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Characterization of ice cream analogue from orange-fleshed sweet potato

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Abstract

This study centered on the effects of partial replacement of cow milk powder (CMP) with cooked orange-fleshed sweet potato (OFSP) residue on the quality of ice cream analogue with a view of elucidating the possible utilization of OFSP in ice cream production using a Completely Randomized Design. Ice cream analogue mixes were formulated from CMP, OFSP and other ingredients by decreasing the quantity of CMP from 800 to 0 g while increasing the quantity of OFSP from 0 to 800 g. The mixes were whipped, packed in a plastic container, frozen quickly and then stored at -18°C. The products were evaluated for chemical, physical and sensory properties using standard methods. Data generated were subjected to Analysis of Variance, while means were separated using Duncan Multiple Range Test at $p<0.05$. The crude protein, minerals except for iron, total soluble solids, overrun and foam stability decreased significantly, while crude fibre, β-carotene and melt rate increased significantly with an increase in OFSP residue in the product. The overall acceptability scores for samples containing 100 g OFSP and 300 g OFSP residue were not significantly different from the sample without OFSP residue (control). The results suggested the possibility of substituting OFSP residue for CMP up to 37.5% of a blend of OFSP and CMP in ice cream production.

1. Introduction

Sweet potato (*Ipomoea batata* L.) is a tropical root crop that belongs to *convolvulaceae* family. It is the world's seventh most important food crop after wheat, rice, corn, potato, barley and cassava (FAO, 2016). The sweet potato is important because it is easy to grow and has high yields (Kamonwan, 2011). It is grown for its starchy roots and immature leaves, which are utilized as human food (Hazra *et al*., 2011), animal feed (Lebot, 2009) and, to some extent, as an industrial feedstock (Woolfe, 1992). It also plays a significant role in improving the economy of rural poor households (Nath *et al.,* 2007). There are several varieties of sweet potato of which orange-fleshed sweet potato (OFSP) is one. According to Burri (2011) and Mica *et al*. (2015), OFSP which is rich in β–carotene, is one of the few crops that are found to be an excellent source of energy and essential nutrients that are capable of improving the nutritional status of the human populace, especially in the developing countries. It has been demonstrated that OFSP contains sufficient levels of β-carotene to combat vitamin A deficiency (VAD) (Hagenimana *et al.,* 1999; Satheesh and Workneh, 2019) when taken as a whole food or used as an ingredient in recipes such as non-alcoholic beverage, ice cream among others.

Ice cream is a popular dairy product among consumers of all ages. However, ice cream produced from cow's milk can present a challenge to those who are allergic to dairy protein and lactose (Okoye *et al*., 2018). Also, whole and skimmed powders are almost exclusively imported by developing countries which dispose of the necessary foreign exchange earnings (Knips, 2005). This has spurred researchers to conduct studies on the utilization of alternatives such as peach fibre (Yangilar, 2016), purple sweet potato (Weenuttranon, 2018), tigernut (Umelo *et al*., 2014) and cape gooseberry (Erkaya *et al*., 2012) for partially replacing cow milk in ice cream to reduce the cost of production. However, the utilization of OFSP for this purpose is yet to be fully exploited. Therefore, this study was geared towards producing and characterizing ice cream analogue produced from cow milk powder (CMP) with OFSP residue which is hitherto regarded as waste in the production of OFSP-based non-alcoholic beverages.

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2. Materials and methods

2.1 Materials

The orange fleshed sweet potato (OFSP) roots used for this study were obtained from the experimental farm of the Department of Food Technology, Federal Polytechnic, Offa, Nigeria. Cow milk powder (CMP), sugar, egg white, flavouring and stabilizing agents were obtained from a local market in Offa, Nigeria. All the reagents used were of analytical grade.

2.2 Experimental design

A completely Randomized Design was used to study the effect of partial replacement of CMP with cooked OFSP residue on the quality parameters of ice cream analogue. Each experiment was replicated thrice.

2.3 Production of ice cream analogue from cooked orange-fleshed sweet potato residue and cow milk powder

The OFSP residue was prepared by using the flowchart in Figure 1 as described by Tariku *et al.* (2010) with slight modifications. Roots of OFSP were sorted, peeled and cut into slices of 10 mm in thickness with a stainless steel slicer. The slices were cooked in potable water at a ratio of 1:9 (w/v) for 15 mins and blended using a blender (Super Interment, Japan) for 5 mins and filtered using a muslin cloth. The residue was used for the formulation of the ice cream analogue.

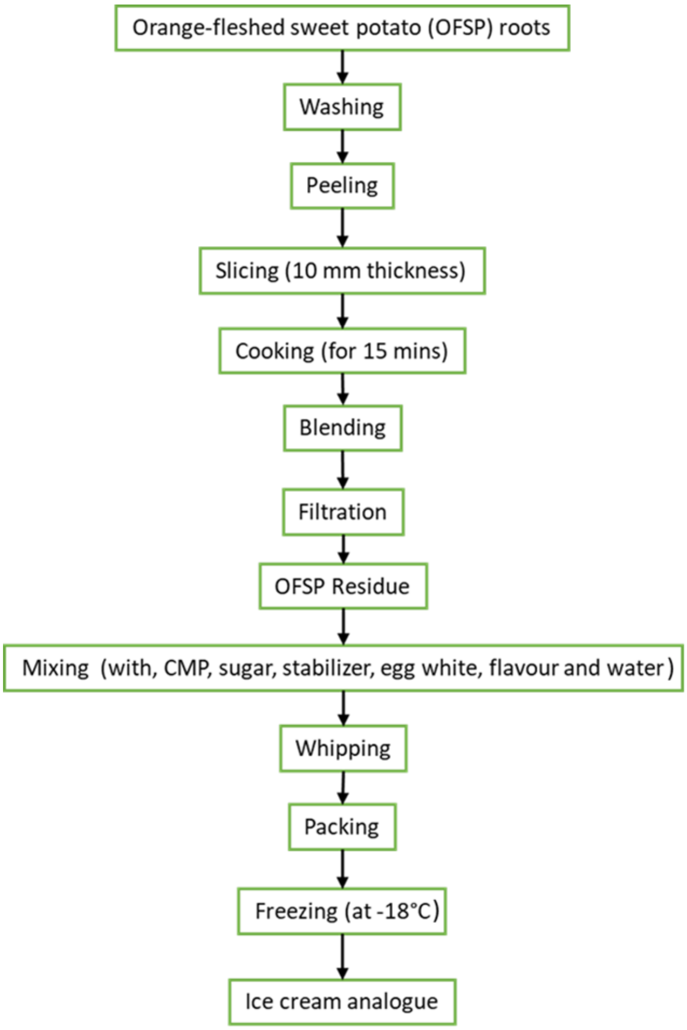

Figure 1. Production of ice cream analogue from orange-fleshed sweet potato (OFSP) residue and cow milk powder (CMP) (Tariku *et al*., 2010).

The ice cream analogue was formulated as summarized in Table 1 and produced by mixing cooked OFSP residue with other ingredients and then whipped to incorporate air, packed in a plastic container and then made to undergo quick freezing to -18°C to avoid the formation of large crystals.

2.4 Chemical analysis

The crude protein, crude fibre, β-carotene and mineral (Ca, K, Fe, P and Zn) contents were determined according to the method of AOAC (2005).

2.4.1 Determination of crude protein

The crude protein was determined by using the Kjeldahl method. The sample (1 g) was digested by heating with 25 mL of concentrated H_2SO_4 in the presence of one tablet of selenium catalyst in a micro Kjeldahl digestion flask. The digest was then diluted with 50 mL of distilled water. The solution (5 mL) was transferred into a distillation apparatus and then 5 mL of 2% boric acid was pipetted into a 100 mL conical flask (receiver flask) and a few drops of screened methyl red indicator were added. About 50% NaOH was continually added to the digested sample until the solution turned cloudy which indicated that the solution had become alkaline. Distillation was carried out into the boric acid solution in the receiver flask and the pink colour of the solution turned blue indicating the presence of ammonia. Distillation was continued until the content of the flask

Table 1. Formulation of ice cream analogue from cooked orange-fleshed sweet potato (OFSP) residue and cow milk powder (CMP)

Sample code	CMP (g)	OFSP residue (g)	Sugar (g)	Egg white (g)	Flavour (g)	Stabilizer (g)	Water (mL)
A	800	0	300	150	0.5	0.25	400
B	700	100	300	150	0.5	0.25	400
C	500	300	300	150	0.5	0.25	400
D	300	500	300	150	0.5	0.25	400
E	100	700	300	150	0.5	0.25	400
F	0	800	300	150	0.5	0.25	400

CMP = cow milk powder, OFSP = orange-fleshed sweet potato

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was about 50 mL after which the delivery of the condenser was rinsed with distilled water. The resulting solution in the conical flask was then titrated against 0.1M HCl. The percentage of crude protein was calculated:

$$\%\text{Crude protein} = 1.4 \times \frac{1}{1000} \times \frac{250}{5} \times T \times \frac{6.25}{W} \times \frac{100}{1}$$

Where w = weight of sample in g, and T = volume of acid used in mL.

2.4.2 Determination of crude fibre

A 3 g sample was weighed into a conical flask and 150 mL of 1.25% sulphuric acid was added. The flask was connected to a reflux condenser and its content was boiled and allowed to reflux for 30 mins. The material was filtered with a muslin sieve. The residue obtained was washed with hot water and then scrapped into the flask. A 150 mL of the 1.25 mL NaOH was added and boiled for 30 mins. The solution was filtered and washed with hot water and followed by methylated spirit. The residue was scrapped into a crucible and dried in an oven at 100°C and cooled in the desiccator and then weighed. This was continued until constant weight, W_1 was obtained. The dry matter was then ashed at 500°C in a muffle furnace and allowed to cool in a desiccator and the weight, W_2 was determined. The percentage of crude fibre was calculated:

$$\%\text{Crude fibre} = \frac{W_1 - W_2}{W_1} \times 100$$

2.4.3 Determination of beta-carotene

A 40 mL sample was mixed with 20 mL of acetone. The addition of acetone was continued until the sample was saturated. The sample was then weighed, covered and stored in a refrigerator overnight. The aqueous layers were extracted by using a pipette and discarded while the remaining content was weighed and recorded. All the water contained in the sample was filtered and the solid substance remaining was placed in another beaker and 20 mL of acetone was added. About 15 g mixed sample was weighed and placed in a funnel followed by the addition of 2 mL of acetone and 15 mL of CH_2Cl_2 to facilitate solubility and filterability. The mixture was then filtered using the vacuum filtration method. The CH_2Cl_2 was removed and 3 drops of $CaCl_2$ were added to enhance the complexation of organic compounds. The samples were taken into weighed and moderately heated vials. About 1 mL of petroleum ether was added and further purified by column chromatography where a small piece of cotton was placed on a layer of sand, a layer of a mixture of silicone gel and hexane in a glass pipette. Air was pumped into the content to seal off hexane, sand and petroleum ether. Beta carotene substance and hexane were captured in a test tube and set aside. In the UV-VIS spectrophotometric detection, the absorbance at 450 nm was read in quartz cells. Reading was taken quickly since petroleum ether is a very volatile solvent. The beta carotene concentration, C (mgl^{-1}) was calculated using Beer-Lambert law from measured data of the absorbance as followed.

$$C = \frac{10^3 \times MA}{L\epsilon}$$

Where C is the concentration of β-carotene, ϵ is the Molar extinction coefficient for β-carotene in Petroleum ether (138900 $Lmol^{-1}cm^{-1}$), M is the molecular weight of β-carotene (536.88 $gmol^{-1}$ and L is the path length (generally equal to 1 cm)

2.4.4 Mineral analysis

The samples were subjected to ashing at 550°C and the ash was boiled with 10 mL of 20% HCl in a beaker and then filtered into a 10 mL standard flask. This was made up to the mark with deionized water. The minerals were determined from the resulting solution. Phosphorous (P) was determined colourimetrically using the spectronic 20 with KH_2PO_4 as standard. While calcium (Ca), iron (Fe) and zinc (Zn) were determined using the atomic absorption spectrophotometer (AAS). A standard flame photometer was used for determining potassium (K) content with the use of KCl as standard. All values were expressed in mg/100 g.

2.5 Determination of total soluble solids

The total soluble solids (TSS) of the samples were determined as described by AOAC (2005) using a hand-held refractometer. The prism of the refractometer was cleaned, and a drop of the samples was placed on the prism and closed. The total soluble solid content (°Brix) was read off the scale of the refractometer.

2.6 Determination of overrun

The overrun of the ice cream analogue was determined as described by Daw and Hartel (2015) by filling an empty container of known weight (W1) with an ice cream mix to give a certain weight (W2). The ice cream mix was frozen at –18°C and the weight (W3) was determined. The overrun of the ice cream was calculated by comparing the weight of a known volume of ice cream to the weight of the same volume of the unfrozen ice cream mix.

$$\%\text{ overrun} = \frac{(W3-W1)-(W2-W1)}{W2-W1} \times 100$$

2.7 Determination of foam stability

The foam stability of the ice cream analogue was determined as described by Coffman and Garcia (1977). A 50 mL sample was dispersed in 500 mL of distilled

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water, mixed vigorously in a blender for 5 mins, and then poured into a 1000 mL measuring cylinder. The initial foam volume (V1) was recorded and left for 1 hr, after which the final volume (V2) was noted. The foam stability was expressed as a percentage of the initial foam volume as follows:

$$\% \text{ Foam stability} = \frac{V2}{V1} \times 100$$

2.8 Determination of meltdown rate

The meltdown rate was determined by placing a known weight of each sample of ice cream analogue at -18°C on a plate at ambient temperature to allow melting. The time taken by each sample to melt completely was determined.

2.9 Sensory evaluation

The sensory evaluation was carried out as described by Meilgaard (2006). A total of fifty panellists who were familiar with ice cream products were used for the evaluation. The sensory attributes: taste, aroma, colour and overall acceptability, were evaluated on seven-point hedonic scale (1 = dislike extremely, 2 = dislike moderately, 3 = dislike slightly, 4 = neither like nor dislike, 5 = like slightly, 6 = like moderately, 7 = like extremely).

2.10 Statistical analysis

The data generated were subjected to Analysis of Variance (ANOVA) and the significant differences were determined at $p<0.05$ using SAS software (version 9.1 SAS) package. Duncan`s Multiple Range Test was used to separate the means. All the determinations were conducted in triplicate and expressed as mean data ± standard deviation (SD).

3. Results and discussion

3.1 Chemical composition of the orange-fleshed sweet potato-based ice-cream analogue

The chemical composition of the ice cream analogue is presented in Table 2. The crude protein content decreased significantly with an increase in OFSP residue in the formulation, with sample A (800 g CMP, 0 g OFSP; control) having the highest value (2.4%) and sample F (0 g CMP, 800 g OFSP) having the lowest value (0.86%). The decrease could be a result of low protein content in the sweet potato which ranges between 1.91% and 5.83% (Mohammed *et al*., 2016) compared to the protein content of some brands of CMP which ranges between 8.58% and 11.7% (Olagunju *et al*., 2013). The values of crude protein are relatively low compared to the range (8.6–14.17%) reported for ice cream from a blend of cow milk and tigernut (Umelo *et al*., 2014) and the range (3.85–5.37%) obtained for ice cream from cow milk and cape gooseberry mix. The OFSP-based ice cream analogue could therefore be utilized when low protein diets are required or consumed along with a protein-rich diet.

The crude fibre content varied from 0.1% in sample A (800 g CMP, 0 g OFSP) to 0.53% in sample F (0 g CMP, 100 g OFSP) as the level of OFSP in the samples increased. It has been reported that OFSP is a good source of non-digestible dietary fibre (Endrias *et al*., 2016) with values ranging from 0.30 to 0.54% (Mohammed *et al*., 2016) in some varieties of sweet potato, whereas milk does not contain any fibre (Vaclavik and Christian, 2014). Therefore, the increase in the fibre content may have resulted from fibre in OFSP residue. The values were higher than the values (0.03 to 0.17%) obtained for the ice cream from a blend of cow milk and tigernut (Umelo *et al*., 2014). Consumption of foods rich in dietary fibre is usually encouraged because it is believed to reduce the incidences of colon cancer, diabetes, heart disease and certain digestive diseases (Ingabire and Vasanthakaalam, 2011; Lockyer *et al*., 2016). The formulated OFSP-based ice cream analogue could therefore contribute to reducing the burdens imposed by these diseases.

The β-carotene content increased significantly with an increased level of OFSP residue in the samples with

Table 2. Chemical composition of orange-fleshed sweet potato (OFSP) based ice-cream analogue

Sample code	Crude protein (%)	Crude fibre (%)	Beta carotene (mg/100 g)	Phosphorus (mg/100 g)	Calcium (mg/100 g)	Potassium (mg/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)
A	2.4 ± 0.2^{d}	0.10 ± 0.4^{a}	0.49 ± 0.2^{a}	35.76 ± 2.7^{f}	74.70 ± 4.2^{f}	49.00 ± 4.0^{e}	0.12 ± 0.03^{a}	0.17 ± 0.05^{c}
B	2.14 ± 0.2^{b}	0.21 ± 0.2^{b}	2.24 ± 0.2^{b}	28.60 ± 3.2^{e}	64.40 ± 4.5^{e}	64.40 ± 4.5^{f}	0.14 ± 0.03^{b}	0.17 ± 0.03^{c}
C	1.90 ± 0.2^{c}	0.23 ± 0.2^{b}	4.15 ± 0.2^{c}	21.03 ± 2.0^{d}	51.20 ± 3.5^{d}	36.00 ± 2.3^{d}	0.16 ± 0.03^{c}	0.14 ± 0.04^{b}
D	1.60 ± 0.2^{b}	0.39 ± 0.2^{c}	13.3 ± 0.2^{d}	10.21 ± 2.3^{c}	47.80 ± 1.9^{c}	24.00 ± 3.2^{c}	0.19 ± 0.04^{d}	0.10 ± 0.03^{a}
E	1.55 ± 0.2^{b}	0.50 ± 0.2^{d}	13.9 ± 0.2^{e}	6.71 ± 1.5^{b}	28.20 ± 3.2^{b}	15.50 ± 2.5^{b}	0.21 ± 0.06^{e}	0.10 ± 0.04^{a}
F	0.86 ± 0.2^{a}	0.53 ± 0.2^{d}	14.0 ± 0.2^{e}	3.31 ± 1.2^{a}	19.30 ± 2.2^{a}	13.00 ± 3.6^{a}	0.25 ± 0.04^{f}	0.09 ± 0.03^{a}

Values are presented as mean±SD of three replicates (n = 3). Values with different superscripts within the same column are significantly different ($p<0.05$).

A: 800 g CMP, 0 g OFSP residue, B: 700 g CMP, 100 g OFSP, C: 500 g CMP, 300 g OFSP, D: 300 g CMP, 500 g OFSP, E: 100 g CMP, 700 g OFSP, F: 0 g CMP, 800 g OFSP.

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sample A (800 g CMP, 0 g OFSP; control) having the lowest (0.49 mg/100 g) and sample F (0 g CMP, 800 g OFSP) having the highest (14.0 mg/100 g). All the samples that contain OFSP had a significantly higher amount of β-carotene than the control sample without OFSP residue. This corroborates the earlier report that OFSP varieties are a recognized excellent source of β-carotene (Mohammed *et al*., 2016) and contain as high as 8000 I.U./100 g, and can, therefore, meet the recommended daily intakes which range between 5000 and 25,000 I.U. (Fesco and Boudion, 2002). The OFSP based ice-cream analogue could, therefore, be used in vitamin A deficiency intervention programs in targeted nations due to its high β-carotene (Kurabachew, 2015).

As the level of OFSP residue in the ice-cream analogue samples increased, phosphorus (P), calcium (Ca), potassium (K) and zinc (Zn) contents decreased significantly from 35.76 to 3.31 mg/100 g, 74.70 to 19.30 mg/100 g, 49 to 13 mg/100 g and 0.17 to 0.09 mg/100 g, respectively, whereas iron (Fe) content increased from 0.12 to 0.25 mg/100 g. However, there was no significant difference in the zinc content of sample A (800 g CMP, 0 g OFSP; control) and sample B (700 g CMP, 100 g OFSP). These observations could have resulted from the fact that the cow milk powder was richer in P, Ca, K, and Zn than in OFSP except Fe which was higher in OFSP. There are similar reports of Ca reduction in persimmon-enriched ice cream (Karaman *et al*., 2014), and Ca and P reduction in vegetable marrow pulp-based ice cream (Dagdemir, 2011). However, Yangilar (2016) reported an increase in all these minerals with the substitution of peach peel fibre for milk in the peach peel fibre-based ice cream analogue. The level of cow milk powder substitution with OFSP may be reduced for appreciable mineral content in OFSP based ice cream analogue. Additionally, the OFSP residue preparation method could be modified for better nutrient retention.

3.2 The physical properties of the orange-fleshed sweet potato ice cream analogue

The physical properties of the OFSP ice cream analogue are presented in Table 3. The total soluble solids (TTS) decreased gradually but significantly from 33°Bx in the control sample (without OFSP residue) to 10°Brix in the sample without cow milk powder (0 g CMP, 800 g OFSP) as the level of OFSP residue increased in the samples. This is similar to the report given for roselle-flavoured ice cream which decreased from 31.18 to 25.59°Bx as the level of roselle in the ice cream mix increased (Singo and Beswa, 2019). The decrease in the TTS of the ice cream analogue could be attributed to the dilution effect of the OFSP residue in the recipe.

The overrun, which is a measurement that relates to an increase in the volume of an ice cream product during processing (Soykoulis and Tzia, 2010), decreased significantly as OFSP residue increased to 300 g in sample D, after which there was no more significant difference in the overrun of the samples. The overrun values (30-46%) of the ice cream analogue samples in this study are much lower than the range (80-120%) reported by Yangılar (2016) for ice cream fortified with peach fibre but greater than the ones (14-33.5%) reported for roselle-flavoured ice cream (Singo and Beswa, 2019). However, the values are similar to the range (43.11–46.67%) reported for the cactus pulp-based ice cream analogue (El-Samahy, 2009) and to the range (43.02–49.8%) reported for cape gooseberry based ice cream analogue (Erkaya *et al*., 2012). This could be a result of a reduction in the protein content as proteins help to incorporate air into ice cream mix, thereby helping to form small bubbles of air (Umelo, 2014); and also as a result of an increase in viscosity (Yangılar, 2016) borne out of the increase in OFSP residue in the ice cream mix. The decrease in the overrun of the OFSP based ice cream samples is in agreement with the results indicated in the literature for ice cream analogues (Hwang *et al*., 2009; Temiz and Yesilsu, 2010).

Table 3. The physical properties of cooked orange-fleshed sweet potato (OFSP) residue based ice cream analogue.

Sample code	Total soluble solids (°Brix)	Overrun (%)	Foam stability (%)	Melt rate (g/min)
A	36.00±0.2^{f}	53.00±0.4^{e}	50.00±0.2^{f}	2.40±0.2^{a}
B	33.00±0.2^{e}	46.00±0.2^{d}	45.00±0.2^{e}	2.60±0.2^{a}
C	30.00±0.2^{d}	37.00±0.2^{c}	33.50±0.2^{d}	3.00±0.2^{b}
D	21.00±0.2^{c}	31.00±0.2^{b}	23.30±0.2^{c}	3.20±0.2^{b}
E	15.00±0.2^{b}	30.00±0.2^{a}	15.00±0.2^{b}	3.50±0.2^{b}
F	10.00±0.2^{a}	30.00±0.2^{a}	6.70±0.2^{a}	3.90±0.2^{bc}

Values are presented as mean±SD of three replicates (n = 3). Values with different superscripts within the same column are significantly different (p<0.05).

A: 800 g CMP, 0 g OFSP residue, B: 700 g CMP, 100 g OFSP, C: 500 g CMP, 300 g OFSP, D: 300 g CMP, 500 g OFSP, E: 100 g CMP, 700 g OFSP, F: 0 g CMP, 800 g OFSP.

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In the case of foam stability of the samples, it decreased significantly from 50% in the sample without OFSP residue to 6.7% with 800 g OFSP residue in the ice cream mix. The decrease in foam stability may have stemmed from a decrease in the protein content of the ice cream mix which is central to the stabilization of air bubbles formed from the covering of fat globules with proteins (Trgo, 2003) in the ice cream matrix. There was only a 5.5% reduction in the foam stability with 100 g OFSP residue in the ice cream analogue which may be desirable considering other advantages of using the OFSP residue. However, the inclusion of more than 100 g OFSP residue in the ice cream analogue may necessitate increasing the level of stabilizer in the recipe to improve the foam stability.

The melt rate increased significantly with the inclusion of OFSP residue, however, there was no significant difference in the melt rate of the control sample and sample with 100 g OFSP residue. The increase could be a result of the high water absorption capacity of OFSP residue. Erkaya *et al*. (2012) and Akin *et al*. (2007) reported longer melting time (67.75 – 75.25 mins) for ice creams with cape gooseberry than the ice cream from 100% milk (3980 s) and increased complete melting times (66.33 mins) on the addition of inulin to ice cream mixes, respectively. Nevertheless, the melt rate values (2.4– 3.9 g/min) obtained in this study are greater than the ones (1.3 – 2.3 g/min) reported for roselle-flavoured ice cream. The increase in the melt rate indicates that the OFSP based ice cream analogue would be more resistant to temperature fluctuations during storage. This may allow ample time for consumption without the loss of ice cream body structure (Januario *et al*., 2018).

3.3 Sensory properties of the cooked orange-fleshed sweet potato residue-based ice cream analogue

The results of sensory properties of OFSP residue-based ice cream analogue samples are presented in Table 4. While sample B (700 g CMP, 100 g OFSP) was not significantly different in taste and colour from sample A (800 g CMP, 0 g OFSP; control), all other samples were significantly different from the control sample (sample A). In terms of aroma, OFSP based ice cream analogue samples containing up to 500 g (62.5%) OFSP residue were not significantly different from the control sample (sample A). The overall acceptability scores showed that samples B (700 g CMP, 100 g OFSP) and C (500 g CMP, 300 g OFSP) were not significantly different from the control sample (sample A). This implies that the sensory properties were not adversely affected by the replacement of milk with OFSP up to 37.5%. Therefore, OFSP residue could substitute milk up to this level in the OFSP residue based ice cream mix. This may have a positive economic implication of reduction in the cost of production as a whole and skimmed milk powders are imported by most developing countries (Knips, 2005), Nigeria inclusive.

4. Conclusion

This study has indicated that OFSP residue, a hitherto waste during non-alcoholic beverage production, could be successfully used as a partial milk replacer and good natural source of β-carotene in an ice cream analogue recipe. The inclusion of OFSP residue resulted in a noticeable reduction in some nutrients and physical attributes of the ice cream depending on the extent of substitution. The OFSP based ice cream analogue, however, had significantly higher levels of crude fibre, Fe, melt rate and β-carotene content than the control sample. Furthermore, the sensory scores suggested the possibility of substituting OFSP residue for milk up to 37.5% in the blend of the cooked OFSP residue and cow milk powder for ice cream analogue production.

Conflict of interest

The authors declare no conflict of interest.

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Table 4. Sensory attributes of orange-fleshed sweet potato (OFSP) based ice cream analogue

Sample code	Taste	Aroma	Colour	Overall acceptability
A	5.22±0.1^{d}	5.12±0.2^{c}	5.33±0.3^{d}	5.33±0.2^{d}
B	5.14±0.3^{d}	5.01±0.2^{c}	5.00±0.2^{d}	5.13±0.1^{d}
C	4.78±0.2^{c}	4.98±0.1^{c}	4.89±0.2^{c}	5.09±0.3^{d}
D	4.56±0.2^{c}	4.78±0.1^{c}	4.78±0.2^{c}	4.71±0.2^{c}
E	4.11±0.1^{b}	4.11±0.2^{b}	4.33±0.3^{b}	4.22±0.3^{b}
F	2.67±0.4^{a}	3.44±0.2^{a}	4.00±0.2^{a}	3.78±0.2^{a}

Values are presented as mean±SD of three replicates (n = 3). Values with different superscripts within the same column are significantly different (p<0.05).

A: 800 g CMP, 0 g OFSP residue, B: 700 g CMP, 100 g OFSP, C: 500 g CMP, 300 g OFSP, D: 300 g CMP, 500 g OFSP, E: 100 g CMP, 700 g OFSP, F: 0 g CMP, 800 g OFSP.

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