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Original Research Article

Effect of Use Some Plant Tubers in the Manufacture of Yoghurt Ice Cream

Jehan, B. Ali[1*], El-Sisy, T. T[1]
[1]Regional Center for Food and Feed, Agriculture Research Central

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Abstract: Yoghurt ice cream can be regarded as a healthy alternative to plain ice cream. Also use of some plant tuber in food formulations can lead to the development of products of improved manufacture, nutritional and health promoting values. So, the present study was produced healthy yoghurt ice cream mixes by replacement of stabilizer with some plant tuber mill and studies their effect at different concentration (A 5%, B 10% and C 15%) on the physicochemical, rheological, microbiological and sensory properties. The result indicated that, Total solid (%) was increased with added the powder of tubers in all mixes and the highest total solid in all samples were yellow sweet potato mix C (35.51%). Protein ranged from 2.44 to 3.24% and Fat % ranged from 4.09 to 4.14%. Total carbohydrate increased with adding the plant tuber and yellow sweet potato mix C had the highest carbohydrate and fiber values. Viscosity of yoghurt ice cream mixes reported showed that yoghurt ice cream of potato mix A was the lowest viscosity (1950.0 cP/s) and the highest values was yellow sweet potato mix C (4053.3 cP/s) in all samples. The yoghurt ice cream sample get highly significant effect of sensory evaluation by control followed by cassava containing 5%, 10 % then 15% and yellow sweet potato 5%. While yoghurt ice cream containing 15% potato got the lowest scores. These results concluded cassava concentration 5 &10 % can be a cost effective and good alternate of traditional stabilizers used for yoghurt ice cream preparation.

Keyword: Plant tubers flour, yoghurt ice cream, physicochemical and Sensory properties.

1.1 INTRODUCTION

Frozen yoghurt product gathers the characteristics of ice cream as a preferable dairy food for consumption because of its high nutritional attributes, as well as its refreshment, and yoghurt as a fermented dairy product in which the yoghurt culture produces certain metabolites during their growth, which allow the milk protein to be digested and inhibits some pathogens. Frozen yogurt is a complex fermented frozen dairy dessert that combines the physical characteristics of ice cream with the taste and nutritional properties of fermented milk products (Soukoulis and Tzia, 2008). Consumers often choose to eat frozen yogurt because they expect that it contains less lactose than ice cream with a similar amount of fat, and provides health benefits from the viable bacteria contained in it (Marshall, 2001). The frozen yogurt environment is not optimum for survival of bacteria (Davidson *et al.*, 2000). Yoghurt is an excellent food that is easy to digest and is of high biological value and is known to lower cholesterol levels (Guven and Karaca, 2002). The use of yoghurt instead of milk decreased the viscosity of ice cream mix and over-run capacity of ice cream (Guner *et al.*, 2007). However, mixing ice-cream mix and yoghurt offers sensory and physical properties that are similar to those of ice cream and yoghurt (Nagar *et al.*, 2002).

Cassava *(Manihot esculenta)* is the third most important source of calories in the tropics after rice and maize (Food Safety Network, 2014). Cassava is one of the world most important food crops, within annual world production of about 2777.957 million tons. Africa is one of the continents of the world where some 600 million people are dependent on cassava for food (International Fund for Agricultural Development (IFAD) 2013). Cassava is known to be cheap, widely grown, readily available and is a reliable source for carbohydrate as it is rich in starch Nweke, (2004). The major processing features of the cassava root are its functional properties and ability to gelatinize, forming thick pastes suitable for human consumption and for use

***Corresponding Author:** Jehan, B. Ali

in many industrial applications. This gelatinization process is a property of the crop's starch granules (Sánchez, *et al.*, 2010), and such functional properties influence the end-use potential of cassava products. Cassava has a lower production value when compared to sweet potatoes.

Sweet potato, *(Ipomoea batatas)* is an important economic crop in many countries. In terms of annual production, sweet potato ranks as the fifth most important food crop in the tropics and the seventh in the world food production after wheat, rice, maize, potato, barley, and cassava (FAO, 2016). Sweet potato roots have high nutritional value and sensory versatility in terms of taste, texture, and flesh color (white, cream, and yellow, orange, purple). Sweet potato is highly nutritive and good source of vitamins (A and C), minerals (iron, potassium, calcium) and fiber. Besides simple starches, raw sweet potatoes are rich in complex carbohydrates, dietary fiber and beta-carotene (a pro vitamin A carotenoid), with moderate contents of other micronutrients, including vitamin B5, vitamin B6 and manganese. Beside its nutritive value, starch is a very versatile raw material it has many application in food, feed, pharmaceutical, paper, textile and cosmetic industries. In the food industry, starch used as a thickener to increase the solid content, to consolidate the mass of food as a stabilizer (Burrel, 2003).

Potato *(Solanum tuberosum)* was the world's fourth-largest food crop after maize (corn), wheat, and rice. The importance of the potato as a food source and culinary ingredient varies by region and is still changing. When a potato is baked, its contents of vitamin B6 and vitamin C decline notably, while there is little significant change in the amount of other nutrients. Potatoes are often broadly classified as having a high glycemic index (GI) and so are often excluded from the diets of individuals trying to follow a low-GI diet. In particular, consuming reheated or cooled potatoes that were previously cooked may yield a lower GI effect (Fernandes, *et al.,* 2005).

Stabilizers are valuable constituent of ice cream mix. Stabilizers slightly change the acidity of the mix; enhance the viscosity, whipping time and surface tension. The stabilizer like gelatin, starch or pectin are used in milk to improve the following ice cream characteristics such as appearance, mouth feel, viscosity and texture. The quantity of stabilizer which is used depends on the quality and kind compulsory to produce the desirable stabilizing effect in the final product. The basic role of a stabilizer is to reduce the amount of free water in the ice cream mix by binding it as "water of hydration", or by immobilizing it within a gel structure. Also it is the ability of small percentage of stabilizer to absorb and hold large amounts of bound water, which produces good body, smooth texture, slow melt down and heat shock in the resultant product (Keeney, 1982). A good stabilizer should be nontoxic, readily disperse in the mix, not produce excessive viscosity or separation or foam in the mix, not clog strainers and filters, provide ice cream with desirable meltdown, be economical, and not impart off flavor to the mix Kilara and Chandan, (2006). There are clear relationship between the food we eat and our health. Therefore, some reports have investigated ice cream and yogurt as probiotic carrier. Hence, frozen yogurt is a novel way of combining the characteristics of ice cream with the therapeutic properties of yogurt that are considered as a healthy alternative to ice cream for the people suffering from cardiovascular diseases and lactose intolerance(Soukoulis, *et al*., 2014 - Pugazhenthi *et al*., 2015, Ferraz, *et al.,* 2012).

Because, the consumption of yoghurt ice cream is higher among children of vulnerable age groups, we need to increase a high nutritional value and reduced chemical additive in industries of yoghurt ice cream. So the aim of this study was to evaluate the effects of added some plant mill on yoghurt ice cream mixes for increase the nutrition value and as stabilizer replacer system on physical, chemical and sensory properties of yoghurt ice cream.

MATERIALS AND METHODS

2.1 MATERIALS

The materials consisted of yogurt (fresh cow's milk and Starter) and other ingredients are cassava milled, yellow sweet potato milled, potato milled, sugar, full cream milk powder, and emulsifiers.

2.2 Plant Tubers samples

Three plant tubers are Yellow Sweet Potato (*Ipomoea batatas),* Potato *(Solanum tuberosum)* were obtained from Potato and Vegetative Propagated Vegetable Department of Horticulture Research Institute and Cassava *(Manihot esculenta)* were obtained from Crop intensification Research Department of Field Corps Research Institute, under supervisor of the Agriculture Research Central. They were taken during 2021. Whole pasteurized cow's milk (3% fat, SNF 8.5%), full cream milk powder (35% fat), Sucrose and vanilla powder were obtained from local market. Stabilizers that were purchased from Polsgaard Mould Ice 156 (Food Emulsifier and stabilizer) (Denmark- Eu). Media and Reagents: Peptone water, Rose Bengal chloramphenicol agar (Biolife, Italy) were used for mold enumeration and identification.

2.3 Preparation of Plant Tubers flour

A five kg of each plant tubers samples used to produce plant tubers flour was according to the method described by (Avula, 2005). The plant tubers were peeled and cut into thin pieces manually. The plant tuber slices were then immersed in (1%) potassium Meta bisulphite for 30 min to prevent browning reactions. Drying of plant tubers slices was done in summer sun temperature until constant weight for (1-2) days. The dried plant tubers chips were milled into flour using the laboratory grinder and passed through 250 µm mesh sieve, packed in airtight containers and stored in the refrigerator till further use. The flow chart for the production of plant tubers flour is shown in Figure 1.

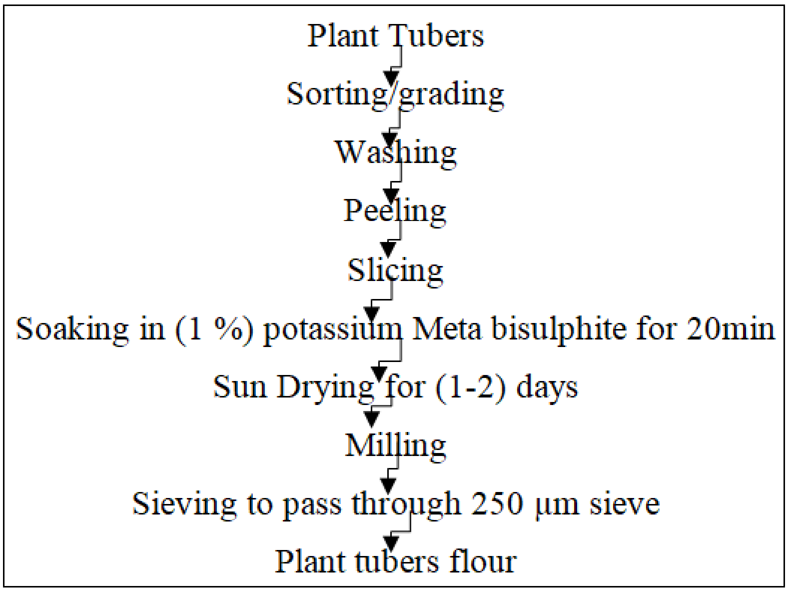

Fig 1: Flow chart for production of Plant tubers flour

2.4 Preparation of yoghurt

Cow milk was poured to a stainless steel container, and then heated at 90 ºC for 10 min followed by cooling to 42 ºC. Starter was added at the rate of 3%. The samples were incubated at 42°C until coagulation occurred, then cooled and stored in a refrigerator for used.

2.5 Preparation of yoghurt ice-cream mix

Ice cream mix was prepared as described by Guner *et al.,* (2007). Formulations of ice cream mix contained 63.8% of water, 18% fat, 18% sugar, 5, 10 or 15% plant tuber flour and 0.4% vanilla as flavor. Nine ice cream formula samples (A, B and C) and control were designed. Control sample contains 1% stabilizer (Denmark- Eu). A, B and C contain 5%, 10% and 15% plant tubers flour of (Cassava, yellow sweet potato, and potato) respectively, alternative to stabilizer. The mixture was heated (80°C) for 30 min. All mixes were cooled to 5°C and then aged over night at the same temperature. Yoghurt was added with ice cream (1:2) prior to freezing. The resulting frozen yogurt was placed in plastic cups (50ml) and hardened at −18 °C for 24 h before analysis (Nagar *et al.*, 2002).

2.6 Chemical analysis

Moisture, protein content, vitamins, ash, total solid, fiber, amino acid, minerals, total acidity and fat were determined according to AOAC, (2005). The pH value was examined for samples. The pH of ice cream was measured using a pH meter model HANNA pH instruments. Total carbohydrate (%) was calculated by difference. Minerals content (Mg, Zn, Ca, P, Cu, Mn, K, Na, Fe, S and Se) were determined after aching of different samples according to AOAC (2005). Elements were carrying out using Atomic absorption spectrophotometer model 3300 Perkin Elmer. The data were calculated as ppm dry sample.

2.7 Physicochemical properties

2.8 Water and oil holding capacity, swelling power and solubility

Water and oil holding capacity (WHO, OHC) of native and acetylated starches, swelling power and solubility of the starch were measured using the method of **(**Garg and Jana, 2011).

2.9 Texture Measurements of yoghurt ice cream

Samples texture measurements of yoghurt ice cream were carried out with Universal Testing Machine, Cometech, B type, Taiwan provided with software according to Bourne, (2003). The texture measurement of each yoghurt ice cream averaged from 5 replicates. Back extrusion cell with 35mm diameter compression disc was used. Two cycles were applied, at a constant crosshead velocity of 1 mm/s, to 25 % depth, and then returned. From the resulting forced- time curve, firmness (N), cohesiveness, gumminess (N), chewiness (N), springiness, resilience and adhesiveness (Ns-1) were calculated using the TPA graphic.

2.10 Apparent viscosity (flow behavior)

Apparent viscosity of yoghurt ice cream was measured directly using Brookfield Digital Rheometer, Model DV III Ultra. Shear stress / shear rate data of the investigated casein protein solutions were obtained by using a rotational viscometer (Brookfield Engineering Labs DV-III Ultra Rheometer .The temperature of the outer cylinder was adjusted to 25 ± 1°C by means of a circulating water bath.

2.11 Over-run and Melting Resistance

The overrun of ice cream samples was determined using the formula of Marshal and Arbuckle, (1996). Meltdown and standup time were determined according to method of Bhandari, (2001).

2.12 Microbiological methods

For the enumeration of Total aerobic bacteria (TAB), Lactic acid bacteria (LAB), Yeast and Mould (YM) and Coliform Bacteria, samples of yoghurt ice cream (10 ml) was dispersed in 90 ml sterile Ringer's solutions and appropriate decimal dilutions were prepared by using 1/4-strength Ringer's solution under the aseptic conditions. Total count of TAB was enumerated by Plate Count Agar (Oxoid) after incubation at 37°C for 48 hours. LAB was counted on MRS agar containing 0.1 g/L of cycloheximide after incubation at 30°C for 72 h in anaerobic conditions. Dichloran Rose Bengal Chloramphenicol Agar (Oxoid) was used for YM enumeration and plates were incubated at 25°C for 5 days. Coliform bacteria were enumerated on Violet Red Bile Agar (Oxoid) after incubation at 37°C for 24 h (Deng *et al.*, 2015).

2.13 Sensory Evaluation

The sensory evaluation was carried out by a group of 10 trained sensory assessors. The evaluation of the yogurt ice cream samples included the following sensory attributes; appearance, viscosity, color, texture, flavor, creaminess and overall acceptability as prescribed by Herald *et al.*, (2008).

2.14 Statistical analysis

Data of three replicates were computed for the course of scoring for each sample was statistically analyzed according to SAS, (2011) using Duncan's multiple range tests.

RESULTS AND DISCUSSION

3.1 Chemical properties of plant tuber flours

Chemical composition of different plant tuber flours (cassava, yellow sweet potato and potato) used in this study is given in Table (1). Plant tuber flours moisture content of ranged from (4.24 to 5.99) for all studied samples. Potato and yellow sweet potato had the highest value while cassava had lowest value among all samples.

Potato had the highest value of protein content among all samples. As regards fat content, cassava and potato had the highest fat (0.30, 0.29%), respectably while yellow sweet potato (0.05%) had the lowest fat content. Plant tuber flours fiber content of ranged from (1.8 to 3.00%) cassava and yellow sweet potato respectably. As, ash and carbohydrates content of all plant tuber flour were found quite close to each other. The results of Total caloric values% showed that yellow sweet potato had significant the highest value (275.37%) and the potato had the significant lowest value (256.08%). In the food industry, starch used as a thickener to increase the solid content, to consolidate the mass of food as a stabilizer (Burrel, 2003). In developing countries, the production of sweet potato about 95% of the world. In food industry application of starch in bakery product, beverages, dessert, sauces, dressings, meat and dairy product (Sajilata *et al.*, 2006). The cassava root contains carbohydrates, 64 to 72 per cent of which is made up of starch, mainly in the form of amylose and amylopectin. Purple sweet potato (PSP) (*Ipomoea batatas*) are starchy tubers which have good nutritional value and positive health benefits as excellent sources of carbohydrate, fiber, vitamins, minerals and phytochemical compounds (Hal, 2000; Teow *et al.*, 2007).

Table 1: Proximate analysis of different plant tuber flours

Chemical properties	Plant tuber flour		
	Cassava	Yellow sweet potato	potato
Moisture %	4.24 [b]	5.55 [a]	5.99 [a]
Protein%	1.40[b]	1.60[b]	2.38 [a]
Fat%	0.3[a]	0.05[b]	0.29 [a]
Ash%	2.60[a]	2.67[a]	2.0 [a]
Fiber%	1.80[c]	3.0[a]	2.20 [b]
Carbohydrates %	69.66[a]	67.13[a]	67.14[a]
Total caloric values%	266.94[ab]	275.37[a]	256.08 [b]

[a,b,…] Values in the same letter are not significantly different ($p < 0.05$).

3.2 Mineral contents of different plant tuber

Data in Table (2) showed the mineral contents of different plant tuber flours. It can be noticed no significant effect in (Mg) for all samples. Potato and yellow sweet potato have the highest value of Zn and cassava has the lowest values. Additionally some micro elements have the highest range for Ca (30 mg/100mg) and Mn (0.99 mg/100mg) for yellow sweet potato, P (57.0) mg/100mg and K (421 mg/100mg) for potato than the other elements. Cassava and yellow sweet potato have the highest value of Cu and the lowest value was potato. Yellow sweet potato had the highest value of Na (55.0 mg/100mg) and the lowest value was potato (6.0 mg/100mg). Potato and yellow sweet potato had the highest value of Fe (0.78- 0.61 mg/100mg) and cassava had the lowest value (0.27 mg/100mg). As a by product of cassava roots, cassava leaves can synthesize high contents of crude protein (177–381gkg−1 dry matter (DM)), vitamins, carotenoids and minerals (such as phosphorus, magnesium and calcium) but contain low levels of manganese, zinc, iron and sodium depending on the cultivar and climatic conditions (Awoyinka *et al.,* 1995). The Sweet potato roots are rich in starch, sugar, vitamin C, β-carotene, iron, and several other minerals (Ellong *et al.,* 2014).

Table 2: Minerals for different plant tuber flours

Minerals (mg/100g)	Plant tuber flour		
	Cassava	Yellow sweet potato	potato
Mg	21.0 [a]	25.0[a]	23.0 [a]
Zn	0.014 [b]	0.3[a]	0.29 [a]
Ca	16.0 [b]	30.0[a]	12.0 [b]
P	27.0 [ab]	0.47[b]	57.0 [a]
S	_	25	_
Cu	0.5[a]	0.32[a]	0.11[b]
Mn	0.003 [c]	0.99[a]	0.15[b]
K	271 [b]	337[ab]	421 [a]
Na	14.0 [b]	55.0[a]	6.0 [c]
Fe	0.27 [b]	0.61[a]	0.78 [a]
Se	_	0.09[a]	0.03 [a]

(-) = Not determined

[a,b,…] Values in the same letter are not significantly different ($p< 0.05$).

3.3 Vitamins content of different plant tuber

Vitamins content of different plant tuber flours used in this study are given in Table (3). It can be noticed no significant effect in Thiamine (B1) and vitamin K for all studied samples. Potato had the lowest value of Riboflavin (B2**)** 3.0% in all samples. Potato had the highest value of Niacin (B3) 105.0 % and the lowest value was Yellow sweet potato 56.0%. Additionally cassava was lower Pantothenic B5 (11%) and the lower in Pyridoxine B6 (9.0%) in completely in other samples. However, highest folic acid B9 was observed in potato (16.0%). Yellow Sweet potato had the lowest value of vitamin C (20.6%).On the other hand, vitamin (A) ranges from 2.00 % (potato) to 141.9% (yellow sweet potato). Additionally yellow sweet potato was highest in vitamin E (26.0%) while potato was lowest (0.01%) than the other samples. Yellow sweet potato is reasonably rich in Pantothenic, vitamin K and vitamin A, but Potato is rich in the pyridoxine, folic acid and niacin contents. Sweet potato is an important food security crop. It has also been identified as the least expensive, year round source of dietary, vitamin A, especially the orange-fleshed type among the poor; the crop is cheap, can be purchased in affordable units and is easily cultivated, yet it is facing a lot of production and post-harvest, (Ellong *et al.,* 2014).

Table 3: Vitamins content of different plant tuber flours

Vitamins %	Plant tuber flour		
	Cassava	Yellow sweet potato	potato
Thiamine(B1)	9.0[a]	7.8[a]	8.0 [a]
Riboflavin(B2)	5.0 [a]	6.0[a]	3.0 [b]
Niacin (B3)	85.0[b]	56.0[c]	105.0 [a]
Pantothenic B5	11.0[c]	80.0[a]	30.0 [b]
Pyridoxine(B6)	9.0[c]	21.0[b]	30.0[a]
Folic Acid B9	7.0 [ab]	3.0[b]	16.0 [a]
Vitamin C	20.6 [a]	2.4[b]	19.7 [a]
Vitamin K	1.9 [a]	1.8[a]	1.9 [a]
Vitamin A	13.0 [b]	141.9 [a]	2.0 [c]
Vitamin E	19.0 [b]	26.0[a]	0.01[c]

(-) = Not determined

[a,b,…] Values in the same letter are not significantly different ($p< 0.05$).

3.4 Amino Acids content of the different plant tuber

Amino Acids content of the different plant tuber flours used in this study is given in Table (4). The highest value of aspartic were observed in Yellow sweet potato and Potato (161.0 and 152.0 mg/100g). Also, Yellow sweet potato had the highest value of Alanine, Arginine and Cystine (650.0, 470.0 and 69.0 mg/100g), respectively. Glutamic, content of potato had the highest value (274.0 mg/100g) while cassava (0.15 mg/100g) had the lowest value. The results of Glycine, Leucine, Lysine and Methionine showed that Yellow sweet potato had the significant highest value in comparison with the other samples. Additionally cassava was lower value in histidine (0.07 mg/100g) than the other samples. Yellow sweet potato was higher in Isoleucine (230.0 mg/100g), Phenylalanine (241.0 mg/100g), Proline (490.0 mg/100g), and Serine (670.0 mg/100g), Threonine (530.0 mg/100g) and in Tryptophan (8.0mg/100g). However, lowest value of Tyrosine and Valine was observed in cassava (0.01-0.04 mg/100g). Additionally, the amount of total essential amino acids in cassava is similar to that in hen's egg but greater than that in spinach leaves, soybean and rice grain (Best, 1978).

Table 4: Amino Acids content of the different plant tuber flours

Amino Acids content (mg/100g)	**Plant tuber flour**		
	Cassava	**Yellow sweet potato**	**potato**
Aspartic	0.13^{b}	161.0^{a}	152.0^{a}
Alanine	0.15^{c}	650.0^{a}	16.0^{b}
Arginine	0.29^{c}	470^{a}	42.0^{b}
Cystine	0.01^{b}	69.0^{a}	2.0^{b}
Glutamic	0.15^{c}	139.0^{b}	274.0^{a}
Glycine	0.01^{c}	630.0^{a}	5.0^{b}
Leucine	0.31^{c}	780.0^{a}	18.0^{b}
Lysine	0.07^{c}	214.0^{a}	16.0^{b}
Methionine	0.03^{c}	106.0^{a}	14.0^{b}
Histidine	0.07^{b}	10.0^{ab}	17.0^{a}
Isoleucine	0.03^{c}	230.0^{a}	28.0^{b}
Phenylalanine	0.03^{c}	241.0^{a}	35.0^{b}
Proline	0.03^{b}	490.0^{a}	18.0^{b}
Serine	0.04^{b}	670.0^{a}	-
Threonine	0.03^{c}	530.0^{a}	35.0^{b}
Tryptophan	0.29^{c}	8.0^{a}	5.0^{b}
Tyrosine	0.01^{c}	146.0^{a}	44.0^{b}
Valine	0.04^{c}	283.0^{a}	65.0^{b}

(-) = Not determined

$^{a,b,\ldots}$ Values in the same letter are not significantly different ($p < 0.05$).

3.5 Physicochemical analysis of different plant tuber flours

Cassava, sweet potato and potato starch were subject to different analysis. All the analyses were performed in triplicate and mean values are presented in Table (5). For The pH value of all samples were ranged from 5.38 to 6.12 in all samples. Cassava was the highest in swelling powder 13.80%value and the lowest value of solubility 1.28%. Also Cassava was the highest value of water holding capacity 96.38% while the lowest value was potato 80.01%. The highest value of viscosity was yellow sweet potato while the lowest value was potato (7569.0 - 3324.0%), respectively. Addition, cassava was the highest white color (30.38%) and the lowest yellow (15.93%) color in all samples. The results obtained in present study are in line with the findings of Frank, (1981). For instance, the granulation characteristics of milled cassava flour affect hydration rates and swelling capacities during processing Hatcher, *et al.*, (2009), while color determines cassava products' visual appearance and influences the appeal of the finished products MacDougall, (2002). Meanwhile, the water binding and absorption capacities, swelling power and solubility of cassava have a bearing on the carbohydrate quality, viscosity and gelling ability of the flours and starches produced Niba, *et al.*, (2002), Oladunmoye, *et al.*, (2004). pH, water holding capacity, solubility and viscosity of sweet potato starch were greater than sagudana powder whereas swelling power of sagudana was higher than sweet potato. The results obtained in present study are in line with the findings of Mweta *et al.*, (2009).

Table 5: Physicochemical analysis of the different plant tuber flours

Physicochemical properties		**Plant tuber flour**		
		Cassava	**Yellow sweet potato**	**potato**
pH		6.12^{a}	5.38^{a}	5.65^{a}
Swelling powder %		13.80^{a}	10.15^{b}	9.37^{c}
Solubility %		1.28^{b}	3.33^{a}	4.43^{a}
Water holding capacity %		96.38^{a}	82.99^{b}	80.01^{c}
Viscosity %(cp)		4326.0^{b}	7569.0^{a}	3324.0^{c}
Colour	White	30.38^{a}	9.0^{b}	10.38^{b}
	Yellow	15.93^{c}	28.95^{b}	33.03^{a}

$^{a,b,\ldots}$ Values in the same letter are not significantly different ($p < 0.05$).

3.6 Chemical attributes of formulated yoghurt ice cream mixes

After making yoghurt ice cream mixes from yoghurt, cream mix 18% fat, sugar18%, plant tuber flour from cassava, yellow sweet potato and potato, in different ratio. Samples for control and mixes which adding plant tuber flour were divided in 3 groups: (A) 5%, (B) 10% and (C) 15% plant tuber flour was added. Control was manufactured using stabilizer 1%. Table (6) shows the physicochemical attributes of formulated yoghurt ice cream mixes. The moisture content of the yoghurt ice cream mixtures were ranged from 64.49 to 68.58 %. The highest value of moisture was in cassava 5% mix. The pH of all samples ranged from 6.4 to 7.2 in all samples. Titratable acidity ranged from 0.50 yellow sweet potato mix A to 0.90% potato mix A for all samples. The highest total solid value was yellow sweet potato mix C (35.51%) while the lowest value was potato mix A and cassava mix A (32.29- 31.42%). Protein ranged from (2.44) yellow sweet potato mix C to (3.24) control and Potato mix c (3.19) were the highest in protein values. Potato mix C samples contained the highest value of ash while the lowest value cassava mix A. It can be noticed no significant effect in fat in all samples. Fiber in the mixes ranged from 0.68 to 1.04 and the highest values were found in the mixes contained yellow sweet potato mix C. Total carbohydrate increased with adding the flour in all treatment, the lowest value was mix A then mix B and the highest value was mix C. Yellow sweet potato mix C gave the highest value of carbohydrate (27.14%) and the lowest value was cassava mix A (23.40%) in all samples. Frozen yogurt is perceived as a healthier alternative to ice cream (Isik *et al*., 2011; Milani and Koocheki, 2011). The result of the present study is consistent with the findings of El-Owni and Zeinab, (2009), who observed relatively the similar TS content of ice cream i.e. in between 31.82 to 33.41%. However, Jaswinder *et al.*, (2006) found a significant decrease in TS content of ice cream mix when yoghurt base was added to it. Protein content of yoghurt ice cream was found to be in a range between 2.44 and 3.24%. The present findings are agreement with the results of Emata et al., (2001) who reported 3.72% protein content in low fat yoghurt ice cream. Similarly, the results of present investigation are also agreement with the findings of El-Owni and Zeinab, (2009) who reported the range of protein content in between 2.49 and 2.69%. Frozen yogurt contains a considerably lower amount of fat (3.25–6%) in comparison with ice cream (10–16%) (Marshall, 2003) and it is well known that excessive intake of fat is connected with a higher risk of obesity and cardiovascular diseases (Devereux, *et al.,* 2003). However, it was relatively similar in fat content to that of light class (5% fat) vanilla ice cream produced by Aimee *et al.* (2001). The ash content of yoghurt ice cream was observed in between 0.70 and 0.98%. These results are higher in consistent with the findings of other reported work i.e. in between 0.39 to 0.64% (El-Owni and Zeinab, 2009).

Table 6: Physicochemical attributes of formulate yoghurt ice cream mixes

Formulations		Moisture (%)	pH	Titratable acidity (%)	Total solid (%)	Protein (%)	Ash (%)	Fat (%)	Fiber (%)	Total carbohydrate %
Control		65.38 ab	6.9 ab	0.85 ab	34.62 abc	3.24 a	0.75 cd	4.09 a	0.70 c	25.84 bc
Cassava	A	68.58 a	6.4 b	0.75 bc	31.42 d	2.57 e	0.66 e	4.11 a	0.68 c	23.40 d
	B	66.17 ab	6.5 b	0.70 cd	33.84 c	2.65 d	0.70 de	4.12 a	0.78 bc	25.58 c
	C	64.93 ab	6.9 ab	0.70 cd	35.09 ab	2.78 c	0.76 cd	4.14 a	0.88 abc	26.54 ab
Yellow Sweet potato	A	66.35 ab	7.2 a	0.50 e	33.75 c	2.82 c	0.76 cd	4.09 a	0.74 bc	25.24 bc
	B	65.75 ab	7.1 a	0.70 cd	34.25 bc	2.66 d	0.77 c	4.10 a	0.91 ab	25.81 bc
	C	64.49 b	6.9 ab	0.60 de	35.51 a	2.44 f	0.78 c	4.11 a	1.04 a	27.14 a
potato	A	67.71 ab	6.5 b	0.90 a	32.29 d	2.78 c	0.77 c	4.10 a	0.72 bc	23.92 d
	B	66.11 ab	6.8 ab	0.85 ab	33.89 c	2.97 b	0.87 b	4.12 a	0.82 bc	25.11 c
	C	64.99 ab	6.9 ab	0.80 abc	35.01 b	3.19 a	0.98 a	4.13 a	0.92 ab	25.79 bc

a,b,… Values in the same letter are not significantly different ($p < 0.05$).

3.7 Physical attributes of formulate yoghurt ice cream mixes

3.8 Over-run

Overrun is the industrial calculation of the air added to frozen dessert products, and it is calculated as the percentage increase in volume of mix that occurs as a result of the air addition and air volume/mix volume. It makes the yoghurt ice cream smooth and reduces crystal size. Overrun percentage in the present study ranged from 12.38 for yellow sweet potato mix C, to 35.65% for potato mix A. Fig (2) shows the effect of add plant tuber flours on overrun. Stabilizer type and quantity had a significant effect on over-run. As overrun decreases, ice crystals and air cells become smaller in size. However, there is the counter balancing effect of weakening of the structure because of thinning of the unfrozen material among the air cells and ice crystals (Marshall *et al*., 2003). Potter and Hotchkiss, (1995) described the shrinkage in ice cream due to collapse of weakened films of mix, causing the ice cream to lose volume. Due to loss of air the shrinkage was reported by Rothwell, (1993). Amount of air in ice cream is directly related to the overrun, is important because incorporation of air effect the product quality and profits. In the work of Güven and Karaca, (2002), overrun of vanilla frozen yogurt with different sugar content ranged from 22 to 32% and was positively influenced by the level of sucrose. Moreover, increasing the sugar content softened the structure and increased the viscosity of frozen yogurt. In a study on probiotic ice cream, Akin *et al.,* (2007) also reported the positive influence of sugar content on overrun and viscosity. Sakurai *et al.,* (1996) found that ice creams with low overruns melted quickly, whereas ice creams with high overruns began to melt slowly and had a good melting resistance. This slower melting rate in the ice creams with high overruns was attributed to a reduced rate of heat transfer due to a larger volume of air but may also be due to the more tortuous path through which the melting fluid must flow **(**Hartel *et al.,* 2003).

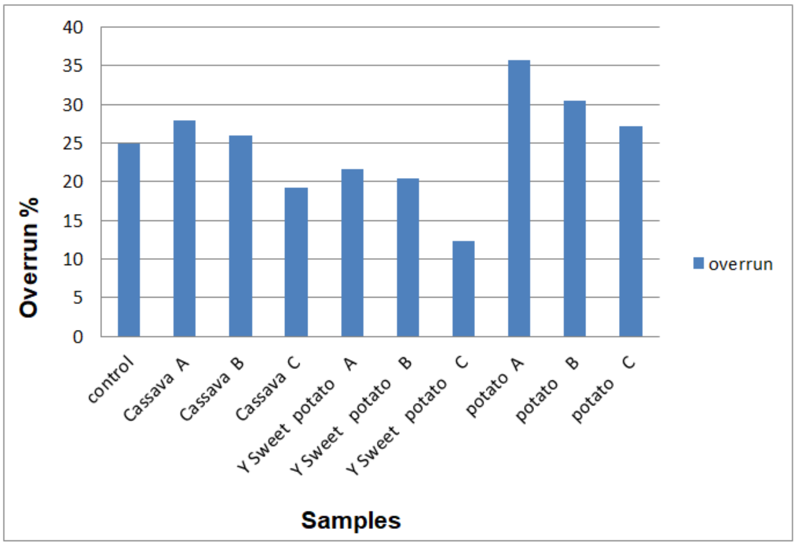

Fig- 2: Overrun % of yoghurt ice cream mix prepared using different plant tuber flour

3.9 One drop/ min (standup time) melting rate of the yoghurt ice cream

The period (min) which elapsed before the first drop of melted yoghurt ice cream fell was noted for each sample and registered as standup time or first dripping. Addition of dibs at different concentrations had appreciable effect on the standup time of the yoghurt ice cream as shown in fig. (3). The highest mean value (60 min) was recorded in potato C treatment, followed by potato B treatment (50 min) and the lowest standup time was observed in both cassava A (20 min) samples. Stabilizer type and quantity had a significant effect on the standup time of yoghurt ice cream mix. Investigation show that significantly difference in standup time by increasing the concentration of stabilizers. The period which elapsed before the first drop of melted ice cream fell was noted for each sample. Ice cream with high melting quality begins to show definite melting within 10-15 minutes when placed at room temperature. The standup time for normal ice cream is 13 min at 20°C as reported by Marshall and Arbuckle, (1996).

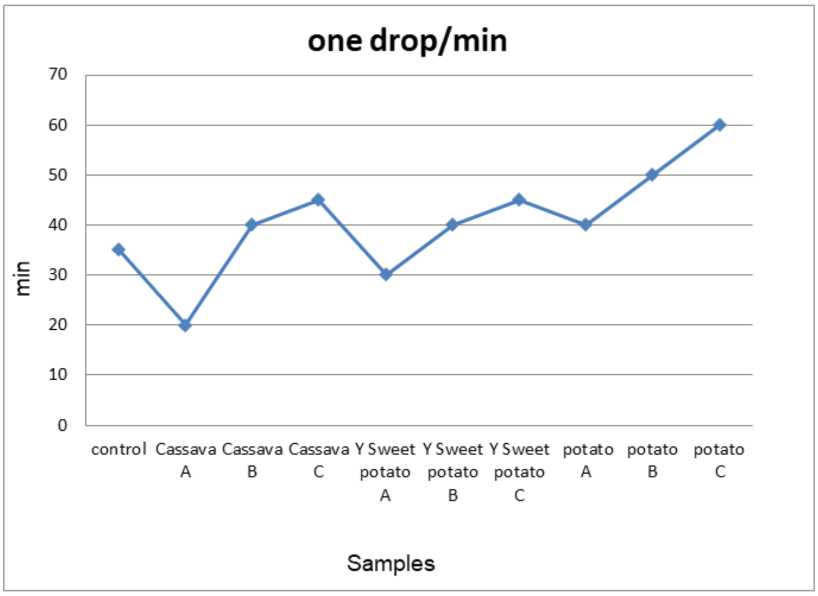

Fig- 3: One drop/ min (standup time) melting rate% of yoghurt ice cream mix prepared using different plant tuber flour

3.10 Melting rate %

Results shows that all melting resistance of the control yoghurt ice cream and with different concentration in Fig (4). The highest value for melting resistance was obtained for yellow sweet potato mix B and the lowest value was cassava mix A after 120 min.

Dietary fibers also showed an increase in the melting of the control yoghurt ice cream. In similar study, the use of fibers improved melting properties, but failed to increase overrun of ice cream (Tiwari *et al*., 2015) and Dervisoglu and Yazici, (2006). The melt-down rate of ice cream is affected by many factors, including the amount of air incorporated, the nature of the ice crystals and the network of fat globules formed during freezing. These results agree with result obtained by Marshall, *et al*., 2003, Goff and Hartel, 2013 and Salem *et al.,* 2016). The melt down of ice cream was affected by its composition and additives and many other, such as the amount of air incorporated, ice crystals nature and fat globules network formed during freezing (Koxholt *et al.*, 2001). The melting of the ice is controlled by the outside temperature and heat transfer. Homogenization improves melt down property of ice cream (Goff, 2001). Ice cream has desirable melting quality when the melted ice cream is very similar in characteristics to that of the original mix (Bhandari, 2001). Results of study describe a correlation between results of over-run and meltdown time as over-run enhances meltdown. Moreover, it has been stated (El-Nagar *et al*., 2002) that the viscosity of ice cream and frozen yogurt is connected with their meltdown characteristics. Higher viscosity is related to higher melting resistance due to the more stable fat-liquid emulsion of the product.

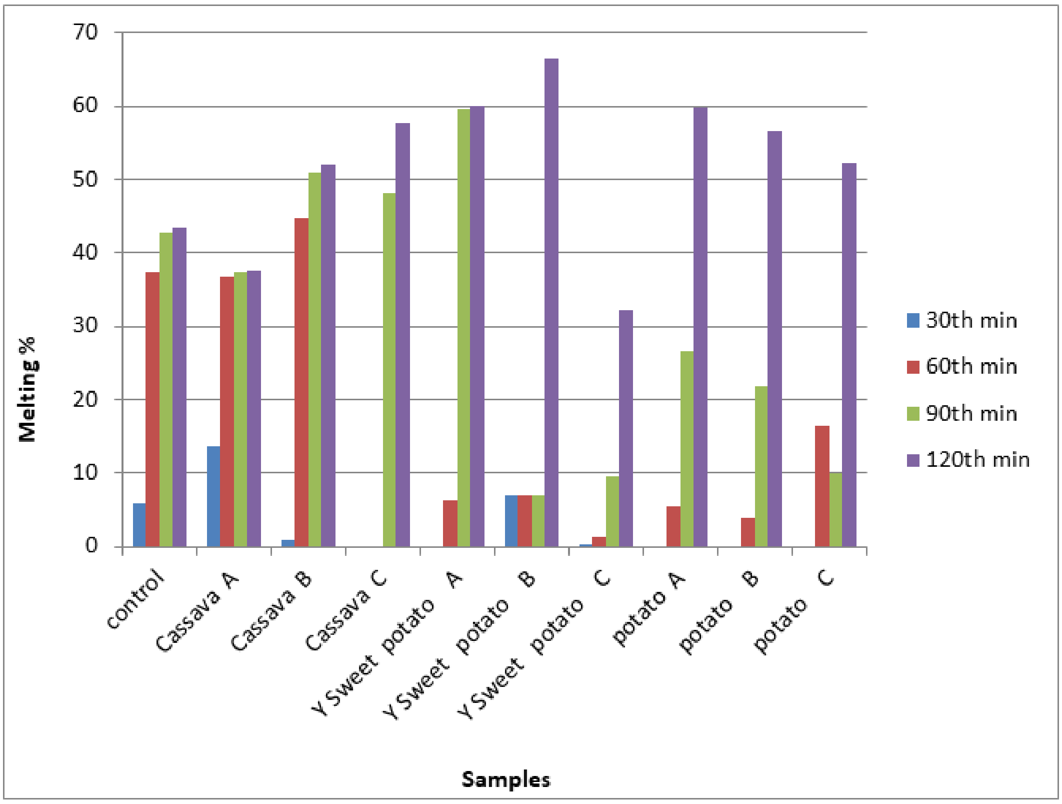

Fig- 4: Melting rate % of yoghurt ice cream mix prepared using different plant tuber flour

3.11 The effect of type and concentration of plant tuber flours on viscosity of yoghurt ice cream mixes

Yoghurt ice cream mixes exhibit non-Newtonian pseudo plastic behavior, meaning that there is a nonlinear relationship between shear stress and shear rate, with the apparent viscosity decreasing with increasing shear rate. The pseudo plasticity or shear thinning behavior has been related to the increased alignment of constituent molecules of the system (Farhoosh and Riazi, 2007). Generally, the power law model is used to fit the rheological properties of the ice cream mix (Kaya and Tekin, 2001): $\tau = K\gamma^n$. Where τ is the shear stress (Pa), K is the consistency index (Pa.sn), $\dot{\gamma}$ is the shear rate (s−1), and n is flow behavior index (dimensionless). The values n and K are important rheological properties of fluid foods, because the flow of these foods is characterized in terms of these quantities **(**Rincon *et al.,* 2006)**.**The smaller the n value, the greater the departure from Newtonian behavior and, hence, the greater the pseudo plasticity. The consistency index, which is considered to be a measure of the viscous nature of the food, increases with stabilizer concentration (Bahram Parvar, *et al*., 2010). The results reported shows yoghurt ice cream in Fig (5) with potato mix A was the lowest viscosity while the highest values was yellow sweet potato mix C in all samples.

Viscosity, which is one of the most important rheological properties of ice cream mix and the unfrozen portion of ice cream, is influenced by mix composition (mainly stabilizer and protein), type and quality of the ingredients, processing and handling of the mix, concentration (total solid content), and temperature (Marshall, *et al.*, 2003) .The viscosity of ice cream mix is set through mix composition, particularly stabilizer content and level (Kus, *et al.*, 2005). Stabilizers decreased the molecular relaxation properties (Goff and Sahagian, 1996, Herrera, *et al.*, 2007) and increased storage (elastic component) and loss moduli (viscous component) in ice cream mixes compared to unstabilized mixes of the same composition. The factors which can affect the viscosity include temperature, type, concentration, state of stabilizer and fat globule size. High water holding capacity of a stabilizer effected the rheological properties of mix (Guinard *et al.*, 1994) so undoubtedly increase in viscosity is depending upon the quantity of stabilizers (Rosalina *et al.*, 2004).

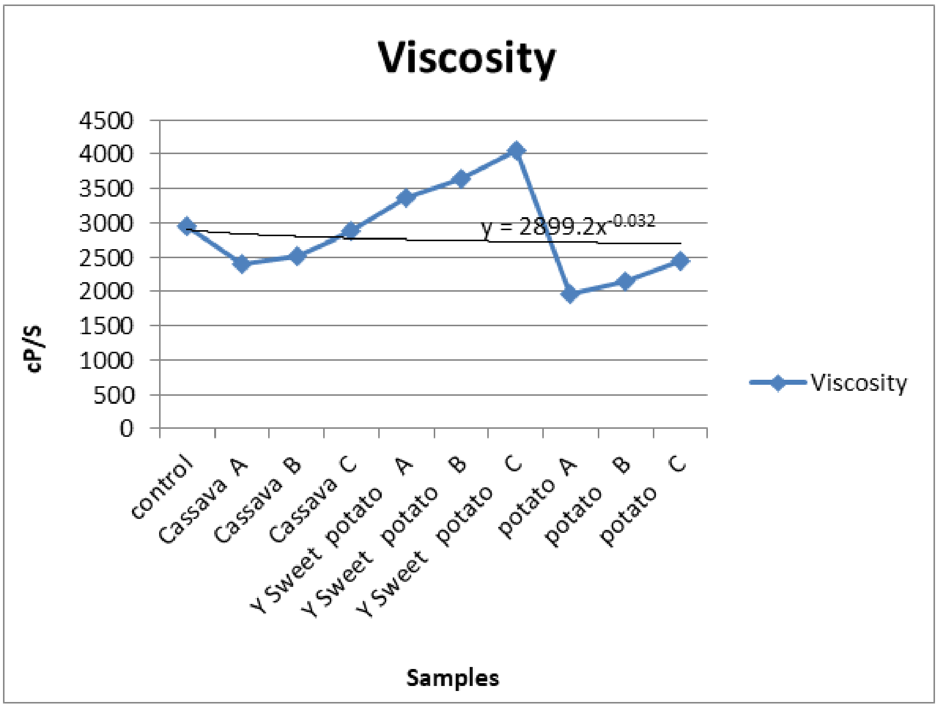

Fig- 5: Viscosity of yoghurt ice cream mix prepared using different plant tuber flour

3.12 Texture profile analysis (TPA) for different yoghurt ice cream mixes made of different plant tuber flours

Texture profile analysis (TPA) of yoghurt ice cream mixes in Table (7) indicated that, control was less significantly effect on hardness than the other samples but cassava mix C and yellow sweet potato mix C was higher in all samples. While cassava mix C was the high significantly effect on cohesiveness on the other treatment. For gumminess, cassava mix B, C and yellow sweet potato C received the greatest average reading, which is more significant gummy than all other treatments. Potato mix A received the least value of gumminess compared to control and other samples. For adhesiveness, Potato mix C received the greatest average reading, which is more significant adhesiveness than all other treatments. The result of the present study is consistent with the findings of Nagar *et al.*, (2002), who reported that low-fat frozen yogurt (5% fat) is considerably less adhesive than high-fat equivalents**.** This is because gumminess are parameters dependant on firmness; therefore, their values, followed a similar trend that of hardness (Gómez *et al.*, 2007). Since the most important characteristic of importance that the product should have a soft texture and be easily spreadable (Shakerardekani *et al.*, 2013). Guinard *et al.*, (1997) who reported that the hardness of the ice cream texture is inversely correlated with the fat content and since the rise in the fat content reduces the ice crystals volume, the increase of the ice crystals could probably lead to a harder texture.

Table 7: Texture profile properties of yoghurt ice cream mixes made of different plant tuber flours

Yoghurt ice cream		Hardness (N)	Cohesiveness	Gumminess (N)	Adhesiveness (Ns-1)
(Control)		2.10 ^{c}	0.35 ^{ab}	7.35 ^{de}	0.47 ^{ab}
Cassava	A	2.26 ^{bc}	0.327 ^{ab}	7.33 ^{de}	0.53 ^{ab}
	B	2.92 ^{ab}	0.42 ^{ab}	13.55 ^{a}	0.43 ^{ab}
	C	3.22 ^{a}	0.47 ^{a}	13.70 ^{a}	0.30 ^{b}
Yellow Sweet potato	A	2.76 ^{abc}	0.27 ^{b}	7.47 ^{de}	0.33 ^{ab}
	B	2.93 ^{ab}	0.32 ^{ab}	9.39 ^{bc}	0.23 ^{b}
	C	3.33 ^{a}	0.41 ^{ab}	12.44 ^{a}	0.17 ^{b}
Potato	A	2.22 ^{bc}	0.31 ^{ab}	6.19 ^{e}	0.30 ^{b}
	B	2.90 ^{ab}	0.34 ^{ab}	8.56 ^{cd}	0.22 ^{b}
	C	3.0 ^{ab}	0.38 ^{ab}	10.30 ^{b}	0.73 ^{a}

[a,b,…] Means with the same letter in the same Colum are not significantly different at (P< 0.05)

3.13 Microbiological

The microbiological quality of yoghurt ice cream samples are shown in Figs (6 and 7). Yeast, molds and coliform bacteria were not found from any research samples within the first dilution analysis, this indicating no contamination in raw materials or during the manufacturing process. Total aerobic bacterial counts (TAB) ranged between 4.08 to 6.1 log cfu /ml^{-1} control to cassava mix C, respectably in zero time (fig. 6). After 15 days, total aerobic bacterial counts (TAB) ranged between 3.7 to 5.2 log cfu/ml^{-1} control to cassava mix C, respectably. Total aerobic bacterial counts (TAB) ranged between 2.5 to 4.6 log cfu/ml^{-1} control to cassava mix C, respectably after 30 days. Total aerobic bacterial counts (TAB) ranged between 1.4 to 3.1 log cfu/ml^{-1} control to cassava mix C, respectably after 60 days. Total aerobic bacterial counts (TAB) decrease degradation during storage period.

Lactic acid bacteria counts: The dairy products, especially frozen yoghurt are good vehicle to transfer probiotics to the human intestinal tract. Consumption of probiotic bacteria via dairy food product is an ideal way to re-establish the intestinal micro-flora balance. Survival of cultures in frozen yoghurt has great importance for the healthy properties of the product (Tamine and Robinson, 1999). In Fig 7 the addition of potato mix c produced highest value of total LAB 3.8 log cfu/ml^{-1} at zero time, but the lowest value of LAB was control 2.8 log cfu/ml^{-1} at zero time.

After 15 days, the addition of potato mix c produced highest value of total LAB, 3.3 log cfu/ml^{-1}, but the lowest value of LAB was control 2.69 log cfu/ml^{-1}. After 30 days, the addition of potato mix c produced highest value of total LAB, 3.0 log cfu/ml^{-1}, but the lowest value of LAB was Yellow sweet potato mix b 2.0 log cfu/ml^{-1}. After 60 days, the addition of potato mix c produced highest value of total LAB, 2.5 log cfu/ml^{-1}, but the lowest value of LAB was control 1.6 log cfu/ml^{-1}. Lactic acid bacterial counts (LAB) decrease degradation during storage period. The longer storage time in freezing temperatures, the lower of ability of LAB to live, thus the quality of the synbiotic ice cream will decline in terms of the presence of LAB; whereas the fermentation product should contain sufficient LAB that are beneficial for health. Moreover, frozen yogurt is a source of lactic acid bacteria, which are able to survive in the product even during one-year storage (Lopez *et al.*, 1998). During the two month, lactic acid bacteria decreased by 2 log unit. The decline in lactic acid bacteria and low number in the total microorganisms may be due to freezing of the cell, incorporation of the oxygen into the mix and osmotic pressure of the ice cream mix as reported by Hagen & Narvhus (1999). Chandan and Shahani (1993) reported that sweeteners in yogurt mix, designed for the manufacture of refrigerated or frozen yogurt, exert osmotic pressure in the system leading to progressive inhibition and decline in the rate of acid production by the culture. Brown *et al.*, (1991) determined the avarage lactic acid bacteria of frozen yogurt retailed in New York State as 1.0 · 105 cfu g) 1. The overall rate of reduction for Lactobacillus bulgaricus and Streptococcus thermophilus in the frozen yoghurt was found during the storage time. This result was in agreement with Gilliland and Kim (1984) & Chandan and Shahani, 1992 that due to the frozen yoghurt environment is not optimum for survival of bacteria. Modler and Villa- Garcia (1993) reported a 2 log10 cfu/ml loss in B. longum concentrations from acidification of frozen yogurt caused by fermentation and refreezing.

Inoue *et al*., reported that viable lactic acid bacteria decreased in number with increasing storage period (Inoue, *et al*., 1998). Increasing total LAB happened because the addition of cilembu sweet potato starch in yoghurt fermentation that used by LAB to support their activities and growth. Cilembu sweet potato starch has high oligosaccharides (Sukardi, *et al*., 2014.).

Ice cream contained Lactobacillus acidophilus stored for 5 weeks at a temperature of -29°C, decreased viability of LAB from 1.0x108 cfu.mL-1 to 4x106 cfu.mL-1 (Hekmat, and Mc Mahon. 1992). That study showed that the storage time of ice cream at freezing temperatures can reduce the viability of LAB, because the longer LAB live in freezing temperatures which is not an optimum temperature for LAB growth.

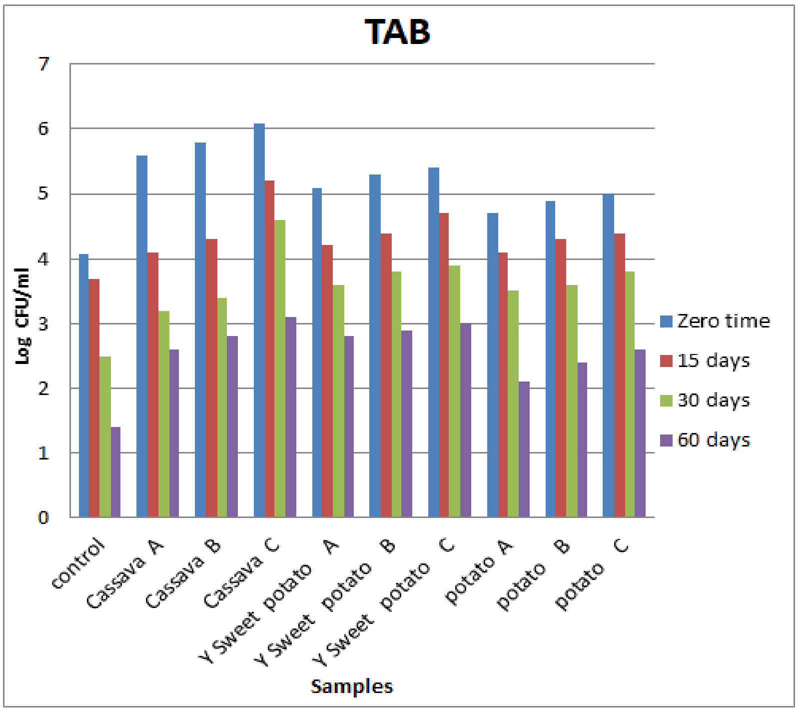

Fig- 6: Total aerobic bacterial counts TAB (log CFU ml) of yoghurt ice cream samples prepared using different plant tuber flours

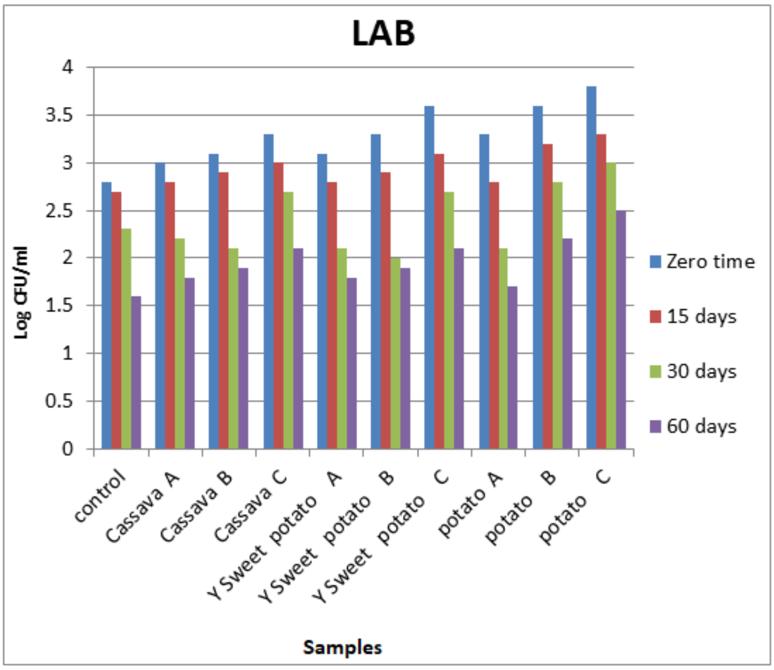

Fig- 7: Lactic acid bacterial counts LAB (log CFU ml) of yoghurt ice cream samples prepared using different plant tuber flours

3.14 Sensory evaluation of yoghurt ice cream mixes prepared using different plant tuber flours

Results of sensory evaluation of yoghurt ice cream mixes prepared using different plant tuber flours at 5, 10 and 15% were shown in Table (8). The highly significant effect of appearance was observed in control in all samples. For texture highest mean score was with control (20.0), and then the lowest was potato mix B and C (16.8). The highest taste was control (19.80) and the lowest was potato C (14.80) in all samples. Maximum flavor (19.8) was obtained by control and the Minimum flavor was obtained by potato mix C (17.8). The highest creaminess was control (19.80) and the lowest was potato C mix (15.4). The statistical analysis for color was significantly differences between all yoghurt ice cream samples from which ranged from 7.2 to 9.5%. With respect to general acceptability of yoghurt ice cream mixes, the highest score (98.90) was obtained by control yoghurt ice cream while lowest score (78.5) was obtained by mix potato C. The yoghurt ice cream sample get highly significant effect of sensory evaluation by control followed cassava containing mix A, mix B then cassava mix C and yellow sweet potato mix A. While yoghurt ice cream potato mixes C got the lowest scores. Similar results of sensory scores of yoghurt ice cream produced from the yoghurt were observed when compared with the control group (Guner *et al.*, 2007). While the score of sensory attributes of flavor, body and texture and overall acceptability differed significantly in yoghurt ice cream prepared with yoghurt organisms (1: 2) using blending yoghurt with ice cream mix prior to freezing (Jaswinder *et al*., 2006). In another study no "acidic-yoghurt taste" was observed in yoghurt ice cream (Caisip and Resubal, 2001). Emata *et al.*, (2001) given the preference to yoghurt ice cream with one hour and thirty minutes incubation period and rating scores were like moderately to like very much in terms of the flavor, aroma, color and appearance, body and texture and general acceptability.

Colour is an important factor of frozen yogurt's attractiveness. It should represent the colour of yogurt and be homogenous. The colour of frozen yogurts was uniform and creamy. Cais-Sokolińska and Pikul, (2006), who explained that the higher acidity causes a decrease in the lightness index L* value in yogurt. Sensory characteristics like mouth feel, creaminess, perception of ice crystals and consistency are crucial factors in consumers' product acceptance (Stampanoni *et al.*, 1996). Viscosity can also provide mouth feel and flavor to the ice cream (Hematyar *et al.* 2012).

Table 8: Sensory evaluation of yoghurt ice cream mixes prepared using different plant tuber flours

Yoghurt ice cream		Appearance 10%	Texture 20%	Taste 20%	Flavor 20%	Creaminess 20%	Color 10%	General acceptability 100%
control		10.0 a	20.0 a	19.80 a	19.80 a	19.80 a	9.50 a	98.90 a
Cassava	A	8.80 ab	18.90 ab	19.20 ab	19.20 ab	19.0 ab	8.60 ab	93.70 b
	B	9.0 ab	19.0 ab	18.50 bc	19.30 ab	17.80 bc	9.20 a	92.80 b
	C	7.90 bc	18.80 ab	19.30 ab	19.30 ab	17.0 cd	9.10 a	91.40 c
Yellow sweet potato	A	8.60 b	18.0 bc	18.30 bcd	19.30 ab	17.70 bc	8.80 ab	90.70 c
	B	6.70 cde	17.90 bc	17.50 cde	18.80 abc	17.0 cd	7.80 bc	85.70 e
	C	5.70 e	17.70 bc	17.30 de	18.80 abc	16.0 cd	6.90 c	82.40 f
Potato	A	7.10 cd	17.80 bc	18.10 cde	18.20 bc	17.80 bc	8.60 ab	87.60 d
	B	5.70 e	16.8 c	17.0 e	18.20 bc	16.0 cd	7.20 c	80.90 g
	C	6.40 de	16.80 c	14.80 f	17.80 c	15.4 d	7.30 c	78.50 h

[a,b,...] Values in the same letter in the same column are not significantly different ($p< 0.05$).

CONCLUSION

The future will continue to bring many changes in the composition and form of frozen dairy desserts as manufacturers try to gain market share and increase profitability. The results of this study show that addition of plant tuber flours at 5, 10 and 15% on yoghurt ice cream improves the physico-chemical and sensory properties of yoghurt ice cream. Also yoghurt ice cream of cassava 5%, 10%, 15% then yellow sweet potato 5% has the most overall sensory characteristics followed by control. Thus we recommend using plant tuber flours in yoghurt ice cream especially with cassava mixes 5% and 10% had good nutritional, technological and sensorial acceptance.

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