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Nutritional evaluation of functional biscuits supplemented with Malva nuts (Sterculia Lychnophora)

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Abstract
Malva nut or Sterculia lychnophora is a traditional medicine and is widely found in the Southeast Asiaregion and China. This traditional medicine is known to have good health effects and can act as a food additive to improve the texture of several food products as well as functional ingredients. In this study, nutritional evaluation of functional biscuits supplemented malva nuts (Sterculia lychnophora) was thoroughly and successfully investigated. Consequently, the crude malva nut powders were extracted by using two different solvents (water and ethanol) and were supplemented into biscuits at the level of 2.5%,5%, 7,5%, and 10%. The physio-chemical determination and sensory evaluation were carried out to all the developed biscuits. Overall, supplementation of crude malva nut powder into biscuits significantly affects the nutritional values and physical properties of developed biscuits. On the nutritional basis, at the same level of supplementation, biscuits supplemented with water extracted crude malva nut powder showed higher fat content while biscuits made with ethanol extracted ethanol demonstrated higher ash, protein, fiber, and total carbohydrates contents, especially at 10% of supplementation. For the sensorial differences, except the 7.5%, biscuits with 2.5%, 5%, and 10% crude malva nut powders clearly un identical. The obtained results of this study have indicated that the developed biscuits were not only improved in terms of nutritional value and health benefits, but also had high potential of being accepted by consumers.

Keywords: malva nut, *Sterculia lychnophora*, solvents, functional biscuits

Introduction

Malva nut fruit is known as Đười ươi or Lười ươi in Vietnam. In other parts of Asia, malva nut is also known as Pangdahai (Mandarin), Samrong (Thai), Samrung (Burmese), Samrang (Khmer) and Cheng T'ng Tree (Singapore). Malva nut [Scaphium scaphigerum (G.Don) Guib and Planch] belongs to the Sterculiaceae family and mostly found in Southeast Asia, China and the eastern region of Thailand (Srichamroen & Chavasit, 2011). So far, Lao has been seen as the largest producer of the malva nut. However, when talking about the quality, malva nut comes from Vietnam is regarded as the best.

In Vietnam, malva nut trees are commonly grown in the central and north regions. The seeds are known to contain a large amount of mucilaginous substance and have been used as a traditional medicine in South-East Asia (Somboonpanyakul, Wang, Cui, Barbut, & Jantawat, 2006). This traditional drug is reputed for its prevention of, and as a remedy against pharyngitis (Wang, Wu, & Geng, 2013). It has also been used for the treatment of tussis and constipation since ancient times in China (Wang et al., 2013). Modern pharmacological studies have showed that extracts and individual compounds isolated from Pangdahai had a wide variety of biological effects, including promoting excretion, reducing blood pressure, inhibiting the formation of calcium oxalate crystal, anti-inflammatory, antihypertensive, antibacterial and weight-loss and so on (Li, 2015). Moreover, malva nut is believed to have the weight-losing effect. An experiment done on rats had proved that the ones that were fed with powdered malva nut pulp decreased their weight significantly in compared to the control group. Another study about weight losing effect of malva nut was performed by Chaitokkia and Nithchatorn (2018), where two groups of hospital officers were put on the test. The group of officers that were given 240ml of liquid containing 2g of fiber extracted malva nut daily for two months had showed a significant reduction in the energy and waist circumferences as well as an increase in the fiber intake in compared to the controlled group. As a result, Chaitokkia and Nitchatorn (2018) have pointed that malva nut gum can enhance the efficacy of fiber and has a high potential to use as a functional ingredient for waist circumference or obesity reduction. Beside the pharmaceutical application, malva nut flesh is now widely used in food production. Commonly, malva nuts are used to produce dessert or drinks that have cooling and refreshing effects. Moreover, due to the gelling property, the gum from malva nut is used as thickening agent or stabilizer for soup and foods that have high viscosity. The replacement of wheat flour by graded amount of crude malva nut gum altered the pasting behaviour, textural properties, and freeze–thaw stability of wheat pastes and gels (Phimolsiripol, Siripatrawan, & Henry, 2011). Furthermore, through the study of Somboonpanyakul, Barbut, Jantawat, and Chinprashast (2007) had showed that the addition of malva nut gum into meat paste can help increase the cooking yield and textural properties of the poultry meat batter; make it a potential additive in the meat industry.

From the malva nut, scientists have found that it is high in polysaccharide, lipids, alkaloids, flavonoids, and other trace element. Chemical composition analysis revealed that Pangdahai imported from Vietnam contained 12.36 % crude protein, 5.89 % crude fat, 53.23 % carbohydrate and 29.45 % reducing sugar (Li, 2015). From the study of Somboonpanyabul et al., 2004, the alkaline extraction of malva nut yielded 83.1g/100g of carbohydrate, 8.4g/100g of ash and 8.3/100g of protein. The major constituents of carbohydrates include arabinose, galactose and rhamnose together with small amounts of uronic acid, glucose, and xylose. The study of Srichamroen & Chavasit, 2011 had successfully extracted the dietary fiber from malva nut planted in Thailand, which yielded up to 80/100g of total dietary fiber. For the lipids content, although it is quite low in the malva nut, fatty acids content is the most studied. According to Li (2015), fatty acids from malva nut are mainly linoleic acid (37.96% of total ethanol extract), palmitic acid (24.77%), oleic acid (19.77%) and stearic acid (5.01%). The research of Samsul, Wahab, and Mohsin (2018) had found that the fatty acid methyl ester from the malva nuts contain high amount of sterculic acid (55%) and linoleic acid. Also, according to Li (2015), the trace elements that are found in Pangdahai mainly included calcium, potassium, magnesium, phosphorus, sulfur manganese, phosphorus, zinc, etc.

Biscuits are now being seen as a source of staple foods, snacks, luxury gifts and dietary products. In British, biscuits are sweet or semi-sweet thinly baked wafer that have crunchy texture. The main ingredients required to produce biscuits including wheat flour, sugar, and fat. These products are extremely low in moisture content; therefore, they have quite long shelf-life. However, in America, biscuits are referred to semi-moist breakfasts that are quite low in sugar. To describe the crunch and thinly baked confectioneries, Americans usually use crackers and cookies. Looking alike biscuits in British, crackers and cookies are also low in moisture content and have relatively long shelf-life. Biscuits, cookies, and crackers are now widely sold on the market due to easily manipulation in the ingredients, convenience and high in profits. Due to the requirements of healthy diets, many versions of biscuits that are varied in flavor, high in dietary fiber, and other nutritional values have been put on the market's shelves. Some studies have used the supplement of mustard powder, fenugreek powder, mango peel powder, etc. to improve the nutritional composition of biscuits. In this project, the malva nut is going to be investigated to evaluate the nutritional values, physical, and sensory properties when supplemented into biscuit.

Materials and Methods

Materials

Malva nut was purchased from the traditional medicine pharmacy in Ho Chi Minh City. All the ingredients required for the making of biscuits including eggs, sugar, butter, wheat flour, and baking powder were purchased from Nhat Huong Company and Coop-mart supermarket, Ho Chi Minh City, Vietnam. The chemicals used for preparation and analysis of samples including sodium acetate, ethanol, aluminum chloride, potassium hydroxide, etc. were purchased from local agents in Vietnam.

Methods

Preparation of crude malva nut powder

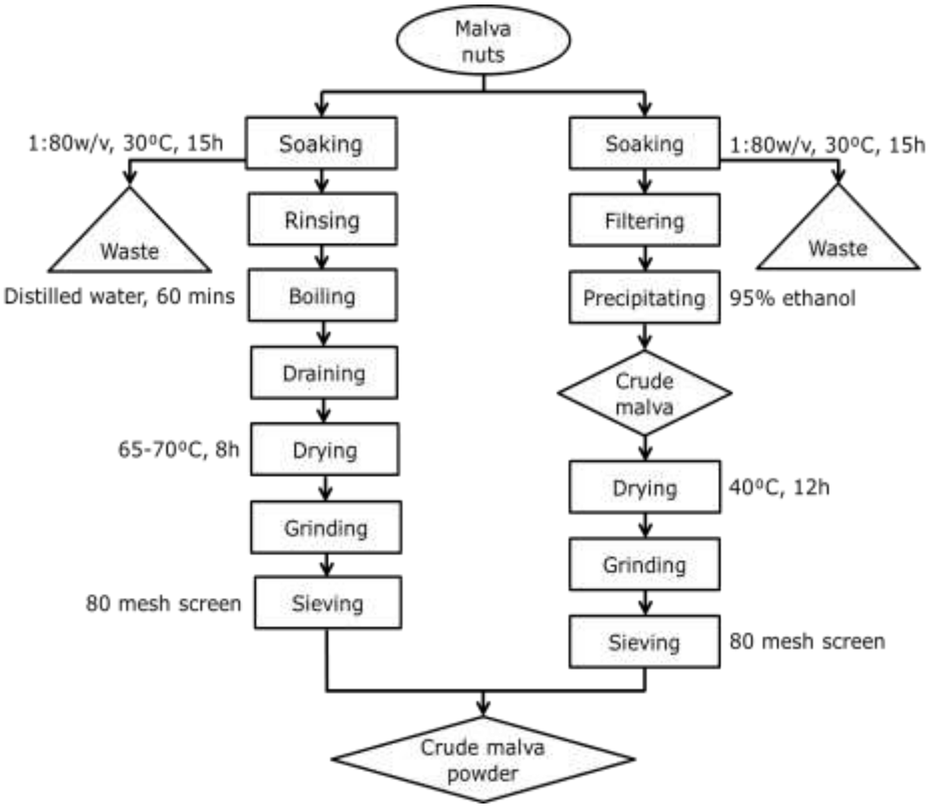

Figure 1. *Malva nut preparation and chemical analysis process*

To collect the sounded nuts, all the molded and defected nuts were removed. The extraction of malva nut followed the method previously described by Phimolsiripol et al. (2017) with a slight modification. Firstly, the malva nuts were soaked in water with ratio 1:60 w/v until fully swell and re-hydrated. The skin of the seed after being soaked was be removed and the flesh (suspension jelly) was be filtered through a 60-mesh silk screen to remove the remaining water. Following was the precipitation of the crude mucilage by using 3 volumes of 95% ethanol and filtering of the precipitation. After that, the precipitation will be oven dried at 60-65ºC for 12 hours. Finally, the dried malva flesh was milled into powder, was sieved through 80-mesh screen, was packed into airtight zip lock bags, and was stored at ambient temperature.

Another method of malva nut extraction was done by following the method from the study of Philcharoenphon, Gritsanapan, Peungvicha, and Sithisarn (2017) with a slight modification. Firstly, soaked the malva nuts into water until fully swelled and re-hydrated. After that, the skin was separated, and the flesh was rinsed. The flesh was boiled in distilled water for 1h and filtered through a piece of cloth. Next, the boiled flesh was spread onto trays and dried at 60-65ºC for about 12h. Finally, the dried malva nut flesh was milled and sieved through 80-mesh screen to collect the powder. The powder was packed into airtight zip lock bags and was stored at ambient temperature until use.

Preparation of crude malva biscuits

To prepare the biscuits, first, cream together 100g of butter and 150g of sugar until light and fluffy then beat in 1 large egg and 7.5ml of vanilla extract. Next, all the remaining dry ingredients including 280g of all-purpose flour, 2.5g of baking powder and 1g of salt were mixed and sieved to remove lumps. After prepared the dry and the wet mixtures, incorporate them until fully combined. Before rolling the dough, the oven was preheated to about 160ºC. The working surface and the rolling pin were dusted with some four to roll out the dough. The dough was rolled into about 3 to 5mm thick then was cut out by using a round cookie cutter to achieve same size and shape biscuits. After cutting, the biscuits were transferred onto baking tray lined with parchment paper and was put into oven to bake for about 20 to 22 minutes.

The developed biscuits were be prepared by replacing the all-purpose flour with 2.5%, 5%, 7.5% and 10% w/w of malva nut powder. The procedure for making samples followed exactly like what are described in the previous paragraph but using the different level of flour substitution. The details of ingredients for different biscuit formulas are shown in Table 1.

From the table as well, the symbols used to indicate different biscuit samples include:

A – Biscuit prepared from 100% wheat flour.

B – Biscuit prepared from 97.5% wheat flour and 2.5% crude malva nut powder extracted with water.

C - Biscuit prepared from 95% wheat flour and 5% crude malva nut powder extracted with water.

D - Biscuit prepared from 92.5% wheat flour and 7.5% crude malva nut powder extracted with water.

E - Biscuit prepared from 90% wheat flour and 10% crude malva nut powder extracted with water.

F - Biscuit prepared from 97.5% wheat flour and 2.5% crude malva nut powder extracted with ethanol.

G - Biscuit prepared from 95% wheat flour and 5% crude malva nut powder extracted with ethanol.

H - Biscuit prepared from 92.5% wheat flour and 7.5% crude malva nut powder extracted with ethanol.

I - Biscuit prepared from 90% wheat flour and 10% crude malva nut powder extracted with ethanol.

*Table 1. **The formulations of biscuit containing crude malva nut powder***

Ingredients	**Biscuit containing crude malva nut powder**								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Butter (g)	100	100	100	100	100	100	100	100	100
Sugar (g)	150	150	150	150	150	150	150	150	150
Egg	1	1	1	1	1	1	1	1	1
Vanilla extract (ml)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Baking powder (g)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Salt (g)	1	1	1	1	1	1	1	1	1
All-purpose flour (g)	280	273	266	259	252	273	266	259	252
Crude malva nuts powder (g)	0	7	14	21	28	7	14	21	28

Figure 2. Flow chart for biscuits production

Proximate analysis of crude malva nut powder samples

Moisture content

The moisture content of the crude malva nut powder samples were measured by using the oven. Three aluminum trays were prepared for each powder sample, each tray contained about 2g of sample. The oven was heated to 105ºC. All the trays were put into the oven for about 30 minutes and were took out and reweigh and put back into the heated oven for another 30 minutes. The procedure was repeated and stopped until the recorded sample weight unchanged. The moisture content of the two crude malva nut samples were calculated by following the equation:

$$MC\ (\%) = \frac{(initial\ tray + sample\ weight) - (final\ tray + sample\ weight)}{sample\ weight}$$

Ash content

The ash content of crude malva nut powder was be determined by using muffle furnace, which was described by Liu (2019) with a slight modification. 2g of sample was weighted into each porcelain crucible and was primarily burnt by using a blow torch under weak or medium flame inside the fume hood. The burning process stopped when there was no white smoke come out and the sample was completely charred.

After that, the crucibles containing charred sample was put into the muffle furnace at 550ºC for about 3 hours. The muffle furnace was let to cool down to about 250ºC then the samples were taken out and let cooled down for about 10 to 15 minutes in the desiccator. After cooling down, weight the crucibles and recorded the data. The ash content of the sample was calculated according to the following equation:

$$\%Ash(wb) = \frac{W2 - W1}{Weighofsample \times 100\%}$$

Fat content

Fat content of the samples was determined by using Soxhlet method (AOAC 2007, Neilsen 2010). First, 3g of crude malva nut powder sample was weighted onto a piece of filter paper and tightly wrap. The weight of the filter paper with 5g of sample was recorded before putting inside the Soxhlet extractor. Next, 300ml of hexane was used to extract the fat of the sample for about 6h. After the Soxhlet extraction was done, the filter paper was removed from the extractor and dried at 70ºC for 24h and let cool. The weight of the sample after cooled down was recorded to determine the fat content, which was calculated by following the equations:

$$fat\ (\%) = \frac{weight\ of\ sample\ after\ drying - weight\ of\ empty\ cup}{weight\ of\ sample\ taken} \times 100$$

Protein content

The protein content of the sample was be determined by Kjeldahl method (Beljkš et al., 2010). About 1g of crude malva nut powder was put into the digestion tube. To prepare for the protein analysis, 0.2g of CuSO4, 1g of K2SO4 and 20ml of concentrated H2SO4 were add to the digestion tube containing the sample. The digestion tube was placed onto the digestion block, covered with exhausted system, and started to run the system. Let the system run until the white fume appears, at which the temperature of the system reached to about 370ºC and the system was let to continue heating for about 60 to 90 minutes until no charred material remaining. After digestion was done, the digestion tube was taken off the digestion block and allowed to cool down on the hang rack. When the sample was cooled, it was diluted with 50ml of distilled water. Next up, the digested sample was distillated. First, the distillation block was rinsed with water, which was automatically done by the distillation system (program 0). In the receiving flask, 50ml of H3BO3 weaned the digestion tube and the receiving flash was installed onto the distillation block to begin the distillation process (program 1). When the program 1 run, 50ml of NaOH was automatically pumped into the digestion tube and the sample was heated until boiled. This process run for about 8 minutes, that was when the ammonia from the digested sample trapped inside the H3BO3 containing flask. The receiving flask was titrated with 0.1N H2SO4 by using the burette until the color of the sample change from green to blue. The protein content was calculated by following the equations:

$$\%N = Normality\ H2SO4\ \times \frac{correctted\ acid\ vol.(ml)}{g\ of\ sample} \times \frac{14\ g\ N}{mol} \times 100$$

Crude fiber content

The crude fiber was be determined by following Weeden method (AOAC 2007) by using the sample after doing the fat analysis. Firstly, 1g of sample (F0) and 1g of filter aid (Celite 545) was weight and put into a crucible. The crucible was inserted into the analyzer and the water valve was opened. 150ml of 1.25% H2SO4 was pre-heated and added into the system up to the second notch as well as three to five drops of n-octanol (anti-foaming agent). The system was let running to boil for about 30 minutes then the H2SO4 was drained by the instrument's vacuum. After draining H2SO4, the sample was washed three times with deionized water while being stirred with compressed air. After the last wash, 150ml of pre-heated 1.25% KOH was added into the system up to the second notch as well as three to five drops of anti-foaming agent and let to boil for another 30 minutes then drained out the KOH. Next, after KOH was drained, the sample was washed three times with deionized water and stirring compressed air. Following was another washing step to cool down the crucible by using deionized water. After cooling down the crucible, the sample was washed three times with 25ml of acetone, with stirring compressed air. When the acetone washing step was done, the crucible was taken out and dried in the oven at 105ºC for 1h and let cooled in the desiccator. Cooled crucible was weighted, and the data was recorded (F1). After that, the crucible was put into the

muffle furnace and heated up to 550ºC for 3 hours and let cooled completely. The sample after being taken out of the muffle furnace and let cooled was re-weighted and the data was recorded (F2). The crude fiber content was be obtained by calculated according to the following equation:
% Crude fiber in ground sample = C = (Loss in weight on ignition loss in weight of ceramic fiber blank) x 100 - weight sample

Total carbohydrate content

Total carbohydrate content follows total carbohydrate (%, DW) = 100% - protein content (%, DW) – lipid content (%, DW) – ash (%, DW) (Hung, P. V, 2012).

Functional properties analysis of the malva nut flour samples

Bulk density

The bulk density of crude malva nut powder supplemented flour samples was measured by following the method was previously described by Oladele and Aina (2007). Weighted 50g of sample and put it into a 100ml cylinder. Continuously tap the cylinder until the volume remains constant. The bulk density was determined by the equation:

$$bulk\ density\ (\frac{g}{cm^3}) = \frac{weight\ of\ sample}{volume\ of\ sample}$$

Water absorption capacity (WAC)

The water absorption capacity of crude malva nut supplemented flour was measured by following the method previously described by Chandra, Singh, and Kumari (2015). 1g of flour sample (Ws) was mixed with 10ml of distilled water into a falcon tube and let stand at room temperature for 30 minutes. After let standing, the falcon was put into the centrifuge for 30 minutes at 3000 rpm. After that, decanting the clear supernatant and weighing the falcon tube (Ws+w). The WAC of crude malva nut powder supplemented flour was determined as gram of water per gram of sample:

$$WAC = \frac{W_{s+w} - W_s}{W_s}$$

Oil absorption capacity (OAC)

The determination of oil absorption capacity was done with the method previously described by Chandra et al. (2015). 1g of flour sample (W_s) and 10ml of soybean oil was mixed in a falcon tube and let stand at ambient temperature for 30 minutes. After 30 minutes of standing, the falcon tube was centrifuged at 3000 rpm for 30 minutes. Decanting the clear supernatant on top and weighing the remaining suspension (W_{s+o}). The OAC of crude malva nut supplemented flour was determined as gram of oil per gram of sample by following the equation:

$$WOC = \frac{W_{s+o} - W_o}{W_o}$$

Proximate analysis of crude malva nut powder supplemented biscuits

The moisture content, ash content, fat content, protein content, and crude fiber content of developed biscuits were examined by following the methods applied for crude malva nut powders analysis.

Physical properties measurement of biscuits

The determination of biscuit's width, thickness, volume, and specific volume was adopted from Ma and Baik (2018). After baking, the biscuits were let cooled for at least 30 minutes before performing the analysis. The weight of each biscuit was measured by using the digital scale. The calipers were used to perform the measurement of each biscuit thickness once and width three times and got the average. The volume of each biscuit was determined by following the equation: $volume = \pi hr^2$ (h is the thickness and r is the average width of each biscuit). The specific volume of each biscuit was calculated by taking the biscuit volume divided by the biscuit weigh. The hardness of biscuit was measured by Brookfield texture analyzer at Industrial University, Ho Chi Minh City.

Sensory evaluation

Triangle test

42 untrained panelists were asked to perform the triangle test to determine whether there is a difference in the biscuits sample with the same level of crude malva nut powder supplementation but distinct in the ways of extraction. For each level of supplementation, the panelists were randomly presented with three samples including two identical samples and a distinct one that had been coded with different 3-digit codes. The panelists were requested to give all the samples a taste and point out the one that they think is the odd sample compared to the other two.

Rating test

The developed biscuit samples were evaluated for consumer acceptance by 40 untrained panelists. The panelists were asked to evaluate the flavor, color, texture, odor, and overall acceptance of nine biscuit samples based on 9-point hedonic scale. Each panelist will be served with a tray including nine randomly arranged biscuit samples that have been distinctly coded with 3-digit codes, a cup of water for palette rinsing, a questionnaire, and a score card.

Statistical analysis

The data obtained from the experiments were be analyzed by using Minitab Statistical Software. All the experiments were done triplicate and analyzed by applying one way ANOVA (95% of confidence interval).

Results and Discussion

Proximate analysis of crude malva nut powder samples

The results of proximate analysis of crude malva nut powder extracted by water and ethanol are presented in the Table 2.

From the Table 2, the moisture content of crude malva nut powder extracted by water and crude malva nut powder extracted by ethanol were 8.83 ± 0.2 and 7.5 ± 0.00% respectively. The powder extracted by using water has a bit higher moisture content, about 1.3% compared to the powder extracted by using ethanol. This parameter is crucial in determining the storing condition of crude malva nut powder since high moisture content allows microorganisms, especially molds to grow and develop. From numbers of researching articles, the moisture content of crude malva nut powder ranging from as low as 5.34% to as high as 15.5% (Phimolsiripol, Siripatrawan, & Henry, 2011; Pramualkijja, Pirak, & Kerdsup, 2016; Promluck Somboonpanyakul, Barbut, Jantawat, & Chinprahast, 2007; P Somboonpanyakul, Wang, Cui, Barbut, & Jantawat, 2006; Srichamroen & Chavasit, 2011). However, the storing conditions of malva nut has not been studied much. For this such low moisture content, storing at room temperature under desiccated condition is good enough.

Table 2. ***Proximate values of crude malva nut powder extracted by water and ethanol***

Components (%)	Crude malva nut powder extracted with water	Crude malva nut powder extracted with ethanol
Moisture	8.83 ± 0.29[a]	7.50 ± 0.00[b]
Ash	6.70 ± 0.00[a]	6.68 ± 0.06[a]
Fat	1.67 ± 0.24[a]	2.17 ± 0.01[a]
Protein	2.57 ± 0.03[b]	2.77 ± 0.03[a]
Crude fiber	13.62 ± 0.25[b]	15.61 ± 0.13[a]
Total carbohydrate	67.11	65.27

Total carbohydrate is calculated by 100 - (moisture + ash + fat + protein + crude fiber)

According to the Table 2, the ash content of crude malva nut powder extracted by using water and the as content of crude malva nut powder extracted by using ethanol was 6.70 ± 0.00 and 6.68 ± 0.06% respectively. These results indicated that the two crude malva nut sample have quite similar ash content. From the studies of numbers of researchers, the ash content of crude malva nut powder ranging from 4.7 to 8.3% (Phimolsiripol et al., 2011; Pramualkijja et al., 2006; Promluck Somboonpanyakul et al., 2007; P somboonpanyakul et al., 2006; Srichamroen & Chavasit, 2011). According to Li (2015), the mineral elements can be found in malva nut including calcium, potassium, magnesium, phosphorus, and zinc. These elements play quite important roles in maintaining and supporting human's biological system.

As can be seen from the Table 2, the fat content of two crude malva nut sample were relatively similar, about 1.67 ± 0.24% for the powder extracted by using water and 2.17 ± 0.01% for the powder extracted by using ethanol

The fat content of malva nut has been reported to be relatively low. The lowest fat content to be ever reported was 0% by Promluck Somboonpanyakul et al. (2007). The highest fat content of malva nut had been recorded by Oppong, Yang Banahene, Shi-Ming, and Feng (2018) was 5.89% from malva nuts originated in Vietnam. Several fatty acids can be found in malva nut and Sterculia family are linoleic, oleic, malvalic, palmitic, and sterculic acids (El-Sherei et al., 2016).

Alike fat content, protein content of two crude malva nut powder sample were relatively low. While the crude malva nut powder sample extracted by using water had 2.57 ± 0.03% of protein, the crude malva nut powder extracted by using ethanol had a bit higher protein content, about 2.77 ± 0.03%. according to other researchers, the protein content of malva nut had been reported to be ranging from 2.17 to 12.36% (Oppong et al., 2018; Phimolsiripol et al., 2011; Pramualkijja et al., 2016; Promluck Somboonpanyakul et al., 2007; P somboonpanyakul et al., 2006).

The study of Srichamroen (2018), the fiber content varied depending on the different part of the malva nut. The middle layer had been reported to have the highest fiber content, following is the outer layer, and the seeds had the lowest fiber content. Through the study of Klinsukon, Somboonpanyakul, and Laohakunjit (2009), the researchers revealed that the fiber content of malva nut could be up to 45.20%. The lowest fiber content of malva nut to be ever recorded was 3.83% by Phimolsiripol et al. (2011). Falling within the range, the recorded fiber content of two crude malva nut powder samples extracted by using water and ethanol were 13.62 ± 0.25 and 15.61 ± 0.13% respectively. Fiber of malva nut had been long studied on the effects of losing weight, reduce energy intake, reduce waist circumference, control blood glucose, control body weight and reduce the risk of obesity (Chaitokkia & Nitchatorn, 2018; Wongnawa &Thaina).

From the Table 2, it is obvious that the total carbohydrates content occupied mostly the chemical content of two crude malva nut powder samples. The total carbohydrates content of powder sample extracted by using ethanol was 65.27%, a bit lower than the total carbohydrates content of the powder extracted by using water, which was 67.11%. According to P Somboonpanyakul et al. (2006), the major carbohydrates components can be found in the mucilage part of the malva nut are monosaccharides arabinose and galactose. The study of Chaitokkia and Nitchatorn (2018) revealed that carbohydrates of malva nut have lower energy and calories content, which is beneficial in controlling weight and prevent obesity.

Functional properties of composite flour

The functional properties contribute heavily to the determination of usage, application of food ingredients in food processing as well as the storage condition since these will affect quality and acceptability of food products.

Table 3. Effect of incorporating crude malva nut powder on the functional properties of the composite flour

Sample	Bulk density (g/cm^3)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)
A	0.82 ± 0.00^e	0.82 ± 0.01^f	0.84 ± 0.01^c

B	0.84 ± 0.00^{d}	1.44 ± 0.01^{e}	0.93 ± 0.01^{ab}
C	0.85 ± 0.00^{cd}	2.22 ±0.03^{d}	0.9 ± 0.01^{bc}
D	0.86 ± 0.00^{bc}	3.09 ± 0.01^{c}	0.95 ± 0.01^{ab}
E	0.87 ± 0.00^{a}	3.76 ± 0.06^{b}	0.98 ± 0.01^{a}
F	0.84 ± 0.00^{d}	1.51 ± 0.02^{e}	0.9 ± 0.03^{b}
G	0.84 ± 0.00^{d}	2.18 ± 0.02^{d}	0.9 ± 0.01^{bc}
H	0.86 ± 0.00^{bc}	3.1 ± 0.08^{c}	0.91 ± 0.03^{b}
I	0.87 ± 0.01^{ab}	3.97 ± 0.01^{a}	0.94 ± 0.01^{ab}

Table 4. ***Functional properties of crude malva nut powders***

Sample	Bulk density (g/cm^3)	Water absorption capacity (g/g)	Oil absorption capacity (g/g)
Crude malva nut powder extracted with water	0.92 ± 0.01^{a}	91.2 ± 1.7^{b}	1.09 ± 0.01^{b}
Crude malva nut powder extracted with ethanol	0.93 ± 0.01^{a}	96.1 ± 0.14^{a}	1.14 ± 0.01^{a}

Bulk density

From the Table 3, the recorded bulk density of nine composite flour sample ranging from 0.82 to 0.87g/cm^3. The highest value of bulk density has been recorded was 0.87 g/cm^3, which belongs to sample E and I with 10% (w/w) crude malva nut powder substitution. As the level of crude malva nut substitution reduces, the bulk density of the composite flour samples also decreases. The flour sample, sample A, has the lowest bulk density, has 0% of crude malva nut powder.

From the experiment and according to Chandra, Singh, and Kumari (2015), decreasing the proportion of wheat flour can increase the bulk density of composite flours. Moreover, the bulk density is one of the factors that determine the packaging types and designs. Generally, the bulk density is affected by the particle of the flour and powder. The larger the particle size, the smaller the bulk density. Therefore, increasing the bulk density of the flour gives more advantages in designing the packaging, saving packaging materials, and higher packing quantities.

Water absorption capacity (WAC)

As can be seen from the Table 3, WAC of composite flour samples increase according to higher level of crude malva nut powder substitution. The composite flour samples that have the highest and second highest WAC is the sample I and E, these are the sample that had been incorporated with 10% (w/w) of crude malva nut powder. The paired samples, H and D with 7.5% (w/w) crude malva nut powder, G and C with 5% (w/w) crude malva nut powder, F and B with 2.5% (w/w) crude malva nut powder, share similarity in the WAC. The flour sample, sample A, is the one that has the lowest WAC. WAC has numerous impacts on different food products and processing. Good WAC demonstrate higher polysaccharide content of composite flour. According to Chandra et al. (2015), high WAC of composite flour suggests that the flour can be used in formulation of some food such as sausage, dough, processed cheese, and bakery products. Good WAC is also an important factor to indicate that the composite flour is suitable for improving the viscosity of foods such as soup, sauce, salad dressing, and gravy. From the study of Srichamroen (2014) additional of crude malva nut can prevent water loss of bread during storage. However, this characteristic may be undesirable in producing biscuits due to high capacity of moisture absorption from the surrounding environment, which can quickly cause sogginess in the biscuits.

Oil absorption capacity (OAC)

According to the Table 3, the composited flour sample that has the highest OAC is the sample E, up to 98%, and the composited four sample that has the lowest OAC is the sample A, only 84%. Following the sample E, the samples D, I, and B are among the samples that have second highest OAC, ranging from 93 to 95%. The third group that share similarity in the OAC include the sample H, F, G, and C, ranging from 90% to 91%. This suggested that the more the crude malva nut powder incorporated into the flour, the higher the OAC. Good OAC among corporate flours suggested that there were improvements in the protein and polysaccharide compositions. According to Elmanan, Al-Assaf, Phillips, and Williams (2008), the mechanism of oil retention is due to the non-polar amino acid side chains can form hydrophobic interactions with hydrocarbon chains of lipid and strongly adsorb onto the surface of oil droplets. However, crude malva nut powder has high WAC due to many chains of polysaccharides. Therefore, a solution is added into the composite flours, the crude malva nut powder will quickly absorb the moisture and extend throughout the dough, prevent the oil droplet from binding with the non-polar amino acid in the flour, and reduce the oil absorption in the bakery products

Physical properties of developed biscuits

All the physical characteristics' parameters of developed biscuits are indicated by the data in the Table 5.

The width, thickness, and spread ratio were affected according to different crude malva nut powder and level of substitution. Overall, all the biscuits samples showed similarity in the width but a slightly different in the thickness and spread ratio. The biscuit sample with zero level of crude malva nut powder substitution had the lowest thickness, but the highest spread ratio compared to the biscuits made from composited flour, which were 0.50 and 6.75mm respectively. The thickness and spread ratio of developed biscuits were relatively similar and significantly lower than the non-substitued biscuit. The value of thickness varied from 0.57 to 0.59mm and spread ratio varied from 5.85 to 6.13mm. According to Akubor (2003), the reason for reduction of spread ratio in the biscuits made from composite flours is due to the competition of available ingredients for available water. Ingredients which absorb water during mixing will reduce it (Akubor, 2003). Through the study of Hooda and Jood (2005), the hydrophilic ingredients increase the viscosity of the biscuit dough during mixing process, thereby limiting the spread and grain fromation during baking. From the ingredients of the composite flour, crude malva nut powder is the one that has high water absorption capacity, therefore, the developed biscuits had relatively lower spread ratio. However, the spread ratio of developed biscuits when using two crude malva nut powder samples and substitued with different level were not affected. It appears that other functional properties besides water absorption may also affect spread (Akubor, 2003).

*Table 5. **Physical properties of developed biscuits***

Sample	**Width (mm)**	**Thickness (mm)**	**Spread ratio**	**Weight (g)**	**Volume (cm^3)**	**Density (g/cm^3)**	**Hardness (N)**
A	3.43 ± 0.03^{a}	0.50 ± 0.02^{b}	6.75 ± 0.11^{a}	3.66 ± 0.05^{c}	18.23 ± 0.14^{e}	0.20 ± 0.00^{ab}	45.53 ± 0.49^{bc}
B	3.40 ± 0.01^{a}	0.57 ± 0.01^{a}	5.85 ± 0.01^{b}	4.10 ± 0.07^{ab}	20.99 ± 0.04^{bcd}	0.20 ± 0.00^{abc}	34.80 ± 1.13^{de}
C	3.39 ± 0.02^{a}	0.57 ± 0.01^{a}	5.96 ± 0.18^{b}	4.01 ± 0.07^{ab}	20.35 ± 0.20^{cd}	0.19 ± 0.00^{abc}	42.57 ± 1.97^{c}
D	3.38 ± 0.04^{a}	0.58 ± 0.02^{a}	5.98 ± 0.01^{b}	4.04 ± 0.09^{ab}	21.07 ± 0.05^{bc}	0.20 ± 0.01^{abc}	46.41 ± 1.95^{bc}
E	3.37 ± 0.05^{a}	0.57 ± 0.03^{a}	6.09 ± 0.17^{b}	4.17 ± 0.12^{a}	20.15 ± 0.33^{d}	0.20 ± 0.00^{a}	52.21 ± 1.16^{a}
F	3.47 ± 0.08^{a}	0.57 ± 0.01^{a}	6.13 ± 0.09^{b}	3.81 ± 0.13^{bc}	21.33 ± 0.44^{ab}	0.18 ± 0.01^{c}	28.64 ± 0.81^{f}
G	3.41 ± 0.04^{a}	0.59 ± 0.01^{a}	5.77 ± 0.01^{b}	4.1 ± 0.16^{ab}	21.95 ± 0.23^{a}	0.19 ± 0.01^{abc}	32.83 ± 1.63^{ef}
H	3.43 ± 0.01^{a}	0.57 ± 0.02^{a}	6.13 ± 0.06^{b}	3.89 ± 0.20^{abc}	20.76 ± 0.07^{bcd}	0.18 ± 0.00^{bc}	37.58 ± 0.92^{d}

I	3.44 ± 0.02[a]	0.58 ± 0.02[a]	5.80 ± 0.06[b]	3.93 ± 0.08[abc]	21.34 ± 0.06[ab]	0.18 ± 0.01[bc]	47.39 ± 1.90[ab]

The volume of biscuits ranges from 18.23 to 21.95cm^3 and the weight of biscuits ranging from 3.66 to 4.17g. The lowest volume and weight belong to biscuit A and the highest volume and weight value belongs to biscuit G and E respectively. The replacement of crude malva nut powder relatively increased the volume and weight of the biscuits in comparision to the wheat flour biscuit. The biscuits that had been supplemented with crude malva nut powder extracted by using water has much higher weight compared to the wheat biscuits while the ethanol extracted crude malva nut powder supplemented biscuits and wheat flour biscuit closer in weight value. As can be seen from these results, the incorporation of crude malva nut powder can prevent weight loss of biscuits during baking. Since the malva nut powder samples are supperiors in holding water, therefore, the evaporation of water while baking might be reduced. While the volume of biscuits increased according to higher level of crude malva nut supplementation, especially among biscuits incorporated with crude malva nut powder extracted by using water, the density of biscuits decreased respectively. The biscuits with the highest density were the biscuit E and the lowest density belongs to biscuit F. From the Table 5, the biscuits made with ethanol extracted crude malva nut powder somehow have lower density compared to the wheat flour biscuit and biscuits with water extracted crude malva nut powder. The reason of decreasing in the density, according to Ostermann-Porcel, Quiroga-Panelo, Rinaldoni, and Campderrós (2017), possibly due to high fiber content. Incorporation of ethanol extracted crude malva nut powder also increase the fiber content of biscuits, therefore, resulted in lower density. The incorporation of water extracted crude malva nut powder might be replacing the fiber loss when subtracting the wheat flour, therefore, the density of biscuits made with water etracting crude malva nut powder and wheat flour were nearly insignificantly different.

From the Table 5, the hardness of biscuit samples varied depending on the level of crude malva nut powder substitution. Comparing to the biscuit sample A, with the hardness value of 45.53 ± 0.49N, the biscuit samples B, C, F, G, and H were softer, with the hardness value ranging from 28.64 to 42.57N. The reasons for softening among biscuit samples could be the storage condition and the WAC of the biscuits. The crude malva nut powders have been found to have very good WAC. Therefore, under high moisture condition, the absorption of moisture will occur strongly, resulting in the softening of biscuits, and by chance, increasing the crumbliness. However, not all biscuit sample softened, the biscuit sample with high crude malva nut powder content, the sample D, E, and I provided significantly higher value of hardness compared to the sample A. Fiber content could be a good explanation for this phenomenon. A similar study has been done by Singh compared to the sample A. Fiber content could be a good explanation for this phenomenon. A similar study has been done by Singh, Sigh, Jha, Rasane, and Gautam (2015) indicated tat high fiber is one of the factors that increase the hardness of biscuits. Beside the fiber, other factors may heavily contribute to the determination of biscuit hardness are protein content, type and amount of fat used, and particle size of used flour (Mamat & hill, 2014; Pauly, Pareyt, Lambrecht, Fierens, & Delcour, 2013; Rao et al., 2016). Hardness is correlated to the sensory parameters of biscuit products, which directly affects the crumbliness, mouthfeel, texture, flavor, and taste of biscuits.

1. **Proximate analysis of developed biscuits**
   The results of proximate analysis of developed biscuits are presented in the Table 6.

Table 6. ***Proximate values of developed biscuits***

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude fiber (%)	Total carbohydrates (%)
A	5.48 ± 0.02[b]	0.71 ± 0.01[e]	16.25 ± 0.07[g]	7.71 ± 0.01[a]	1.30 ± 0.02[g]	68.55
B	5.98 ± 0.02[a]	0.72 ± 0.01[e]	23.25 ± 0.07[a]	7.18 ± 0.01[e]	1.31 ± 0.01[g]	61.56
C	5.99 ± 0.02[a]	0.80 ±	22.45 ±	7.17 ±	1.39 ± 0.01[f]	62.20

		0.01[c]	0.07[b]	0.01[e]		
D	5.99 ± 0.02[a]	1.00 ± 0.01[a]	19.95 ± 0.07[e]	7.37 ± 0.01[c]	1.44 ± 0.02[e]	64.25
E	6.00 ± 0.01[a]	0.90 ± 0.01[b]	20.75 ± 0.07[d]	6.89 ± 0.01[g]	1.54 ± 0.02[d]	61.92
F	5.98 ± 0.02[a]	0.73 ± 0.02[de]	21.50 ± 0.14[c]	7.25 ± 0.01[d]	1.94 ± 0.02[c]	62.60
G	5.98 ± 0.02[a]	0.76 ± 0.02[d]	19.65 ± 0.07[e]	7.50 ± 0.02[b]	1.98 ± 0.02[c]	64.13
H	6.15 ± 0.28[a]	0.91 ± 0.02[b]	17.85 ± 0.07[f]	7.13 ± 0.01[f]	2.16 ± 0.02[b]	65.80
I	6.16 ± 0.30[a]	0.89 ± 0.02[b]	19.80 ± 0.14[e]	6.90 ± 0.01[g]	2.57 ± 0.02[a]	63.68

Total carbohydrate is calculated by: 100 - (moisture + ash + fat + protein + crude fiber)

As can be seem from the Table 6, the moisture content of biscuits increased according to higher level of crude malva nut powder supplement. At 0% of crude malva nut powder supplement, the moisture content of biscuit A was 5.48%. When the crude malva nut powder was incorporated, the moisture content of biscuits increased noticeable in compared to the biscuit A but relatively similar despite the different crude malva nut powder level. The higher in moisture content was possibly due to good water holding capacity of the crude malva nut powders and the composite flours. A similar result has also been shown through the study of Srichamroen (2014), indicated that incorporation of malva nut powder can increase the moisture content of the final product. The percentage of ash increased according to higher crude malva nut powder supplement. Overall, the biscuit made with 100% wheat flour had the lowest ash content, at 0.71 ± 0.01% only, and the biscuit made with 7.5% crude malva nut powder extracted by water had the highest ash content, at 1.00 ± 0.01%. Through the Table 6, it can be seen that with the same level of crude malva nut powder substitution, the biscuits made with water extracted crude malva nut powder had slightly higher ash percentage compared to the biscuits made with ethanol extracted crude malva nut powder, except the sample B and F. Supplementing crude malva nut powder into biscuit can relatively increase the ash content of the product, which is used to indicate the mineral content in food, is one of the most important parameters in daily nutritional requirement.

From the Table 6, the fat content of biscuits ranging from 16.26 to 23.25%. The sample A had the lowest fat concentration, and the sample B had the highest fat concentration. Overall, supplementation of crude malva nut powder can increase the fat content of biscuits. This could be due to good oil absorption capacity of the coporated flours. However, higher crude malva nut powder level did not result in higher fat concentration in biscuit. During the biscuit making process, the mixing process helped the crude malva nut powder quickly absorbing the moisture from wet ingredients better. As can be seen from the Table 3, the higher crude malva nut powder level, the better water absorption. As a result, the absorption of water limited the retention capacity of oil, which resulted in lower fat content. With the same level of substitution, the biscuits made with ethanol extracted crude malva nut powder had relatively lower fat content compared to the biscuits made with water extracted crude malva nut powder because of better water absorption.

The value of biscuits'protein content ranging from 6.89 to 7.71%. As can be seen from the table, the biscuit sample A, which was made completely with wheat flour, had the highest percentage of value, 7.71 ± 0.01%. However, when the crude malva nut powders were substitued, the protein content of biscuits tended to decrease noticeable. At the same level of substitution, excepting the biscuits H and D, the biscuits made with ethanol extracted crude malva nut powder had higher protein content compared to the biscuits made with water extracted crude malva nut powder. The biscuits I and E with 10% of crude malva nut powder had the lowest percentage of protein, only 6.89 ± 0.01 and 6.90 ± 0.01% respectively. From this data, it proposed that replacing wheat flour with crude malva nut powder does not help improving the protein content of pastries. One of the reasonable explanations for this phenomenon is depending on the protein content of the wheat flour and the crude malva nut powders. The protein content of the wheat flour, according to the manufacture of the wheat flour used for this experiment, ranging from 9.5 to 11%, much higher than the crude malva nut powder (about 2.57% for the water extracted crude malva nut powder and about 2.77% for the ethanol extracted crude malva nut powder). Therefore, when replacing the wheat flour with crude malva nut powder, the protein content of composited flour tended to decrease, resulted in lower protein biscuits.

Also, from the Table 6, overall, the fiber content of biscuits increased according to higher level of crude malva nut powder. Biscuit sample A had the lowest fiber content, only about 1.3 ± 0.02% whereas biscuit sample I had the highest fiber content, about 2.57 ± 0.02%. At the same level of substitution, the biscuits made with ethanol extracted crude malva nut powder gave significantly higher fiber content compared to the biscuits made with water extracted crude malva nut powder. This could be explained by the fiber content of the two malva powder in the Table 2. As can be seen from the Table 2, the crude fiber content of ethanol extracted malva nut powder is significantly higher than the water extracted malva nut powder. Fiber has been seen as one of the most important nutrients required in daily food consumption. Moreover, the fiber of malva nut powder has been found to be health beneficial such as losing weight, reduce energy intake, reduce waist circumference, control blood glucose, control body weight and reduce the risk of obesity (Chaitokkia & Nitchatorn, 2018; Wongnawa & Thaina). This study might be useful in applying malva nut into developing various food products and increasing the fiber intake in daily meals.

When subtracting all the collected data about the moisture, ash, fat, protein, and crude fiber content, the total carbohydrates content of the wheat flour biscuits was the highest while the malva powder incorporated biscuits provided much lower results. A similar pattern in total carbohydrates content has been seen among biscuit sample made with crude malva nut powder extracted by water and ethanol. At 2.5%, 5%, and 7.5% of crude malva nut powder, the total cabohydrates content of biscuits increased gradually, from 61.56 to 64.25% among biscuits made with water extracted malva nutpowder and from 62.60 to 65.80% among biscuits made with ethanol extracted malva nut powder. However, at 10% of crude malva nut powder, the total carbohydrates content decreased dramatically, to only 61.92% in the biscuit made with water extracted malva nut powder and 63.68% in the biscuit made with ethanol extracted malva nut powder. Decreasing of total crabohydrates content when incorporating crude malva nut powder may indicate the reduction of starch and sugar, which is beneficial for controlling glycemic index and diabete patients.

Sensory evaluation

Triangle test

The triangular or triangle test is a discrimination test designed primarily to determine whether a perceptible sensory difference existed or not between two products (Sinkinson, 2017). In a triangle test, three samples will be presented to the panelists, two of which are identical. The requirement of the test is to point out the odd sample, which is different from the other two. There are six possible serving orders: AAB, ABA, BAA, BBA, BAB, and ABB, which should be randomized across al panelists to prevent psychological erros due to position, as often the temptation is to perceive the second sample as the different one (Sinkinson, 2017). The considered null and alternative hypothesis for these triangle tests was:

- H_o: there is no significant different between two biscuit samples with the same level of supplementation.

- H_1: there is a significant difference between two biscuit samples with the same level of supplementation.

To accept or reject H_o , α risk, β risk, and P_d must be taken into consideration. Alpha risk is the risk of concluding that a perceptible difference exixts between the two products, when in truth they are the same (false positive or type I error) and Beta risk is the risk of concluding that no perceptible difference exists between the two products, when in truth they are different (false negative or type II error) (Sinkinson, 2017). To determine the similarity between biscuit samples, the β risk must be considered at minimum. For similarity, P_d is the maximum proportion of “distinguishers” that the sensory professional can tolerate being able to detect a differnce between products (Sinkinson, 2017). Therefore, to accept the H_o, the chosen β, and P_d for the tests were 5%, and 30% respectively.

There were 42 panelists participated into the test, they were asked to evaluate three biscuit samples prepared from two crude malva nut powders at the same level of substitution and identify the odd one. There were four tests done according to four level of crude malva nut powder substitution 2.5%, 5%, 7.5%, and 10%. The number of panelists guessed correctly were 15 for 2.5% of crude malva nut substitution, 14 for 5% of crude malva nut substitution, 18 for 7.5% of crude malva nut substitution, and 15 for 10% of crude malva nut substitution. According to the Appendix 5, at n = 42, β = 0.05 and P_d = 30% the maximum number of correct responses needed to conclude that two biscuit samples with the same level of supplementation are similar is 16. Reflecting with the collected data, the biscuit samples with 2.5%, 5%, and 10% of crude malva nut powder substitution have lower number of correct answers while the biscuit samples with 7.5% of crude malva nut powder substitution gave higher number of correct responses compared to the requested correct answers. Therefore, the triangle tests done for biscuits with 2.5%, 5%, and 10% of crude malva nut powder substitution accepted the null hypothesis while the triangle test done for biscuits with 7.5% of crude malva nut powder substitution rejected the null hypothesis. Hence, the panelists can recognize the difference between the two biscuit samples at 7.5% of crude malva nut powder substitution. When being asked about the differences between the samples, the responses from the panelists mostly were about the flavor and the taste of the biscuits despite the identical ingredients beside the crude malva nut powder in the recipe. Surprisingly, some panelists told that they can perceive the differences based on the hardness, which was relatively parallel to the differences in the penetration force exerted on the biscuits in the instrumental hardness determination test.

Rating test

The sensorial rating test involves two or more samples, and the panelist is asked to rate his or her preference for one of the samples on a specific quality on the score sheet. There are many types of scale used in testing, including category scales, line scales, and magnitude estimation scales. In this test, categorial scaling, especially hedonic scale, was used to measure the extent of like or dislike for the characteristic of food (Rousseau, 2004). Hedonic scale may include verbal descriptive terms, numbered scale (5-point, 9-point, etc.), or specially designed for children's panelists. For a food product to be successful in the marketplace, consumers must prefer it over other products (Rousseau, 2004). Therefore, consumer panels often are used to indicate preference of one sample over another (Rousseau, 2004). Panelist training is an exception in this test. The number of consumers participating in the test must be large enough to ensure representation of different age, sex, race, and income level. According to Rousseau (2004) and Watts, Ylimaki, Jeffery, and Elias (1989) the number of panelists required for a consumer rating test must range from 100 to 500. With this such large scale of panelists, the interviews or tests may be conducted at a central location such as a market, school, shopping mall, or community center, or may take place in consumers' home (Watts et al., 1989). However, performing this is relatively costly and time consuming. Therefore, untrained in-house consumer panels are commonly used to provide initial information on product acceptability and often are conduct prior to truer consumer tests. In-house panels are much easier to conduct, consist of 30 to 50 panelists, allow for more control of testing variables and condition. The consumer test performed for the study on developed malva biscuits was an in-house test using 9-point hedonic scale. In-house panels, however, meant to augment, not replace, true consumer tests (Watts et al., 1989).

Table7. *Sensory evaluation scores of developed biscuits in terms of color, taste, flavor, texture and overall acceptability in 9-point hedonic scale*

Sample	Color	Flavor	Taste	Texture	Overall acceptance
A	6.65 ± 1.44[a]	6.80 ± 1.32[a]	6.90 ± 1.41[a]	7.00 ± 1.16[a]	6.98 ± 1.29[a]
B	6.45 ± 1.41[a]	6.75 ± 1.34[a]	6.80 ± 1.44[a]	6.65 ± 1.44[a]	6.83 ± 1.30[a]
C	6.58 ± 1.20[a]	6.53 ± 1.52[a]	6.98 ± 1.39[a]	6.75 ± 1.28[a]	7.05 ± 1.15[a]
D	6.28 ± 1.22[a]	6.05 ± 1.26[a]	6.05 ± 1.30[a]	6.38 ± 1.58[a]	6.23 ± 1.37[a]

E	6.25 ± 1.58 [a]	6.25 ± 1.45 [a]	6.18 ± 1.65 [a]	6.08 ± 1.59 [a]	6.23 ± 1.54 [a]
F	6.25 ± 1.08 [a]	6.55 ± 1.28 [a]	6.83 ± 1.13 [a]	7.03 ± 1.29 [a]	7.08 ± 0.97 [a]
G	6.58 ± 1.32 [a]	6.33 ± 1.40 [a]	6.75 ± 1.35 [a]	6.70 ± 1.42 [a]	6.60 ± 1,45 [a]
H	6.95 ± 1.32 [a]	6.88 ± 1.27 [a]	6.85 ± 1.35 [a]	6.55 ± 1.36 [a]	7.05 ± 1.01 [a]
I	6.58 ± 1.50 [a]	6.20 ± 1.24 [a]	6.53 ± 1.45 [a]	6.48 ± 1.32 [a]	6.75 ± 1.34 [a]

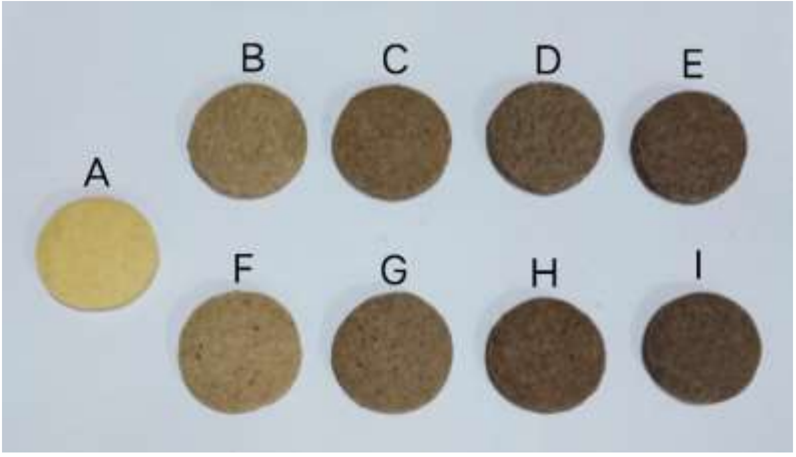

Figure 2. *Developed biscuits with different level of crude malva nut powder*

The mean score of five different attributes given by the consumers is presented in the Table 7. According to the table 7, the sample H, which was made with 7.5% crude malva nut powder extracted by ethanol obtained fairly high score in color (6.95 ± 1.32) and flavor (6.88 ± 1.27). The most preferred biscuits taste and texture belong to sample C with 5% water extracted crude malva nut powder and sample F with 2.5% ethanol extracted crude malva nut powder accordingly. The sample A, made with 100% wheat flour, was the second sample to score the highest in color (6.65 ± 1.44), flavor (6.80 ± 1.32), taste (6.90 ± 1.41), and texture (7.00 ± 1.16). In the overall acceptance, the samples that have high acceptance potential are sample F, C, and H with 7.08 ± 0.97, 7.05 ± 1.15, 7.05 ± 1.01 respectively. However, the preference of consumers of five attributes were statistically similar among developed malva biscuits and the control sample. The reason for no distinction in the score could be due to the flavor and the taste of biscuits. Most of the panelists commented that they barely recognize any differences in the flavor and taste among nine biscuit samples. After extraction, both crude malva nut powders relatively flavorless and odorless. Therefore, these attributes were not affected despite the difference in the extracting method and level of crude malva nut powder. The most noticeable attribute, obviously, was the color. According to Figure 2, the higher amount of crude malva nut powder incorporated into the biscuit, the darker the color. Moreover, according to the instrumental hardness determination test, supplementing crude malva nut powders did affected the crispiness of the biscuits. However, blending in the crude malva nut powders did not seems to affect the liking of consumers on the nine evaluated samples.

Conclusions

- ✓ In this study, the potential of supplementing crude malva nut powder into biscuits to develop new biscuit recipe, to improve nutritional values, and to improve biscuit qualities were successfully and thoroughly investigated.

- ✓ The chemical analysis of the prepared biscuits made with crude malva nut powder extracted using two different solvents brought significant differences in nutritional values and physical properties of developed biscuits.

- ✓ Nearly no sensorial differences were detected among biscuits made with two crude malva nut powders with the same level of substitution.
- ✓ Consumer acceptance for the developed biscuits were relatively positive, especially the biscuits made with 2.5% and 7.5% ethanol extracted crude malva nut powder.
- ✓ The obtained results from this study have shown that the developed biscuits made with ethanol extracted crude malva nut powder significantly improved nutritional values and had higher chance of being accepted by consumers.

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52. Zone, G. E. 18. Sterculia lychnophora Hance. *Maintenance of forest genetic resources is of crucial importance to sustainable development. However, global forest loss and degradation is resulting in a dramatic loss of biological diversity and options for utilisation and development. Cambodia is no exception, with several valuable indigenous tree species presently vulnerable to extinction at species, and in particular, at population level.*, 47.