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Development of a Ripened Jack (*Artocarpus heterophyllus* Lain) Fruit and Soy (*Glycine max*) Milk Incorporated Set Yoghurt

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ABSTRACT

The research was conducted to develop fruit yoghurt fortified with the acceptable combination of milk, soy milk (*Glycine max*) and ripened jack fruit (*Artocarpus heterophyllus* Lain). Incorporation of suitable percentages of soy milk and jack fruit were determined by organoleptic evaluation. Different levels of soy milk viz., 5, 10, 15, 20 and 25% (v/w) were used for the preparation of yoghurt. Subsequently after the 10% soy milk was determined as optimum level; 5, 7 and 9% level of jack fruit chunks (3-5 mm) were used in the preparation of fruit yoghurt. The yogurt without the addition of soy milk and jack fruit was used as control. Selected yoghurt sample (10% soy milk toned yoghurt, 10% soy milk with 7% jack fruit incorporated yoghurt) and control were analysed for proximate composition, *E. coli* count, shelf life and sensory attributes. The means for total solids, fat, protein and fiber for the control samples were 19.73±0.12, 4.00±0.06, 3.30±0.02, 0.00%, respectively. Whereas, for the soy-jack yoghurt samples the means were 22.92±0.86, 4.08±0.03, 3.35±0.02, 0.2±0.01%, respectively. The products were packed in cartons and stored under refrigerated conditions at 4±1°C for a period of sixteen days whereas pH, titratable acidity and syneresis were measured once in three days. The means of pH decreased significantly ($p<0.05$), whereas, titratable acidity increased significantly ($p<0.05$) throughout the storage period. The *E. coli* were not detected at 10^{-1} dilution. Yoghurt sample prepared by incorporating 10% soy milk and 7% jack fruit resulted in superior organoleptic properties and nutritional qualities compared to control sample.

Key words: Jack fruit, nutrition, soy milk, soy yoghurt, soy-jack yoghurt

INTRODUCTION

Yoghurt is an increasingly popular cultured dairy product in most countries. This is partly because of an increased awareness of the consumers regarding possible health benefits of yoghurt. Current trends and changing consumer demand provide a great opportunity for innovations and developments in fermented milk products. According to the Department of Census and Statistics, Per capita consumption of milk and milk products in Sri Lanka is low compared to other South Asian countries and at present per capita consumption of milk is 43.8 kg year^{-1} (DCS, 2011). In developing countries, due to the continuous increase in population and inadequate supply of protein has inadvertently increased the occurrence of malnutrition (Siddhuraju *et al*., 1996).

Yadav and Chauhan (2005) reported that soy milk resembles bovine milk in physical appearance and consistency and contains less amount of fat and higher amount of Fe and Cu as compared to cow milk. Therefore, it can be blended with milk.

In Sri Lanka wide variety of seasonal fruits are available. It is possible to prepare yoghurt by adding seasonal fruits. Jackfruit is one of the most popular and important fruit crop in Sri Lanka. During the peak production time, a large amount of jack fruit undergoes spoilage. Therefore, an attempt was made to develop an acceptable combination of milk, soy milk and jack fruit chunks blend for the preparation of yoghurt and to study the nutritional composition of most preferred products.

Objectives of the study:

- Find out optimum percentage of jack fruit chunks and soy milk to be incorporated into set type fruit yoghurt through organoleptic evaluation
- To determine the physicochemical and microbiological qualities of the selected products
- To develop a low cost and nutrient rich fruit flavoured set type yoghurt

MATERIALS AND METHODS

The experiment was conducted from March 2011 to August 2011 in Laboratory of the Department of Animal Science and Department of Chemistry, Faculty of Agriculture, University of Jaffna, Sri Lanka. Fresh milk was collected from Jaffna District Development Cooperative Society, Sri Lanka. Jack fruit, Soybean for soy milk preparation, sugar and starter culture were purchased from local market.

Preparation of soy milk: Soy milk was prepared by soaking beans for 10 h and grinding soybean grains in a grinder by adding a known quantity of water. The slurry obtained was diluted so that 100 g of soybean could produce 800 mL soymilk (Kapoor *et al*., 1977). The slurry so obtained was boiled at 100°C for 45 min. Then it was filtered using muslin cloth.

Preparation of fruit preserves: Fruits were prepared by "osmodehydrofrozen" method using high fructose corn shrub.

Preparation of plain yoghurt: In accordance with the procedure developed by Sri Lanka Standard (SSI, 1989) yoghurt mix (sugar 10%, gelatine 0.7%) was prepared. The milk mix was pasteurized and heated to reduce about one-third of its original volume. Subsequently, the milk was cooled to inoculation temperature of 42±2°C and then inoculated with 3% yoghurt starter culture. Formulated yoghurt samples were packaged in plastic cartons and incubated at 40°C until the complete curd formation/coagulation of yoghurt (3-4 h). Then the samples were chilled in a refrigerator and used for further studies.

Preparation of soy yoghurt and fruit yoghurt: Soy yoghurt was prepared with different percentage of soy milk (5, 10, 15, 20 and 25% (v/v) and cow milk combinations. All other ingredients remained constant as for plain yoghurt. Subsequently after the 10% soy milk was determined as optimum level; 5, 7 and 9 (w/v) percent levels of jack fruit chunks (3-5 mm) were used in the preparation of fruit yoghurt. All other ingredients was maintained as same except the sugar content where the sugar percentage of plain and fruit yoghurt were 10 and 8%, respectively.

Sensory analysis: After complete curd formation, the samples were judged separately by a team of experienced judges for organoleptic parameters of appearance, aroma, colour, taste, overall acceptability and texture.

Chemical analysis of fresh milk, soy milk, jack fruit and different types of yoghurt: Total solids, fat, protein, sugar, fibre, ash, pH and titratable acidity were measured by the methods described in AOAC (1990).

Determination of Syneresis: A method of Wu *et al.* (2000) was used to measure the syneresis of yogurt samples. Syneresis was measured with three days interval up to 16 days.

Microbiological tests: Prepared yoghurt samples were examined for coliforms count. For coliforms counts Mac Conkey's agar was used. Diluted samples (9 mL peptone water with 1 mL sample) were applied directly on the Mac Conkey's agar plates and incubated at 37°C for 24 h (Weerasekara *et al.*, 2010).

Statistical analysis:

- **Sensory analysis:** Friedman non parametric statistical method was used to analyze the sensory evaluation data based on 5-point hedonic scales and analysis was done using Minitab software
- **Proximate analysis:** Data were analyzed in a Complete Randomized Design (CRD) using the SAS statistical software package and mean separation was done using Duncan's Multiple Range Test (DMRT)

RESULTS

Proximate composition of milk, soy milk and jack fruit: Quality of milk, soy milk and jack fruit used for yoghurt production was analyzed before use. Moisture, total solid, fat, protein, ash, lactose, titratable acidity, pH and specific gravity were determined. Results of proximate analysis of milk, soy milk and jack fruit were shown in Table 1 and 2.

Comparison of sensory attributes of soy yoghurt: Median values for appearance, colour, aroma, texture, taste and overall acceptability of yoghurt toned with 5, 10, 15, 20 and 25% level of soy milk were presented in Table 3. Yoghurt sample toned with 10% of soy milk showed significant ($p<0.05$) different in taste and overall acceptability from other treatments.

Table 1: Mean and SD of chemical composition of cow milk and soy milk

Ingredients	Moisture	Total solids	Fat	Protein	Lactose	Fibre	Ash	pH	Acidity	Specific gravity
Cow milk (Mean±SD)	87.39±0.10	12.61±0.10	04.07±0.06	3.30±0.05	4.51±0.00	0	0.73±0.01	6.5±0.26	0.17±0.01	1.029±0.001
Soy milk (Mean±SD)	90.34±0.24	9.66±0.24	1.87±0.47	3.50±0.09	2.67±0.31	1.15±0.00	0.48±0.02	6.74±0.15	0.23±0.02	Not determined

Table 2: Mean and standard deviation of chemical composition of jack fruit

Ingredients	Moisture	Total solids	Fat	Protein	Carbohydrate	Fibre	Ash
Wet weight basis (Mean±SD)	77.49±0.15	30.30±1.37	0.94±0.03	1.33±0.05	26.11±1.29	0.96±0.04	0.96±0.05

Table 3: Median values for sensory scores in yoghurt samples toned with different percentage of soy milk

Attributes	5% soy milk	10% soy milk	15% soy milk	20% soy milk	25% soy milk
Appearance	4.40^{b}	5.00^{a}	4.70^{a}	4.40^{b}	4.00^{b}
Colour	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.90^{b}
Aroma	4.80^{a}	5.00^{a}	4.80^{a}	4.90^{a}	4.00^{b}
Texture	4.95^{a}	4.95^{a}	4.85^{a}	4.05^{b}	3.95^{b}
Taste	4.20^{b}	4.80^{a}	4.00^{b}	4.00^{b}	4.00^{b}
Overall acceptability	4.50^{bc}	5.00^{a}	4.70^{ab}	3.60^{c}	3.20^{d}

$^{a-d}$Values in the same column with the same letter of alphabet do not differ significantly ($p>0.05$)

Table 4: Median values for sensory scores in different percentage of jack fruit incorporated with 10% (v/v) of soy toned yoghurt samples

Treatment	Appearance	Colour	Fruit distribution	Aroma	Texture	Taste	Overall acceptability
5% jack fruit 10% soymilk	3.00^{b}	4.00^{a}	4.00^{a}	2.67^{b}	4.00^{a}	2.00^{b}	2.67^{c}
7% jack fruit 10% soymilk	5.00^{a}	4.00^{a}	4.00^{a}	4.33^{a}	4.00^{a}	4.00^{a}	4.50^{a}
9% jack fruit 10% soymilk	5.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.73^{b}

$^{a-c}$Values in the same row with the same letter of alphabet do not differ significantly ($p>0.05$)

Table 5: Median values for sensory scores of NY, SY and SJY

Attributes	Appearance	Colour	Aroma	Texture	Taste	Overall acceptability
NY	2.00^{c}	2.88^{c}	2.19^{c}	2.00^{c}	2.38^{c}	2.38^{c}
SY	4.00^{b}	4.13^{b}	4.06^{b}	4.00^{b}	4.13^{b}	4.00^{b}
SJY	5.00^{a}	5.00^{a}	4.94^{a}	5.00^{a}	5.00^{a}	5.00^{a}

$^{a-c}$Values in the same row with the same letter of alphabet do not differ significantly ($p>0.05$) NY: Normal yoghurt, SY: Soy (10% v/v) yoghurt, SJY: Soy (10% v/v) Jack (7% w/v) fruit yoghurt

Comparison of sensory attributes of jack yoghurt: Median values of various sensory parameters of 10% (v/v) soy milk toned yoghurt incorporated with 5, 7 and 9% jack chunks were presented in Table 4. There was no significant difference among the colour, fruit distribution and texture scores of different percentage of fruit yoghurt. Higher overall acceptability score (4.5) was recorded in the case of 7% jack fruit incorporated sample.

Comparison of sensory attributes of normal yoghurt, soy yoghurt and soy jack yoghurt: Normal yoghurt (no fruit and soy milk added) (NY) was compared with 10% soy milk toned yoghurt (SY) and 10% soy toned with 7% jack fruit incorporated yoghurt (SJY) for different sensory attributes. Results of organoleptic tests were presented in Table 5. Statistical analysis showed that there was significant difference ($p<0.05$) among the all attributes of different types of yoghurt.

Microbiological and physico-chemical parameters of NY, SY and SJY: Chemical characteristics are important indicators of quality measures of prepared yoghurts. Mean values of moisture, total solid, fat, protein, carbohydrate, fiber and ash content of NY, SY and SJY were shown in Table 6. Statistical analysis showed that there was significant difference ($p<0.05$) among the mean values of total solids, fat, fiber and ash contents of different treatments.

Physical and microbiological characteristics are indicators of safety, quality and shell life of prepared yoghurt. pH, titratable acidity and syneresis values were determined on 1st, 4th, 7th, 10th, 13th and 16th day of storage. Results obtained were illustrated in Fig. 1-3. Coliforms were not detected throughout the period of storage.

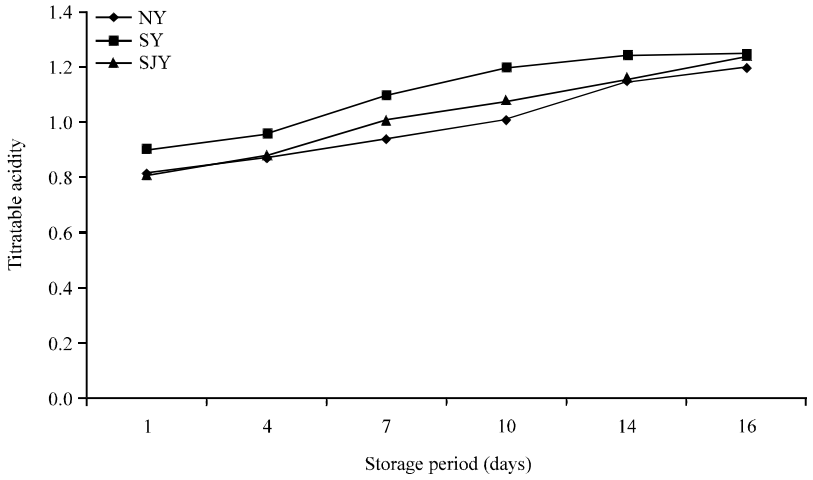

Fig. 1: Changes in titratable acidity of yoghurt samples during the storage time

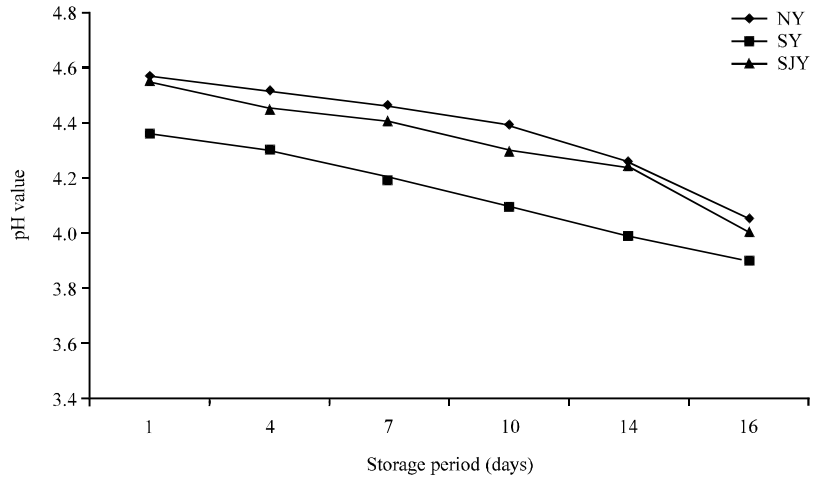

Fig. 2: Changes in the pH of yoghurt samples during the storage time

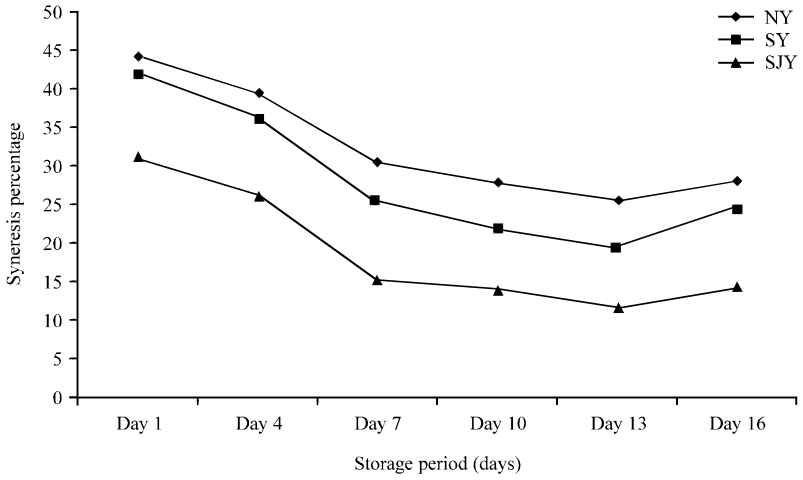

Fig. 3: Changes in the syneresis percentage of yoghurt samples during the storage time

Table 6: Means and standard deviation of compositional contents of NY, SY and SJY

Constituents	Moisture	Total solids	Fat	Protein	Carbohydrate	Fibre	Ash
NY	80.27±0.12^{a}	19.73±0.12^{b}	4.00±0.06^{b}	3.30±0.02^{b}	11.91±0.04^{b}	0.00±0.00^{c}	0.82±0.02^{b}
SY	80.74±0.08^{a}	19.26±0.81^{b}	3.84±0.08^{c}	3.34±0.01^{ab}	11.44±0.04^{b}	0.14±0.01^{b}	0.79±0.01^{c}
SJY	77.38±0.32^{b}	22.92±0.86^{a}	4.08±0.03^{a}	3.35±0.02^{a}	14.45±0.32^{a}	0.2 0±0.01^{a}	0.84±0.01^{a}

$^{a-d}$Values in the same row with same letter of alphabet do not differ significant (p>0.05). NY: Normal yoghurt, SY: Soy (10% v/v) yoghurt, SJY: Soy jack (7% w/v) yoghurt

DISCUSSION

Proximate composition of milk, soy milk and jack fruit: Average specific gravity of milk sample was 1.029±0.001. Mean value of specific gravity is within the normal range of specific gravity of milk (1.025-1.035, Eckles *et al.*, 1951) and all parameters of cow milk and jack fruit samples were within normal range.

Total solids, pH, titratable acidity, protein content of the soy milk were 9.66±0.24, 6.74±0.15, 0.23±0.02, 3.50±0.09, 1.87±0.47%, respectively. Similar values for pH and titratable acidity were reported by Osman and Razig (2010) but the same authors reported higher values for total solid, fat and protein than the values observed in the present study. Deshpande *et al.* (2008) reported the values of total solids, fat, protein, pH value and ash content were 9.8, 2.6, 5.8, 6 and 0.6%, respectively. Lee *et al.* (1990) stated the variations in the chemical composition and other factors may be due to varietal differences and processing condition.

Comparison of sensory attributes of soy yoghurt: Yoghurt sample toned with 10% of soy milk was most preferred for taste and overall acceptability. Present result are in agreement with the statement of Tamime and Robinson (1985) who reported that the addition of soy milk to cow milk or buffalo milk should not exceed 10% because the starter culture counts decreases with increasing soy milk concentration and the acceptability of the product decreased owing to the detection of beany aroma.

Comparison of sensory attributes of jack yoghurt: The highest overall acceptability score was obtained for yoghurt with 7% fruit incorporation. According to the Sri Lanka Standard the fruit content of yoghurt must be at least 5% in all type fruit yoghurt (SSI, 1989). The FAO/WHO recommendations for fruit yoghurt are a fruit content between 5 and 15%. The results of organoleptic testing fell within the recommendation levels of SLS and FAO/WHO for fruit yoghurt.

Comparison of sensory attributes of NY, SY and SJY: According to Table 5 SJY sample had the highest score for all attributes and it was significantly differed in all attributes from other samples. This could be due to the combined effect of pleasant colour and aroma, attractive appearance, texture and taste. Drake *et al.* (2000) stated that the fortification of soy protein can improve the functional properties such as viscosity and colour of yoghurt. Rahman *et al.* (2001) reported that the addition of jack fruit juice to the yoghurt increased the smell and taste score.

Microbiological and physico-chemical parameters of NY, SY and SJY: The average total solids content of NY, SY and SJY were 19.73, 19.26 and 22.92%, respectively. Present results obtained for total solids content of NY fell within the range reported by Karagozlu *et al.* (2005) who stated that an average total solids content of normal yoghurt varied between 12.45-20.76%. Results obtained for fruit yoghurt was in alliance with the results of El Bakri and El Zubeir (2009), who

reported that an average total solids content of fruit yoghurt was 21.7±1.34%. Also, lower total solids content was reported for NY by the same authors. Who reported that normal yoghurt had average total solid content of 14.04±1.83%. According to SLS the higher value for yoghurt is not mentioned but they have specified the solid not fat of at least 8% for all types of yoghurt. From Table 6 it is evident that total solid content of fruit yoghurt was higher than plain yoghurt. However, the total solid contents of plain yoghurt and soy yoghurt did not differ significantly. El Bakri and El Zubeir (2009) stated that addition of fruit significantly increased the total solids content of yoghurt sample.

There was a significant difference in the fat content between the formulated products. Fat level was lowest in SY (3.84±0.08%) and the highest in SJY (4.08±0.03%). According to SLS all three products to be declared as full fat products. In Sri Lanka standard specification for fermented milk products, yoghurts are classified according to their fat contents. The full fat, low fat and non- fat yoghurt must contain minimum 3, 0.5 and less than 0.5% milk fat, respectively. Low fat content of soy yoghurt may be as a result of toning of soy milk with whole milk (Table 1).

The average protein content of NY, SY and SJY were 3.30, 3.34 and 3.35%, respectively. Mean protein values of SY and SJY were slightly high due to addition of soy and jack fruit (Table 1 and 2). El Bakri and El Zubeir (2009) found that the fruit yoghurt contains higher protein value than normal yoghurt. Salim-ur-Rehman *et al.* (2007) found that the soy-cow milk blend had higher crude protein contents than cow milk.

The data from the Table 6 revealed that the carbohydrate contents of SJY (14.45%) differed significantly from NY and SY. The lowest value of carbohydrate content was recorded in case of SY (11.44%) and the value was decreased due to toning of soy milk (Table 1). The analysis showed that the ash content of SJY, NY and SY differed significantly ($p<0.05$). Mean ash content of NY (0.82±0.02%) of current study agrees with the work of El Zubeir *et al.* (2005), who reported that the ash content of yoghurt made from cow milk was 0.81±0.29%.

Fiber content of SJY was the highest compared with NY and SY. This could easily be justified by the incorporation of jack fruit and soy milk. Most dairy products do not contain dietary fiber, there are a few dairy foods which contain certain non-dairy ingredients contributing varying amounts of fiber (DTSI and NDRI., 2005). Present study reveals that incorporation of jack fruit and soy milk can add product diversification and dietary fiber to the SJY.

The mean Titratable Acidity (TA) values of NY, SY and SJY showed a significantly ($p>0.05\%$) increasing trend with storage days (Fig. 1). The increase in TA values could be attributed to the activity of lactic acid bacteria which usually converts lactose into lactic acid (Obi *et al.*, 2010). Mean TA values for NY, SY and SJY ranged from 0.81-1.2, 0.9-1.25 and 0.81-1.24%, respectively. According to the SLS, the TA value as lactic acid percentage of yoghurt ranges from 0.8-1.25% (SSI, 1989). Whereas, International Dairy Federation Consumption Statistics for milk and milk products document specifies a minimum acidity value of fermented milk products is 0.70%. Present TA values of all samples fell within the recommendation levels of SLS and International Dairy Federation Consumption Statistics. The acidity and level of proteolysis in yoghurt play important roles in the formation of yoghurt aroma. Therefore, the acidity is another quality criterion for yoghurt (Karagozlu *et al.*, 2005).

Mean pH values of NY, SY and SJY were decreased significantly ($p>0.05$) with storage days (Fig. 2). Present trend agrees with the report of Tarakci and Kucukoner (2003) who stated that in general, the pH values of all yogurt samples decreased during storage. Activity of micro organisms causes the decrease in pH of fruit yoghurt and yeasts also used sugar and organic acids and so will

result in pH decrease (Vahedi *et al.*, 2008). Furthermore, mean pH values of SJY and SY samples during storage were significantly lower than the NY. The pH values of NY, SY and SJY ranged from 4.56-4.05, 4.36-3.9 and 4.55-4.01, respectively. The result of NY was within the normal range of pH of yoghurt (3.7-4.85, Karagozlu *et al.*, 2005).

As shown in Fig. 3, syneresis value decreased until 13th day of storage but increased until 16th day of storage. However syneresis value in whole period was lower than first day of production, similar trend was reported by Vahedi *et al.* (2008) for apple and strawberry added yoghurt. Mean syneresis value of NY, SY and SJY were 41.85±1.32, 44.28±1.22 and 31.11±1.48%, respectively on first day of storage. Introduction of soy and jack fruit increased the fiber contents in SJY which could be able to hold the water and thus decrease the syneresis. Syneresis reduction can be relating to absorption of unbound water by fruit cubes (Tarakci and Kucukoner, 2003). Total solids content of the yoghurt samples had significant effect on syneresis. Mahdian and Tehrani (2007) reported that the reduction of free water and increasing the proportion of solids contents, are two main factors decreased rates of wheying off in the samples with high total solids.

All yoghurt samples showed negative results for coliforms test with 10^{-1} dilution. This could be attributed to the high hygienic conditions obtaining in the laboratory that prevented post-production contamination. This study was in conformity with the work of Yaygin and Kilic (1980) who reported that fermented milks are characterized by low levels of oxygen, high acidity and production of antimicrobial compounds by the starter bacteria which prevent the survival of some pathogenic or spoilage organisms. Coliforms prefer 7-44°C temperature and minimum initial pH 4.4- 4.5. Both refrigerator conditions which used for yoghurt storage and pH reduction can make undesirable condition for coliforms to continue their growth (Vahedi *et al.*, 2008). According to the SLS, the number of coliforms in yoghurt must be less than 1 CFU g^{-1}. In the present study, we found that all yoghurt samples examined were in good agreement with the standards SSI (1989).

CONCLUSION

The jack fruit incorporated soy yoghurt bears significance on different attributes. It has better nutritional value than normal yoghurt and soy yoghurt. A 7% (w/v) level of jack fruit and 10% (v/v) level of soy milk showed better performance in relation to preference by panelists. Soy milk toned jack yoghurt consists of high protein% and low fat% in addition to nutritionally valuable fiber content. It has 15 days of appreciable shelf life under refrigerated conditions. This new product will help to open new door in dairy industry in the island through the creation of an opportunity to offer comparatively low cost yoghurt with higher nutritional and sensory qualities.

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