Evaluation of Nutritional, Physico-chemical and Sensory Properties of Jackfruit (*Artocarpus heterophyllus*) Incorporated Frozen Yoghurt

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Abstract- The study was conducted to develop frozen yoghurt, flavoured with jackfruit pulp. Sensory data revealed that, the sample incorporated with 15% jackfruit pulp had the best qualities. Protein content of all jackfruit pulp incorporated frozen yoghurts was significantly higher ($p < 0.05$) and their fat content was significantly lower ($p < 0.05$) compared to the control. Significantly higher ($p < 0.05$) overrun was observed in the frozen yoghurt containing 20% of jackfruit pulp compared to the control. Titratable acidity increased and pH decreased in all samples during the storage. Though total plate count of all jackfruit pulp incorporated frozen yoghurts increased upon storage, it was less than that of the control. *Escherichia coli*, yeast and mould were not detected for a period of 35 days at frozen storage. In conclusion, physicochemical, microbiological, and sensory properties of frozen yoghurt improved significantly by adding jackfruit pulp at rate of 15% (w/w).

Index Terms- Frozen yoghurt, Jackfruit, Quality evaluation, Value addition

I. INTRODUCTION

Cow milk contains high uality proteins with a good balance of all essential amino acids and minerals, especially calcium and phosphorous than human milk (FAO, 2013). Milk obtained from dairy cows can be processed to produce various fermented dairy products such as curd, cheese, and yoghurt (Saarela, 2014). Yoghurt is one of the most popular fermented dairy products which has a wide acceptance worldwide as its nutritional and health benefits are well known for centuries. The origin of yoghurt is dated back to the 6000 B.C. (Igbabul and Shember, 2014).

Frozen yoghurt is a unique dairy product with physical properties related to ice cream while nutritional and sensory characteristics are similar to fermented dairy products (Desai *et al.*, 1994). Its process consists in mixing all ingredients to make natural stirred yoghurt with stabilizers/emulsifiers and sugar, then freezing the mix in a conventional ice cream freezer (Tamine and Robinson, 2007). Frozen yoghurt has evolved when the consumer started preferring low acidic foods over high acidic foods in late 1970s (Muzammil *et al*., 2015). Now frozen yoghurt popularity has increased and continues to grow making it one of the most frequently consumed frozen desserts around the world. Consumers are interested to the frozen yoghurt as a dessert because it is a low-fat replacement for ice cream and it has probiotic benefits of the live cultures present in the yoghurt (Davidson *et al*., 2000).

Jackfruit is a high yielding crop which bears fruits all over the year with peak production during the months of June and December. Jackfruit is consumed both as a vegetable in the unripen stage and also as a fruit when ripen (Jagadeesh, 2007). The pulp of jackfruit contains 74% of water, 23% of carbohydrates, 2% of protein and 1% of fat. Also 100 g of raw jackfruit portion provides 400 kJ (95 kcal) (Jetro, 2010). It is a rich source of vitamin B and C, potassium and phytochemicals including phenolic compounds (Jagtap and Bapat, 2010).

Addition of fruit pulp into frozen yoghurt may increase its beneficial and nutritional effects on the host. Also, it may increase the consumer's attractiveness towards the frozen yoghurt. In many cases, the plain frozen yoghurt is served by adding various toppings made from fruits. But incorporation of a fruit pulp into the frozen yoghurt will be a new approach for adding flavours to the frozen yoghurt. Moreover, it will be a solution for the people who do not like the flavour of plain frozen yoghurt. Therefore this study was conducted to develop frozen yoghurt and to determine the effect of addition of jackfruit pulp on the physicochemical, sensory and microbiological characteristics of frozen yoghurt.

II. MATERALS AND METHODS

This research study was conducted at the Dairy Science Laboratory, Department of Animal and Food Sciences, Faculty of Agriculture, Rajarata University of Sri Lanka, Puliyankulama, Anuradhapura.

Materials: Fully matured Jackfruits were collected from Puliyankulama area and Fresh cow milk was obtained from the Dairy farm of Faculty of Agriculture, Rajarata University of Sri Lanka. Starter culture and stabilizer/emulsifier were purchased from Pettah essence at Colombo. Sugar, skim milk powder and gelatin were purchased from Cargills food city at Anuradhapura**.**

Milk composition: Composition of fresh cow milk was measured using milk analyzer. The total solid content of milk was measured by using oven dry method (AOAC, 2003). Temperature, specific gravity and pH of the milk were measured by using thermometer, lactometer (Fssai, 2015) and pH meter (Eutech700, USA) respectively.

Preparation of jackfruit pulp: Fresh well ripen jackfruit were peeled out and seeds were removed. The flesh was washed well and cut into small pieces. Then they were blended to make the pulp and the pulp was pasteurized at 70°C for 10 minutes in water bath.

Analysis of jackfruit pulp: Total soluble solid content and pH of the pulp were measured using refractometer and digital pH meter respectively (AOAC, 2003).

Preparation of plain yoghurt: Fresh cow milk was standardized up to 2.5% of fat, and it was heated to 60°C and homogenized about 15 minutes. Then sugar and gelatin were added and milk was pasteurized at 85ºC for 5 minutes. Then the mixture was cooled to 45°C and it was inoculated with 0.03% starter culture. The inoculated yoghurt mixture was poured into plastic cups and they were incubated at 45°C for 6 hours. Then, they were cooled rapidly to 4°C.

Preparation of ice cream mixture: Fresh cow milk was standardized up to 2.5% fat. Then it was heated to 60°C and homogenized about 15 minutes. Then milk was pasteurized at 85ºC for 5 minutes after adding sugar, butter, skim milk powder and emulsifier/stabilizer. Thereafter mixture was cooled to 10°C and it was aged about 18 hours at 4°C.

Preparation of frozen yoghurt incorporated with jackfruit pulp: Prepared plain yoghurt mixture and ice cream mixture were mixed well **(**75% yoghurt and 25% ice cream (w/w)). Then jackfruit fruit pulp was added at the rate of 10%, 15%, and 20% (w/w) separately. The final mixture was homogenized for 5 minutes in constant stirring. Then it was aerated and frozen in an ice cream maker about 15 minutes. Finally the mixture was poured into plastic cups and they were kept at -18°C until further analysis was carried out. Plain frozen yoghurt was made as the control without adding jackfruit pulp.

Sensory evaluation of frozen yoghurt incorporated with jackfruit pulp: Sensory evaluation was conducted using nine point Hedonic scale to evaluate colour, aroma, taste, texture, meltability and overall acceptability of the samples using 50 untrained panellists. The samples were served in white colour cups with randomly selected three digits numbers (Syed and Babar, 2018).

Chemical analysis of frozen yoghurt incorporated with jackfruit pulp: Fat, fibre, ash, dry matter and protein contents were analysed according to the AOAC procedures (AOAC, 2003). Titratable acidity was analysed by titrating the samples with 0.1N NaOH solution (Fssai, 2015). pH level was measured by using digital pH meter (Eutech700, USA). pH and titratable acidity were measured in 7 days time interval for 35 days at frozen storage.

Microbial analysis of frozen yoghurt incorporated with jackfruit pulp: Total plate count, coliform count, yeast and mould count of prepared frozen yoghurt samples were taken. Plate count agar was used to enumerate total bacteria in frozen yoghurt and the plates were incubated at 37ºC for 24 hours. MacConkey agar was used to enumerate coliforms in frozen yoghurt and the plates were incubated at 37ºC for 18 hours. Potato dextrose agar was used to enumerate yeast and mould counts in frozen yoghurt and the plates were incubated at 25ºC for 5 days. Spread plate technique was used for enumeration and colonies were counted manually.

Testing overrun of frozen yoghurt incorporated with jackfruit pulp: Overrun of prepared frozen yoghurt samples were tested by using the method described by Abdelazez *et al*. (2017).

Data analysis: Treatments were arranged according to the Complete Randomized Design (CRD) with four replicates. Parametric data were analysed using one way Analysis of Variance (ANOVA) procedure in Statistical Software for Data Analysis (SAS) software package version 9.0 (SAS, 2002) with 95% confidence interval. Data from sensory evaluation were analysed using Friedman non-parametric test in MINITAB software package version 17.1.0 (Minitab, 2010) with 95% confidence interval.

III. RESULTS AND DISCUSSION

Physio-chemical parameters of cow milk: Table 1 shows the physiochemical parameters of raw cow milk samples used for the production of yoghurt mixture and ice cream mixture. The high fat content and low protein content were observed in the milk with compared to the values found by Lampert (1970). Composition of cow milk may change with many factors such as diet of the cow, breed, age, lactation period, health conditions, and environmental conditions. Anyhow the observed values are in concordance with the accepted values for the cow milk composition.

Table 1: Physico-chemical parameters of raw cow milk

Milk composition	**Value**
Fat (%)	4.42 ± 0.36
Solid nonfat (%)	3.21 ± 0.18
Total solid (%)	7.61 ± 0.47
Protein (%)	2.80 ± 0.07
Lactose (%)	4.19 ± 0.1
Specific density (gm^{-3})	25.84 ± 0.001
pH	6.59 ± 0.06
Acidity %	0.15 ± 0.04

Data are presented as means±SD

Physico-chemical parameters of jackfruit pulp: Table 2 shows the physicochemical parameters of the jackfruit pulp used for the production of jackfruit incorporated frozen yoghurt. It contained more moisture than total solids. These results are in agreement with the findings of Jagadeesh (2007) and Muangwong *et al.* (2013) who reported the chemical composition of jackfruit pulp.

Table 2: Physico-chemical parameters of jackfruit pulp

Physiochemical Property	**Value**
pH	5.13 ± 0.31
Titratable acidity	0.15 ± 0.05
Moisture Content%	73.45 ± 0.33
Total Soluble Solids	27° Brix ± 0.18

Data are presented as means±SD

Nutritional properties of frozen yoghurt incorporated with jackfruit pulp: Table 3 shows the comparison of nutritional properties of frozen yoghurts incorporated with levels of jackfruit pulp. The fat% of all jackfruit incorporated frozen yoghurts was significantly different from that of plain frozen yoghurt ($p<0.05$). The highest fat percentage was recorded in plain frozen yoghurt. Fat content of frozen yogurt samples decreased with addition of jackfruit pulp. As jackfruit contains very lower amount (0.1-0.4%) of fat (Haq, 2006) and yoghurt and ice cream mix contributes more for the fat% of the final product, addition of jackfruit pulp to the frozen yoghurt may reduce the fat content of frozen yoghurt.

The protein% of all jackfruit pulp incorporated frozen yoghurts was significantly different from the plain frozen yoghurt ($p<0.05$). But there was no significant difference in the protein content among the jackfruit pulp incorporated frozen yoghurts ($p>0.05$). The highest protein% was noted in the frozen yoghurt containing the highest jackfruit pulp percentage. Increased concentrations of jackfruit pulp in the frozen yoghurt increased the protein content. A similar trend is reported by Sarmini *et al.* (2014) who studied the quality of jackfruit pulp added set yoghurt.

Ash content and the fibre content of the frozen yoghurts containing 15% and 20% of jackfruit pulp only showed a significant difference ($p<0.05$) with the plain frozen yoghurt. No significant difference ($p>0.05$) in ash content was observed among the jackfruit

pulp incorporated frozen yoghurt samples. Fibre content of the frozen yoghurt containing 10% of jackfruit pulp was significantly different from that of frozen yoghurts containing 15% and 20% of jackfruit pulp. These results showed that both ash and fibre contents increased with the addition of more jackfruit pulp. It may be due to the jackfruit is a good source of fibre. El-Bakri *et al.*, (2015) also reported that fruit added yoghurts contain higher fibre content than plain yoghurts.

There was a no significant ($p>0.05$) difference in dry matter content of all treatments. In the other hand incorporation of jackfruit pulp at a rate of 10, 15 and 20% had not a significant effect on the dry matter content of frozen yoghurts. But the highest dry matter content was noted in the frozen yoghurt incorporated with the highest jackfruit pulp concentration. These results are not in agreement with the findings of ozturk and Akyuz (1995). Because they observed that adding fruit pulp could increase the dry matter content of frozen yoghurt.

Table 3: Nutritional properties of frozen yoghurt incorporated with different levels of jackfruit pulp

Treatment	**Fat%**	**Protein%**	**Ash%**	**Dry matter%**	**Fibre%**
T1 (0%)	8.47 ± 0.50^{a}	4.85 ± 0.35^{b}	1.40 ± 0.41^{b}	31.21 ± 0.11^{a}	1.99 ± 1.36^{b}
T2 (10%)	5.30 ± 0.53^{b}	5.84 ± 0.12^{a}	2.29 ± 0.17^{ab}	30.81 ± 0.53^{a}	2.38 ± 0.63^{b}
T3 (15%)	3.59 ± 0.39^{c}	5.93 ± 0.39^{a}	2.55 ± 0.26^{a}	30.87 ± 1.12^{a}	9.83 ± 0.98^{a}
T4 (20%)	3.50 ± 0.15^{c}	6.01 ± 0.12^{a}	3.20 ± 0.46^{a}	31.34 ± 0.11^{a}	10.94 ± 1.93^{a}

Data are presented as means$\pm$SD
a, b, c, d means, within the same column with different superscripts are significantly different ($P < 0.05$)

Shelflife of jackfruit pulp incorporated frozen yoghurt: Shelflife of all the products was detrmined by measuring the variations in pH, titratable acidity and mirobial counts (total plate count, yeast and mould and coliforms) throughout the storage period of 35 days. During the storage period, pH of all frozen yoghurt**s** gradually decreased showing increase in acidity (Figure 1). These observations are in agreement with the previous research findings (Obi *et al*., 2010). The plain frozen yoghurt had the highest initial pH value. Jackfruit incorporated frozen yoghurts possessed lower pH values compared to the control. Normally pH of yoghurt decreased during storage due to post-acidification because of the accumilation of lactic acid (Tamime and Robinson, 2000). Anyhow the pH reduction was drastic in plain frozen yoghurt compared to the jackfruit pulp incorporated frozen yoghurts. It may be due to the heat treatment given to jackfruit pulp before incorporating into the frozen yoghurt which might result in reduced microbial growth.

Figure 2 shows the variation in titratable acidity of jackfruit incorporated frozen yoghurts with storage time period. The initial titratable acidity of all treatments was almost same and during the storage period, titratable acidity of all frozen yoghurt samples increased. The plain frozen yoghurt sample had the highest acidity at the end of storage period. The increase in titratable acidity values could also be attributed to the activity of lactic acid bacteria which usually convert lactose in to lactic acid (Temesgen, 2015). Acidity is one of the most important quality parameter for the yoghurt related products which is important for the palatability, shelf-life and consumer acceptance of the product (Sarmini *et al*., 2014).

During the storage period of 35 days, coliform, yeast and mould were not detected in all frozen yoghurt samples. But Total Plate Count (TPC) of all frozen yoghurt samples increased with the time (Table 4). The highest initial TPC was recorded by the plain frozen yoghurt sample and its TPC was comparatively high even at the end of storage period. With addition of jackfruit pulp, TPC reduced. This may be due to the high acidity of jackfruit pulp. But there are no standards used in Sri Lanka for the frozen yoghurt yet.

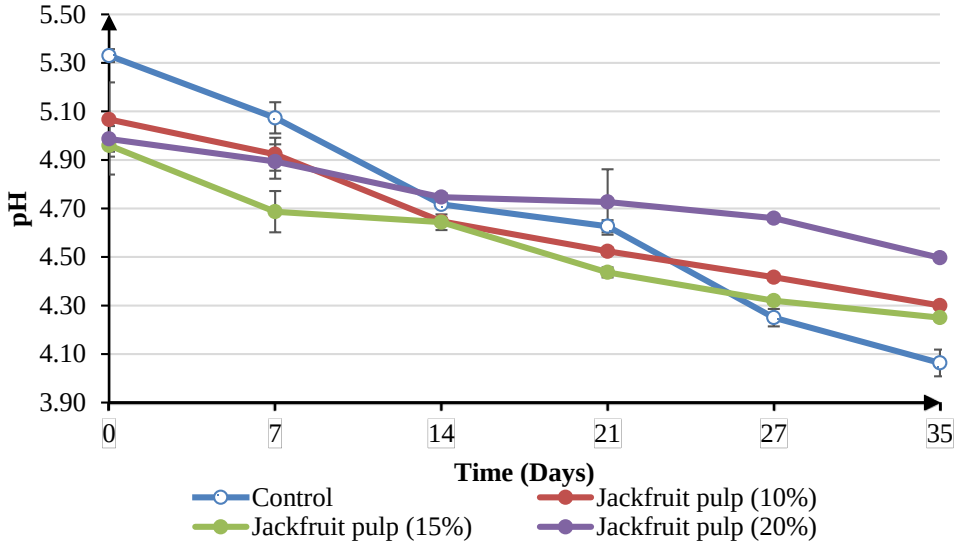

Figure 1: Variation in pH of frozen yoghurt incorporated with different levels of jackfruit pulp during 35 days of storage

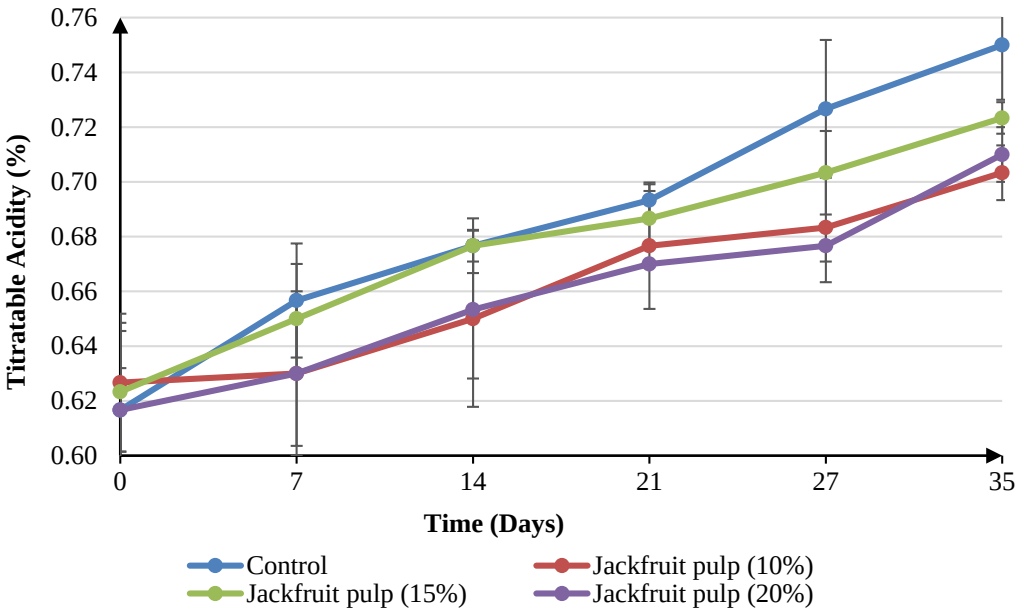

Figure 2: Variation in titratable acidity of frozen yoghurt incorporated with different levels of jackfruit pulp during 35 days of storage

Table 4: Variation of total plate count of frozen yoghurts incorporated with different levels of jackfruit pulp during 35 days of storage

Treatment	Time (Days)					
	1	7	14	21	27	35
T1 (0%)	8.90 ± 0.3	9.10 ± 0.2	9.50 ± 0.2	9.80 ± 0.2	10.00 ± 0.1	11.40 ± 0.1
T2 (10%)	8.00 ± 0.1	8.40 ± 0.1	8.70 ± 0.1	9.00 ± 0.2	9.40 ± 0.1	10.20 ± 0.1
T3 (15%)	7.60 ± 0.1	8.00 ± 0.3	8.40 ± 0.1	8.80 ± 0.1	9.00 ± 0.3	9.50 ± 0.3
T4 (20%)	7.00 ± 0.1	7.50 ± 0.1	7.80 ± 0.1	8.50 ± 0.2	8.80 ± 0.1	9.10 ± 0.2

Data are presented as means ±SD, (x 10^8) CFU/g

Sensory evaluation: The frozen yoghurt containing 15% of jackfruit scored best for all the sensory attributes except the meltability (Figure 3). Further, colour, taste, texture, meltability, and overall acceptability of prepared frozen yoghurts had significant difference ($P<0.05$) among the treatments. But aroma was not observed to be significantly different ($P>0.05$) among the treatments.

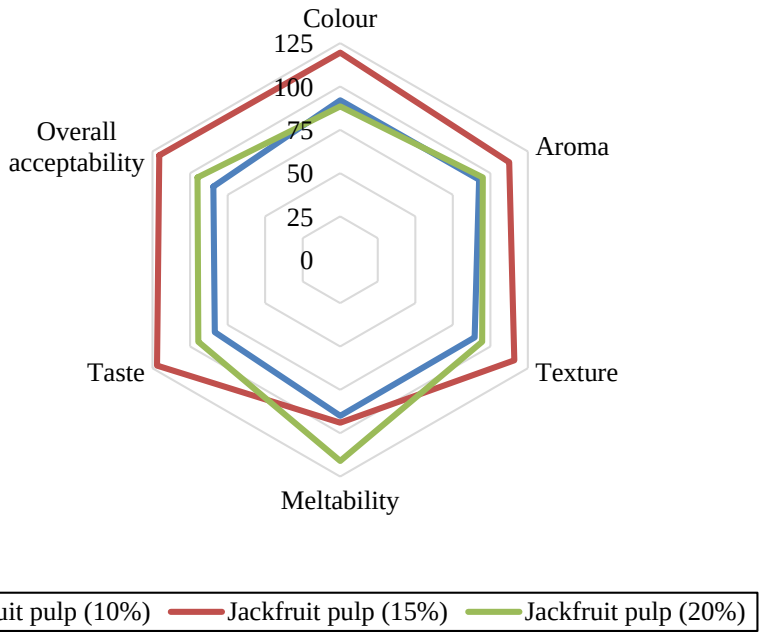

Figure 3: Sensory properties of frozen yoghurts incorporated with different levels of jackfruit pulp

IV. CONCLUSION

Physicochemical, microbiological, and sensory properties of frozen yoghurt improved significantly by adding jackfruit pulp at rate of 15%. Hence it can be introduced as a value added healthy dairy product. Frozen yoghurt containing 15% of jackfruit pulp had the best sensory properties and the developed products could be stored for 35 days with minimum alterations of microbiological and physicochemical properties.

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