.3165, y=0.3329). The colorimetric data was operated as CIE lab scale and displayed as L* (Lightness), a* (green to red) and b* (blue to yellow) values. The triplicated measurements were averaged.

Texture Profile Analysis (TPA) was used to evaluate fruit bar texture with a Texture Analyzer (TA500, Lloyd instrument, UK) (12). Compression force was determined using a cylender prob (SMS P/25, 25 mm diameter) with a 5 kg load cell. Samples were prepared by cutting in size of 3x3x1 cm^3. A probe penetrated to a depth of 10 mm of sample at a speed of 10.0 mm/min. Five pieces of sample were measured for each treatment. The hardness was expressed as maximum force (kg) achieved at the first bite. Springiness related to the height that the fruit bar recovers during the time that elapses between the end of the first bite and the start of the second bite, and its unit was mm. Cohesiveness was calculated as ratio of area of second compression cycle to that of area of first compression cycle. Gumminess and chewiness are defined as "the product of hardness x cohesiveness and the product of gumminess x springiness, respectively.

The content of total ascorbic acid and total phenolic acid, including antioxidant activity as DPPH assay of the developed bastard oleaster fruit bar was analyzed following as:

Total ascorbic acid (TAA) was conducted by the titrimetric method of AOAC (11) using an auto-titrator (DL53, Mettler-Toledo, Switzerland), in which of visual reduction of 2,6 dichlorophenolindo phenol dye was measured and expressed as mg of ascorbic acid per 100 g sample.

Total phenolic content (TPC) was determined according to the modified method of Brand-Williams et al. (1995) (13) by a colorimetric spectrophotometry, using gallic acid as a working standard. The 0.5 mL of extracted sample solution or working standard solution (0-100 mg/L) was mixed with 2.5 mL of 10% (v/v) Folin-Ciocalteu's reagent. Then, 2.0 mL of 7.5% (w/v) sodium carbonate was mixed thoroughly. After incubation at room temperature in darkness for 30 min, the absorbance at 765 nm was measured using an UV/Vis spectro-photometer (U2900, Hitachi, Japan). The content of total phenolic was calculated by a plotted linear equation of gallic acid standard and expressed as milligram of gallic acid equivalents (mg GAE) per gram of sample weight (g).

Antioxidant activity was conducted by the scavenging activity of DPPH radical using modified method of Nowak et al. (2016) (14). DPPH radical stock solution (80 µM) in ethanol was prepared fresh daily. The 40 µL of extracted sample solution was mixed with 4.0 mL of DPPH solution. The mixture was placed in the darkness at room temperature for 30

min. The spectrophotometer absorbance at 517 nm was then measured. The DPPH free radical scavenging activity (%AA) was computed as the following equation (2.1), where, A_{blank} is absorbance of blank at 0 minute; A_{sample} is absorbance of the sample at 30 minutes; A is absorbance of the control reaction (only DPPH solution).

$$\%AA = \frac{(A_{blank} - A_{sample}) \times 100}{A_{control}} \quad (2.1)$$

2.4 Sensory evaluation

The sensory evaluation was made by 25 panelists in laboratory conditions. Samples were prepared by cutting in size of 3x3x1 cm^3 and coded by 3-digit random numbers in a random order for each panelist. The following most important characteristics of developed bastard oleaster fruit bar products in terms of appearance, color, taste, flavor, texture, and overall liking were asked and also the acceptability test was conducted for selection. There were the following categories of sensory analysis on a 7 pointed hedonic scale anchored by: '1-dislike very much', '4-neither like nor dislike' and '7-like very much'.

2.5 Statistical analysis

Data were analyzed by the analysis of variance procedure (ANOVA) using a completely randomized design (CRD) with the different of syrup concentration for fruit preparation. Values are showed as mean±S.D. Mean separation was calculated according to the Duncan's New Multiple's Range Test (DMRT) at the 95% confidence level. Moreover, T-test differential mean within two level of citric adjustment was analyzed. All statistical analysis was performed with SPSS version 18.

3. Results and Discussion

3.1 The effect of syrup concentrations on bastard oleaster fruit bar characteristics

As the results in Table 1, it is observed that the increased concentration of sugar syrup (20 - 40 °Brix) was significantly increased in the moisture content but decreased in the a_w and content of total soluble solid, ($p \leq 0.05$). In contrast, no significant difference ($p > 0.05$) in pH value and ascorbic acid content were found. The mass transfer during osmotic dehydration process is important to the composition of the final products. Within two different flows of mass occur; water with solutes (sugar, acid, pigment, etc.) from the fruits to the osmotic solution and, in the opposite way, from the solution (mainly sugar syrup) to the fruit matrix (15). The result of total soluble solid in fruit bar samples also observed a decrease from 70.10 °Brix to 67.50 °Brix and an increase in pH values (from 2.75 to 2.85). An increase in TSS might be due to the changing of moisture content of product (10). During a drying process, the invert sugar acts as bonding agent and the water passage at the product surface is slow (16). The moisture content of fruit bar was also found to be increased when syrup concentration increased. Moreover, due to the sourness of bastard oleaster fruits, the pH value of fruit bar products ranged from 2.75 to 2.85. In terms of color analysis, the increasing of syrup concentrations exhibited the darkness color of bastard oleaster fruit bar which was considerably decreased in L* value and increased in a* and b* values ($p < 0.05$). Thermal degradation during process and oxidation may also have contributed to this reduction in color and acidity value which is very sensitive to heat, oxygen, and light. The content of vitamin C of fruit bar products might be low since it readily oxidized (17). The result showed that a lower water content (a_w=0.58) was found at a higher syrup concentration (40 °Brix) affecting the color changing. According to the report of Samborska et al. (18), this higher concentration of osmotic solution and a larger addition of fruit juice significantly affected the color changes of dehydrated apples. The texture characteristics (Table 2) showed that the measured hardness significantly decreased from 1.18 kgf to 0.42 kgf while the syrup concentration was increased. Similar to hardness value, the gumminess and chewiness also decreased ($p < 0.05$). However, no significant differences in cohesiveness and springiness were found with the increase of the syrup concentration. The soft texture means it is easy to bite and chew. It is interesting to note that hardness and chewiness are undesirable characteristics of fruit bar (19) hence the increasing of syrup concentration has a desired effect on product texture.

Table 1 Physico-chemical properties of the fruit bar contained osmotically bastard oleaster fruit preparing from the different syrup concentration

Physico-chemical properties	Concentration of syrup		
	20 °Brix	30 °Brix	40 °Brix
Moisture content (%)	14.15±2.11^{c}	18.57±0.93^{b}	23.71±3.23^{a}
a_w	0.62±0.02^{a}	0.59±0.01^{b}	0.58±0.02^{c}
pH value^{ns}	2.75±0.01	2.81±0.02	2.85±0.01
TSS (°Brix)	70.10±0.52^{a}	68.70±0.79^{b}	67.50±0.17^{c}
TTA (%)^{ns}	0.60±0.01	0.50±0.01	0.40±0.01
L* value	26.10±0.01^{a}	24.06±0.02^{b}	23.99±0.01^{c}
a* value	14.19±0.05^{c}	16.04±0.02^{b}	17.18±0.02^{a}
b* value	8.96±0.02^{c}	11.23±0.03^{b}	12.35±0.03^{a}
Hardness (kgf)	1.18±0.10^{a}	0.65±0.03^{b}	0.42±0.02^{c}
Cohesiveness^{ns}	0.08±0.01	0.08±0.01	0.09±0.01
Springiness^{ns} (mm)	0.61±0.17	0.56±0.04	0.56±0.08
Gumminess (kgf)	0.10±0.01^{a}	0.05±0.05^{b}	0.04±0.00^{b}
Chewiness (kgf.mm)	0.06±0.02^{a}	0.03±0.01^{b}	0.02±0.01^{b}

^{ns}no significant difference values ($p \geq 0.05$)
$^{a\text{-}c}$Rows with different letters are significantly different between each syrup concentration treatment ($p < 0.05$).

With regard to the sensory evaluation (Table 2), it indicated that no significant differences among the three syrup concentrations in terms of appearance, color, flavor, texture, and overall liking

scores were found. The liking score of each attribute ranged from 5.3 to 6.0 in the corresponding of "like slightly to like moderately". The result showed statistically significant value of taste, which was increased with the increasing of syrup concentration ($p<0.05$). This was the reason to select the formulation which using 40°Brix sucrose syrup concentration to prepare the fruit bar product which was achieved the highest scores in terms of taste and overall liking including 100% acceptability from panelists.

Table 2 Sensory scores of fruit bars contained bastard oleaster fruit preparing from the different syrup concentration

Attributes	Concentration of syrup		
	20 °Brix	30 °Brix	40 °Brix
Appearance^{ns}	5.5±1.0	6.0±0.8	5.8±1.0
Color^{ns}	5.4±1.0	5.8±0.8	5.7±0.9
Flavor^{ns}	5.3±1.1	5.6±0.9	5.6±0.9
Texture^{ns}	5.3±1.1	5.5±0.8	5.4±1.0
Taste	5.3±0.9^{b}	5.5±1.0^{ab}	5.9±0.7^{a}
Overall liking^{ns}	5.5±1.0	5.4±1.0	5.8±0.8
Acceptability (%)	72	92	100

^{ns}no significant difference values ($p\geq0.05$)
$^{a-c}$Rows with different letters are significantly different between each syrup concentration treatment ($p<0.05$).

3.2 The effect of pH adjustment on bastard oleaster fruit bar characteristics

Table 3 showed the physico-chemical properties of the bastard oleaster fruit bar controlling pH of syrup by citric acid addition. The results were found that the increasing of pH adjustment from 2.5 to 2.8 was subsequently decreased in the moisture content, pH value, total soluble solid, total titratable acidity, and color parameters; L*, a*, and b* values ($p<0.05$). However, there were no significant differences among the three syrup concentrations in water activity value and texture properties ($p>0.05$). Shakoor et al. and Gharsallaoui et al. (16, 20) described that the association of added sugar and water through hydrogen bonding reduction was occurred at low a_w. The invert sugar acts as bonding agent and the water passage at the product surface is slow. The increase in citric acid content might stimulate the inversion of non-reducing into the reducing sugar by acid hydrolysis of sucrose (21), in addition; a higher moisture content of fruit bar product also was found with pH adjustment at 2.8.

With respect to the texture profile, it showed 0.42-0.67 kg force for hardness, a small cohesiveness (0.05-0.09) and 0.56-0.81 mm. of springiness values ($p<0.05$). The chewiness ranged from 0.02 to 0.03 kgf.mm whereas the gumminess was 0.04 kgf. They are softer than the prototype fruit bar product (Data not shown). It indicates that it may be a soft bar, not stick on teeth or gum with a low stiffness.

Table 3 Physico-chemical properties of the fruit bar contained bastard oleaster fruit using the different pH level of syrup

Physico-chemical properties	pH control	
	2.5	2.8
Moisture content (%)	23.71±3.23^{a}	11.07±1.47^{b}
aw^{ns}	0.58±0.02	0.58±0.02
pH value	2.80±0.01^{b}	2.88±0.00^{a}
TSS (°Brix)	70.50±0.52^{b}	74.40±0.02^{a}
TTA (%)	2.42±0.25^{a}	1.70±0.00^{b}
L* value	23.99±0.01^{b}	26.98±1.39^{a}
a* value	17.18±0.02^{b}	23.90±2.14^{a}
b* value	12.35±0.03^{b}	26.13±4.60^{a}
Hardness (kgf)	0.42±0.02^{b}	0.67±0.06^{a}
Cohesiveness	0.09±0.01^{a}	0.05±0.01^{b}
Springiness (mm)	0.56±0.08^{b}	0.81±0.14^{a}
Gumminess^{ns} (kgf)	0.04±0.00	0.04±0.01
Chewiness^{ns} (kgf.mm)	0.02±0.01	0.03±0.01

^{ns}no significant difference values ($p\geq0.05$)
$^{a-b}$Rows with different letters are significantly different between each citric acid concentration treatment ($p<0.05$).

According to Table 4, the sensorial qualities of fruit bar products with reducing pH level adjustment showed a higher liking score in all attributes: appearance, color, flavor, texture, and overall liking. In terms of color and taste, there were statistically significant values, which was increased with the decreasing of citric acid addition ($p<0.05$). However, Bastard oleaster fruit bar controlling pH level at 2.8 had good taste and texture, including the achievement of a higher liking score in all attributes, which ranged from 5.9 to 6.4 (like slightly to like moderately). The 100% overall acceptability of panelists was found. Thus, the pH level at 3.0 by citric acid addition gave good organoleptic evaluation.

Table 4 Sensory scores of the fruit bar contained bastard oleaster fruit using the different pH level of syrup

Attributes	pH control	
	2.5	2.8
Appearance^{ns}	5.8±1.0	6.4±0.7
Color	5.7±0.9^{b}	6.3±0.5^{a}
Flavor^{ns}	5.6±0.9	6.0±0.8
Texture^{ns}	5.4±1.0	5.9±0.8
Taste	5.4±0.7^{b}	5.9±0.5^{a}
Overall liking^{ns}	5.8±0.8	6.0±0.7
Acceptability (%)	100	100

^{ns}no significant difference values ($p\geq0.05$)
$^{a-b}$Rows with different letters are significantly different between each citric acid concentration treatment ($p<0.05$).

3.3 The characteristics of the bastard oleaster fruit bar products

The biochemical characteristics of frozen flesh bastard oleaster fruit has been presented in Table 5. It was found that total soluble solid content was approximately 9.90%, 1.00% of titratable acidity and pH value of 2.93. Moreover, it was also revealed that ascorbic content of 1.06 mg/100 g and total phenolic

acid of 0.43 mg GAE/g were in the agreement of Singh et al's report (10). They found that the content of titratable acidity and total soluble solid content of bastard oleaster fruit was varied in the range of 0.05-4.00% and 6.7-21.1 °Brix, respectively. The other researchers also found that total solid content of fruit was 8.58 °Brix (22) and pH 2.72 (23). However, the content of vitamin C and total polyphenol showed the lower content than the study of (10) which was reported in the range of 2.37-17.26 mg/100 g and 2.32-3.81 mg/ g, respectively. It might be due to the different geographical regions of growth area (23).

Regarding the biochemical properties bastard oleaster fruit bar product (Table 5), it showed 11.07% of moisture content, 0.58 a_w, pH value of 2.88, 74.40 °Brix of TSS, and 1.13% of total acidity. For the selected fruit bar prototype, it had 10.61% of moisture content while the water activity showed 0.54. Within the main composition of berry fruit (64% by weight), it showed pH 3.75, 1.99% of total acidity based on ascorbic acid, and a high content of total soluble solid (68.7 °Brix). Both of fruit bar products consistent with the TIS 919-2532 dried fruit standard; the moisture content and a_w should not exceed 18% and 0.85, respectively (24). Moreover, the content of ascorbic acid and phenolic acid in bastard oleaster fruit bar product were 1.78 mg/100 g and 1.27 mg GAE/g, respectively. This product also exhibited a high antioxidant activity as DPPH assay (86.23%).

Table 5 The biochemical properties of the fresh bastard oleaster fruit and their fruit bar

Biochemical properties	Fresh fruit	Fruit bar	Commercial product
Moisture content (%)	ND	11.07±1.47	10.61±1.18
a_w	ND	0.58±0.02	0.54±0.01
pH value	2.93±0.00	2.88±0.31	3.75±0.09
TSS (°Brix)	9.90±0.06	74.40±0.00	68.7±4.06
TTA (%)	1.00±0.07	1.13±0.03	1.99±0.49
TAC (mg/100 g)	1.06±0.00	1.78±0.31	ND
TPC (mg GAE/g)	0.43±0.06	1.27±0.04	ND
%AA	88.23±3.80	86.23±1.28	ND

**ND means not determine.

4. Conclusions

This presented results indicate that the different in sucrose syrup treatment and citric acid adjustment affected on the characteristics of bastard oleaster fruit bar products. The moisture content, water activity, and total soluble solid of bastard oleaster fruit bar were significantly changed with an increase in sucrose syrup concentration. The increasing of sucrose syrup concentration also increases the moisture content of product, resulting to changing the softness and chewiness of fruit bar. The citric acid addition affected significant variation on total acidity, pH value, color, sourness, including texture properties. The ascorbic acid content of raw fruits which may be lost due to the heat during the process. Bastard oleaster fruit bar treated with 40% sucrose syrup and controlling pH level at 2.8 was achieved the most acceptabilities with a well sensorial and textural properties. These process can be suitable for Thai entrepreneurs to apply for the low sugar and natural fruit snack product.

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Declaration of conflicting interests

The authors declared that they have no conflicts of interest in the research, authorship, and this article's publication.

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