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Effect of incorporating sweet potato (*Ipomoea batatas*) flour to tapioca flour on the proximate composition, antioxidant activities and sensory evaluation of ice cream

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Ice cream is known as one of the popular frozen dairy products with delicious flavour, smooth texture and pleasing mouth feel while sweet potato has been discovered as a functional food containing high level of phytochemical and antioxidant content. In ice cream manufacturing, the ingredients used play an important role to achieve the desired finished product. Thus, the proximate composition, antioxidant activities and sensory properties of ice cream incorporated with sweet potato flour (SPF) were investigated in this study. Different amount of SPF was used in three different ice cream formulations: F1 using 100 % tapioca flour (TF), F2 using combination of 50 % TF and 50 % SPF and F3 using 100 % SPF. The proximate composition showed that the incorporation of sweet potato flour to tapioca flour was found to give significant ($p \leq 0.05$) effects on the protein, fat and fibre content of the ice creams. The results also revealed that the antioxidant content of ice cream formulated with sweet potato flour was higher than ice cream formulated with tapioca flour. From the six attributes analysed on sensory evaluation, aroma of the three formulations was not significantly different ($p \leq 0.05$) while the other attributes including colour, iciness, mouthfeel, and flavour showed significant different ($p \leq 0.05$). For overall acceptability, the formulations incorporated with SPF were considered acceptable by the consumers since the score was in the range of 5.13 to 6.17 which equal to 'like' to 'like much' in hedonic scale. From the data obtained, it could be recommended that ice cream with nutritive value can be produced by incorporating sweet potato flour in the formulation.

Keywords: Sweet potato, Ice cream, Proximate composition, Antioxidant activity, Sensory evaluation

INTRODUCTION

Ice cream is the most widely consumed product within the frozen dairy dessert category. Frozen dairy dessert contains milk solid which either including milk fat or not and being consumed in a frozen state and also aerated (Goff & Hartel, 2013). According to the Malaysia Food Regulation 1985, ice cream is made from milk or milk product with milk fat, vegetable fat, cream, butter or a combination of these and sugar, and may contain other wholesome food. The percent of milk should not less than 10% milk fat or vegetable fat. The quality of the final product

depends on the processing (Adapa et al. 2000).

Sweet potato (*Ipomoea batatas*) is a dicotyledonous species belonging to the family of morning glory which is Convolvulaceae (Mohammad et al. 2014). It is one of the important food crops after rice, wheat, potatoes, maize and cassava (MARDI, 2017). The production of sweet potato in Malaysia at 43,211.84 Mt per year. The main production areas of sweet potato cultivation in Peninsula Malaysia are Perak (16,455.04 Mt), followed by Kelantan (12,272.15 Mt), Selangor (4,778.76 Mt), Johor (12,900.78 Mt) and Terengganu (2,463.73 Mt) (Department of Agriculture Peninsular Malaysia, 2016).

Sweet potato is a highly nutritious vegetable that rich in source of protein content, better in terms of dietary fiber, certain minerals and vitamin content. Unlike cassava, sweet potato nutritionally good as rice, in term of protein content, dietary fiber, also certain mineral and vitamin content. Dietary fiber positively affects against diabetes, constipation, and colorectal disease. Potassium is also specified against hypertension and cardio-vascular defense. Calcium provides the growth of bones and iron important towards a pregnant woman (Tan, 2015). Other than that, it also provides antioxidants, carotenoids and phenolic compounds that contribute to the flesh color (cream, deep yellow, orange, and purple) of sweet potato (Teow et al. 2007). According to the USDA Nutrient Database, sweet potato has higher in beta-carotene (8509 µg) and vitamin A (14187 IU) compared to others staple food and also claimed as low glycemic index (GI) of 50 whereas white rice is 70. Therefore, due to high nutrient content and its anti-carcinogenic and cardiovascular disease properties, it is good for human health (Teow et al. 2007).

In Malaysia, ice cream is consumed by all levels and ages throughout the year. However, ice cream is always considered as unhealthy food due to the high calories and contains high amount of sugar and artificial flavorings. Thus, in this study, sweet potato flour (SPF) will be incorporated in ice cream formulation to substitute tapioca flour as a thickener.

The objectives of this study were to determine the proximate composition, antioxidant activities and consumers acceptability of the ice cream incorporated with sweet potato flour.

MATERIALS AND METHODS

Materials

The orange-fleshed sweet potato was bought from a local farmer near Tembila, Besut, Terengganu. Only the high quality sweet potato was chosen without any disease and physical damage. Fresh milk, whipping cream, sugar, tapioca flour and skim milk powder were purchased from a supermarket in Jerteh. The stabilizer, carboxymethyl cellulose (CMC) and emulsifier, glycerol monostearate (GMS), were obtained from the laboratory.

Ice cream formulation

There were three ice cream formulations used in this study as shown in Table 1. The difference among the formulations was the amount of sweet potato flour used. Tapioca flour (100%) was used for formulation 1 (F1), while formulation 2 (F2) involves combination of 50% of tapioca flour and 50% of sweet potato flour and for formulation 3 (F3), 100% of sweet potato flour was used in the formulation.

Table 1: Ice cream formulations

Ingredients	F1 (g)	F2 (g)	F3 (g)
Fresh cow's milk	1000	1000	1000
Whipping cream	270	270	270
Skim milk powder	62.5	62.5	62.5
Sugar	202.5	202.5	202.5
Sweet potato flour	-	15.5	30.9
Tapioca flour	30.9	15.5	-
Carboxymethyl cellulose (CMC)	8.1	8.1	8.1
Glycerol monostearate (GMS)	3.4	3.4	3.4

Preparation of sweet potato flour

The sweet potato flour (SPF) was prepared according to the method described by Zainun et al. (2005). The raw sweet potatoes surfaces were cleaned by washing it with tap water and wiping using a clean cloth. The skins of sweet potatoes were peeled manually. Then, it was sliced using a semi-automated slicer to produce 0.1 cm thickness of sweet potatoes slices. According to Pedreschi (2005), some of the loose starch might attached to the surface, so it was removed by rinsing off the slices immediately using distilled water for approximately one minute. Then, the slices were immersed in 0.2% sodium metabisulphite solution for 15 minutes to inhibit the enzymatic activity that may cause the browning of the sweet potato slices. Next, the slices were dried in a lab drier at 50°C for 24 hours to reduce the moisture content to below than 7%. The dried sweet potatoes slices were

ground using a grinder to produce flour. Then, the sweet potato flour was strained using 80 mesh number strainer.

Production of ice cream

The preparation of ice cream was started by weighing all the ingredients according to the formulations listed in Table 1. The fresh cow's milk was added to the cream to become milk sample. The skimmed milk powder, sugar, stabilizer, and emulsifier were then mixed with the milk sample. After that, the sweet potato flour was added to the milk sample at 65°C and homogenized. The final mixture was pasteurized at 85°C for 20 minutes and stored at 4°C and aging for 24 hours. Then the mixture was placed into the hard ice cream machine Model FHICM-45T (Euroasia Food Equipment Sdn Bhd, Penang, Malaysia) at -5°C for six minutes for the churning and freezing process and placed at -20°C for 24 hours for hardening process.

Proximate analysis

Moisture, ash contents, protein, fat, crude fiber of the SPF, TF and ice creams were analyzed using methods described by AOAC (2000). Moisture was determined by oven drying method, ash by combustion, protein by Kjedahl method, fat by soxhlet method extraction, crude fiber by acid and alkali digestion method and carbohydrate was calculated by subtracting from the total sum of moisture, ash, protein, fiber and fat.

Total phenolic content

Estimation of total phenolic content in the ice cream was done as described by Wolfe et. al (2003) with slight modification. Ice cream samples of 1 g was blended with 5 ml of distilled water. It was mixed with 1 mL of Folin-Ciocalteu reagent. After 2-3 minutes, 2 mL of 20% sodium carbonate was added. The mixture was incubated for 10 minutes. After that, by using spectrophotometer and using Gallic acid as standard, the absorbance value of mixture sample was measured at 730 nm.

DPPH radical scavenging activity assay

DPPH assay of the ice cream was determined according to method described by Rahman et al. (2015) with slight modifications. The 0.4 mM DPPH reagent was prepared in methanol and then 4 mL of this reagent was added to 1 mL of sample ice cream in test tube. The test tube was vortexed at 500 x g for 2 minutes. After that, the test tube was incubated in the dark at room temperature for about 30 minutes. The reduction in colour was measured by using double beam spectrophotometer at 517 nm. A volume of 4 mL of methanol and 1 mL of DPPH was used as control. The percentage of scavenging was evaluated by comparing with control.

Ferric Reducing Ability of Plasma (FRAP) assay

The total antioxidant potential of sample ice cream was determined by using ferric reducing antioxidant power (FRAP) assay as described by Benzie and Strain (1996). A solution of 10 mmol/L TPTZ in 40 mmol/L HCl and 12 mmol/L ferric chloride was diluted in 300 mmol/L sodium acetate buffer (pH 3.6) at a ratio of 1:1:10. Aliquots (200µL) of sample was added to 30 mL of the FRAP solution and allowed to react for 90 minutes at 37°C before reading the absorbance at 593 nm.

Sensory Evaluation

For this sensory evaluation, consumer acceptance test was conducted for thirty untrained panellists. Each panellist was provided with room temperature water to cleanse their palate in between each sample. Then, each panellist evaluated the samples for acceptability in terms of color, aroma, flavor, iciness, mouth feel and overall acceptance using a 7-point hedonic scale which 1-dislike much, 4- either like or dislike and 7- like much.

Statistical Analysis

All the analysis were done in triplicate and data was presented as mean ± standard deviation (SD). The data was statistically analysed by one way ANOVA using SPSS. Values with a confidence level superior to 95% ($p<0.05$) was considered to be significant.

RESULTS AND DISCUSSION

Proximate and antioxidant analysis of flours

Table 2 shows the results of proximate and antioxidant analysis of tapioca flour and sweet potato flour. Based on the result, sweet potato flour contains higher nutritional value of ash content, protein content, fat content and fibre content compared to tapioca flour. It also contains higher antioxidant content compared to tapioca flour based on the result of total phenolic content (TPC), DPPH and FRAP value. While tapioca flour had higher moisture content and carbohydrate compared to sweet potato flour.

Table 2: Proximate and antioxidant analysis of flours.

Parameter	TF	SPF
Moisture (%) (%content(%)(%)	12.86±0.04[b]	6.27±0.09[a]
Ash content (%)	0.17±0.02[a]	1.10±0.04[b]
Crude protein (%)	0.42±0.03[b]	3.87±0.00[a]
Fat content (%)	0.24±0.21[b]	1.38±0.08[a]
Crude fiber (%)	0.58±0.08[b]	2.63±0.39[a]
Carbohydrate (%)	85.73±0.22[a]	84.75±0.42[b]
TPC (mg/mL GAE)	0.46±0.15[a]	0.38±0.09[b]
DPPH (%)	85.40±0.23[a]	90.73±0.14[b]
FRAP (mM/g)	0.22±0.06[b]	1.53±0.11[a]

Effects of incorporating sweet potato flour to tapioca flour on the proximate values of ice cream

Figure 1 presents the moisture content of the ice creams. It can be seen that moisture content decreased significantly when 50% of sweet potato flour was incorporated. The sweet potato flour contain significantly lower moisture content compared to tapioca flour causing the reduction in moisture content of F2 sample. Besides, water present in ice cream mixture my bind with amylose and amylopectin of sweet potato during gelatinization. However, a slight increment can be observed when 100% of sweet potato flour was used in the ice cream formulation. However, the moisture content was still around the range of standard moisture content of ice cream which is 61.0% according to USDA (2018).

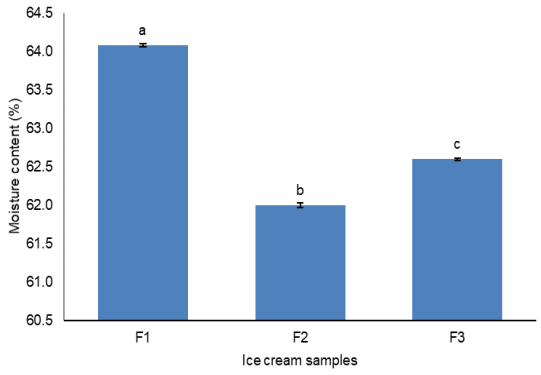

Figure 1: Moisture content of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at p > 0.05.

Figure 2 shows the ash content of the three ice cream formulations. The ash content of F2 and F3 ice creams was expected to increase as the ash content of the sweet potato flour was significantly higher than that of tapioca flour. However, there was no significant increase in ash content was observed possibly due to the minerals loss during filtration of the cooked ice cream mixture before aging process. Manju and Mark (1999) reported that minerals can either be removed from foods during processing such as leaching or physical separation.

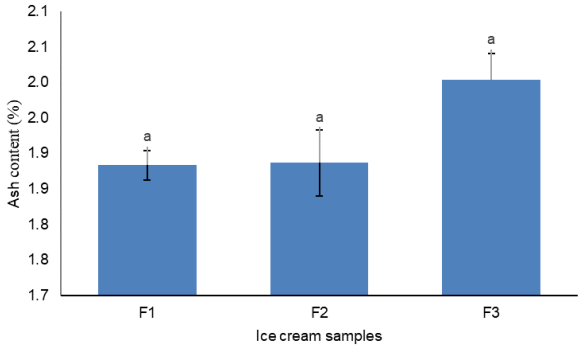

Figure 2: Ash content of the ice cream samples. Means with the same lower letter at different formulation do not differ significantly at p > 0.05.

The result in Figure 3 shows the protein content of the ice creams. There were significant increase in the protein content of ice cream with the increasing of the amount of sweet potato flour used in the ice cream formulations. The sweet potato flour was found to contain higher amount of protein compared to tapioca flour which led to the increasing of protein content of ice cream samples incorporated with sweet potato flour.

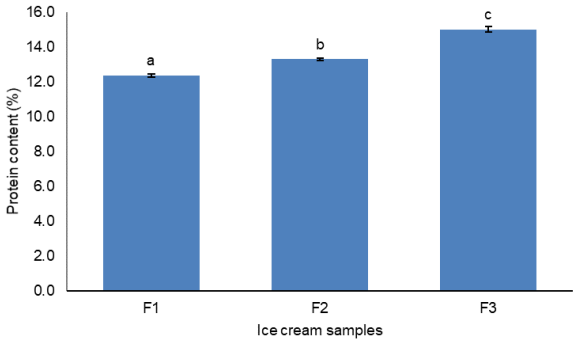

Figure 3: Protein content of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at p > 0.05.

Figure 4 illustrates the fat content of the ice creams. Based on the result, the fat content increased significantly when 50% of sweet potato flour was incorporated in the ice cream formulation. However, there was no significant change observed when 100 % of sweet potato used.

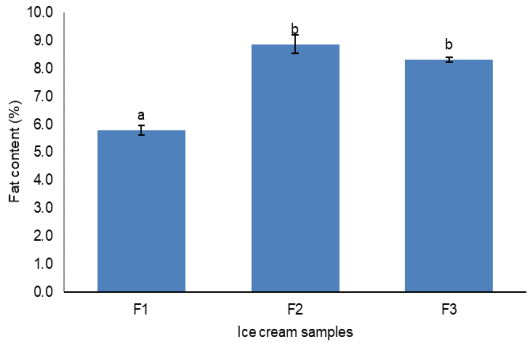

Figure 4: Fat content of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at p > 0.05.

For fibre content, the results are displayed in Figure 5. The result showed that F1 contains 5.46%, F2 contains 0.10% and F3 contains 0.37% of fibre. A significant decrease can be observed when 50% of sweet potato flour was incorporated in the ice cream formulation. Ice cream is known as product with high fat content which have particular functionalities. Incorporation of ingredient with high fiber not only replaces fat but also serves to provide viscosity, improve emulsion, foam, freeze/thaw stability, control melting properties, reduce syneresis, promotes formation of smaller ice crystals and facilitate extrusion (Alexander, 1997). Small ice crystals present in ice cream gives its smooth and creamy texture which favoured by consumers. Even though the fibre content reduced in F2 and F3 ice creams, it was still around the standard of fibre content of ice cream (0.7%) stated by USDA (2018).

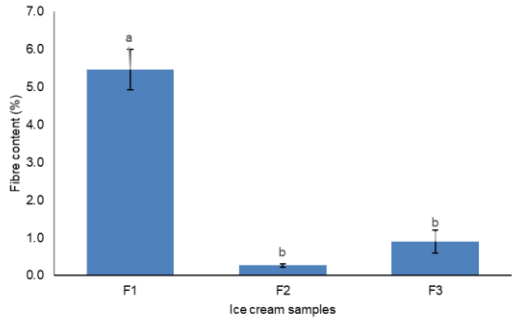

Figure 5: Fibre content of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at p > 0.05.

Effects of incorporating sweet potato flour to tapioca flour on the antioxidant properties of ice cream

The total phenolic content of the three ice cream formulations is shown in Figure 6. The result shows that the concentrations of total phenolic content were 0.175 mg/ml GAE, 0.22 mg/ml GAE and 0.34 mg/ml GAE for F1, F2 and F3 ice creams respectively. A significant increase was observed when 100% of sweet potato flour was used in the formulation.

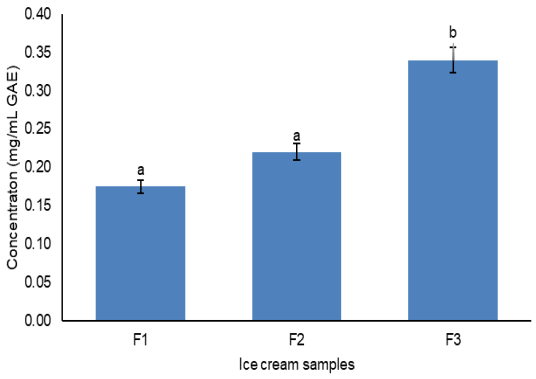

Figure 6: Total phenolic content of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at p > 0.05.

Figure 7 displays the DPPH free-radical-scavenging activity of the three ice creams. The result reveals that the DPPH scavenging activity for sample F1 was 50%, 65.27% for F2 and 79.99% for F3. It shows a significant increase as the amount of sweet potato flour was increased as more phenolic compounds present in sweet potato reacted with DPPH radicals and decolorised the original deep purple DPPH to

yellow color. The scavenging potential is indicated by the degree of decolorisation due to donation of hydrogen protons to terminate the free radical mechanism.

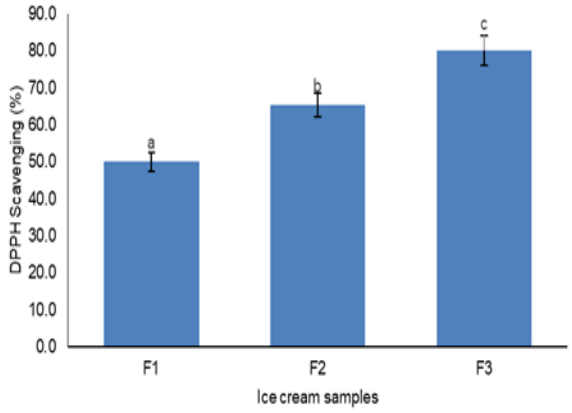

Figure 7: DPPH scavenging activities of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at $p > 0.05$.

Figure 8 shows the FRAP value for F1, F2 and F3 were 1.10 mM/g, 1.21 mM/g and 1.67 mM/g respectively. These results showed that FRAP value increased significantly as the amount of sweet potato flour increased. This study also points out that the incorporation of sweet potato flour in the ice cream formulation contributed to the higher antioxidant activity of the ice creams. It can be correlated with the antioxidant activity of the sweet potato flour which was found to be higher than that of the tapioca flour. Previous study by Dian and Handajani (2011), who used purple sweet potato as an ingredient in ice cream making reported similar results where the increasing in the percentage of purple sweet potato flour used in the ice cream led to the increase in antioxidant activity of ice creams.

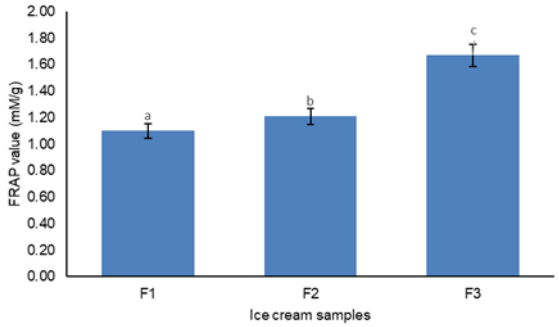

Figure 8: FRAP value of the ice cream samples.
Means with the same lower letter at different formulation do not differ significantly at $p > 0.05$.

Effects of incorporating sweet potato flour to tapioca flour on the sensory evaluation of ice cream

The addition of SPF influences all the sensory parameters analysed. The higher the amount of SPF added into the formulation led to the reduction of sensory acceptability. The mean score for overall acceptability shows that F1 ice cream has higher mean score compared to F2 and F3 ice creams.

Besides, the range for consumers' acceptability were from 5.13 to 6.17 which means from 'like' to 'like much' on hedonic scale. The reduction in the consumers' acceptability towards ice cream formulated with sweet potato flour was possibly due to the texture of the ice cream produced. Similarly, previous study where the addition of cassava derivative in the ice cream formulation (Fernandes et al, 2017) and ice cream with 2% of banana peel flour (Yangilar, 2015) also resulted in a low score in acceptability.

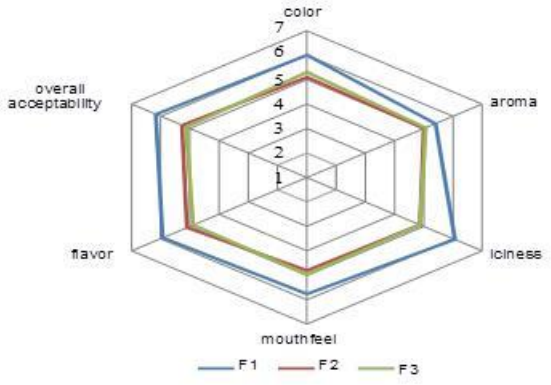

Figure 9: The spider web of sensory analysis of the ice cream formulations.

CONCLUSION

The incorporation of sweet potato flour affected the protein, fat and fibre content of the ice creams. The antioxidant content of ice cream formulated with sweet potato flour was higher than ice cream formulated with tapioca flour. Overall, the ice cream formulations incorporated with sweet potato flour were accepted by the consumers.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Mohamad Faris, S. and Noor Atikah A. L. performed the experiments, run data analysis and drafted this manuscript, while Nurul Zaizuliana, R. A. supervised the experiments and reviewed the manuscript. Nurul Zaizuliana, R. A. is also the project leader for this research grant. Zarinah, Z., Norshazila, S. and Che Abdullah A. B contributed the ideas to design and improve the experiments.

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