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Development of value-added low-fat yoghurts using mixed-fruits, Cassava flour (*Manihot esculenta* L.), Cereal mixture and evaluation of their physicochemical, microbiological and sensory properties

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Abstract

Value-added yoghurts are reported to have many health benefits on humans compared to normal yoghurts because consumption of value-added yoghurts are associated with many therapeutic and nutritional properties. Therefore, value-added yoghurts are becoming popular among a health conscious population in Sri Lanka. The objectives of the research were to develop different low-fat value-added yoghurts incorporated with mixed-fruit pulp, cassava flour, Cereal mixture and evaluation of their physicochemical, microbiological and sensory properties.

Recipes for low-fat yoghurt consisted of gelatin (0.4%; w/w), milk powder (2.8%; w/w), sugar (9.7%; w/w), coloring (0.13%; w/w), flavors (0.1%; v/v), culture (2.6%; v/v) and skim milk (83.4%; w/w). Three different mixed-fruit yoghurt products were prepared with the addition of 12.71%, 12.61% and 12.52% (w/w) fruit pulp and another three Cassava flour incorporated yoghurt were prepared with the addition of 3.25%, 4% and 4.5% (w/w) cassava flour. Further, three cereal yoghurt products were prepared using 8%, 10% and 12% (w/w) Cereal mixture (corn, soya, rice and green gram). Physicochemical properties of all the yoghurts such as titratable acidity and pH (AOAC, 2002) were determined during storage at 4°C for 20 days. Furthermore, microbiological and sensory properties of yoghurts were also determined and were compared with those of a commercial brand of yoghurt. Sensory properties were determined on a seven-point hedonic scale using 18 members of trained sensory panel. Sensory results were analyzed using Kruskal Wallis non-parametric ANOVA test with STATISTIX Computer software (Ver 2.0) for Windows.

Cassava yoghurt (4%; w/w), Cereal mixture yoghurt (10%; w/w) and mixed-fruit yoghurt (12.71%; w/w) were selected as the best yoghurts because of their significantly higher ($P<0.05$) sensory properties. Titratable acidity of cassava yoghurt increased gradually from 0.64% in the beginning to 0.78% at the 15 days of storage. Titratable acidity of cereal yoghurt increased gradually from 0.64% in the beginning to 1.23 % in the 15th day of storage while the titratable acidity of mixed fruit yoghurt increased gradually from 0.64% in the beginning to 1.23 % in the 15th day of storage. Yeast and mold populations in all the yoghurts were less than 10^3 CFU/ml and *E. coli* was not detected throughout the storage period. Shelf-life of all three yoghurts was approximately 15 days considering the changes in titratable acidity, microbiological and sensory properties. Therefore, it can be concluded that Cassava flour, Cereal mixture (corn, soya, rice and green gram) and mixed-fruit pulp can be introduced to the yoghurt industry successfully in order to develop novel value-added low-fat yoghurts with improved sensory and nutritional properties.

Keywords: low-fat, yoghurt, cassava flour, cereal mixture, mixed-fruit pulp

Introduction

The increase in the per capita annual consumption of yoghurt in many countries can be attributed both to the ever-increasing availability and production of fruit or flavored yoghurt, and to the diversity of presentations of the product. A variety of different flavoring ingredients such as fruits, natural flavors or synthetic flavors are currently added to yoghurts. It can be observed that the flavors, which are in regular demand, are surprisingly few in number, and the rest are introduced by the yoghurt manufacturers merely to encourage a wider popularity for the product. The types of flavoring material used in the yoghurt industry are fruits, fruits preserves, canned fruit, frozen fruits and miscellaneous fruit products (Tamime and Robinson, 1985). Added flavoring usually refers to sweetened or unsweetened chunks or concentrated and natural fruit substances. A previous study revealed that addition of high levels of fruit into yoghurt would increase sensory qualities of the yoghurts (Tarakci and Kucukoner, 2003). Further, addition of various non-fruit substances has also been the subject of research in the past.

Cassava (*Manihot esculenta*) is a high-carbohydrate tropical root-crop and the starch-rich thickened roots or tubers are the parts used as human foods, starch-based industrial raw material and animal feed. The productivity of cassava in terms of biological and calorific yields is significantly higher than that of many other cereal crops. Since the tubers are rich in starch they are increasingly used as raw materials for extraction of starch. The industrial uses of starch and starch products are numerous. Cassava is low in saturated fat and harmful presence of sodium. Cassava is also health-friendly in the sense that it does not add high cholesterol levels to the body. People who are keen to reduce their body weight are often advised by health experts to include cassava in their diet. It is estimated that every hundred grams of this root vegetable provides three hundred and sixty calories of energy. Cassava is found to be low in nutritional value as the presence of essential vitamins and minerals are minimal. Cassava contains a high level of carbohydrates and also has other nutrients in minute quantities (Ghosh *et al.*, 1988).

Cereal mixture is a highly nutritious Supplementary food being a pre cooked food made from locally grown legumes and cereals such as corn, soya, rice and green gram. The combination of legumes in Cereal mixture ensures high quality protein with all the required amino acids needed by humans. Cereal mixture contains protein, carbohydrate, fat, fiber and 11 essential vitamins and minerals. Corn, soya, rice and green gram added Cereal mixture is a perfect food product for the entire family as it contains all the goodness a family or an individual needs for a healthy, strong and energetic life.

Even though the current demand for the yoghurt increases, there are no certified milk-based cereal-yoghurt and low fat mixed-fruit yoghurt in the market. Therefore, the objectives of the present study were to explore the possibility for producing different value-added low-fat yoghurts incorporated with mixed-fruit pulp, cassava flour (*Manihot esculenta*) and Cereal mixture and evaluation of their physicochemical, microbiological and sensory properties.

Materials and Methods

Full cream milk powder (FCMP) and skimmed milk were used in the yoghurt manufacture in the laboratory. FCMP and skim milk were added in appropriate concentrations to obtain a homogenized mix (fat 1.5%) at the laboratory. Then fat and solid non fat content (SNF) of the standardized milk were determined using the Gerber method (AOAC, 2002). Standardized milk was heated up to 60°C and sugar and gelatin (0.4%; v/v) were added to the mix. Then the mix was thoroughly stirred to ensure uniform mixing of solids. It is important to keep at 60°C to ensure complete mixing of gelatin with milk, as otherwise clotting of gelatin may occur affecting the texture of the final product. Further, gelatin was first mixed with sugar and then the sugar-gelatin

mixture was added to the heated milk to ensure proper mixing of gelatin. Prepared yoghurt mix was aseptically poured into the pasteurizing pan and the temperature of the yoghurt mix was increased up to 95°C and held for 5 min. Then the mix was cooled to 6 - 8°C immediately using cold water and ice packs. Then the temperature of the yoghurt mix was increased up to 44°C and the required proportion of starter culture (10%; v/v) was added into the mixture and stirred thoroughly for few minutes at the same temperature of 44°C. Correct amounts of coloring (0.13%; v/v) and flavoring (0.1%; v/v) agents were added to obtain the desirable color and aroma of the yoghurt. Prepared yoghurt mix was immediately filled into yoghurt cups (80ml) and cups were closed tightly with lids and transferred without disturbing the samples into the incubator at 44°C temperature as soon as possible. When the acidity of the yoghurt was 4.6 - 4.8, the incubation was interrupted by cooling as the pH/acidity was the most critical factor. If the incubation period was not interrupted at the correct pH, over setting or under setting conditions can occur. In such a case, the unique characteristics of the yoghurt may seriously be affected. After the product reached the correct pH, yoghurt containers were immediately transferred into the refrigerator at 6 - 8°C. The titratable acidity (AOAC, 2002) and storage temperature of the yoghurt were examined throughout the storage period.

One day after manufacture of yoghurts, correct amounts of cassava, Cereal mixture and mixed-fruit pulp were added (Tables 1, 2 and 3) to yoghurts, stirred well and kept at the chill temperature of 4°C.

Table 1: Recipe for production of low-fat Cassava incorporated yoghurt in the laboratory

Product	milk*	milk powder*	cassava*	sugar*	gelatin*	culture**	flavor**
A	83.07	2.8	3.25	9.73	0.40	2.6	0.1
B	83.03	2.8	4.0	9.69	0.35	2.6	0.1
C	82.86	2.8	4.5	9.70	0.30	2.6	0.1

*as a percentage on weight basis **as a percentage on volume basis

Table 2: Recipés for production of low fat Cereal mixture yoghurt in the laboratory

Ingredients	Product with 8% cereal	Product with 10% cereal	Product with 12% cereal
Milk(2.5%fat standardized)	95.35 ml	95.35 ml	95.35 ml
Full cream milk powder	3 g	3 g	3 g
Sugar	18.18 g	18.18 g	18.18 g
Gelatin	2.62 g	2.62 g	2.62 g
Coloring	0.045 ml	0.045 ml	0.045 ml
Cereal mixture	8 g	10 g	12 g
Flavor	0.35 ml	0.35 ml	0.35 ml
Culture	3 g	3 g	3 g

Sensory evaluation was carried out with 18 sensory panelists using a 7-point hedonic scale. The results of the sensory evaluation were analyzed using Kruskal Wallis non-parametric one-way ANOVA method with STATISTIX Computer software (Ver 2.0) for Windows. Fat percentage by Gerber method, titratable acidity/pH and total solid (TS) contents (AOAC, 2002) were determined

during storage for 15 days. The yeast and mould and *E. coli* populations in each yoghurt were also determined using Potato Dextrose Agar (PDA: Oxoid Ltd, Hampshire, UK) and *E. coli* broth (EC Broth; Oxoid Ltd) in the beginning and after 15th days of manufacture. All the experiments were completely homogeneous and statistical analysis was carried out according to the Complete Randomized Design (CRD) and a probability value of 5% ($\alpha = 0.05$) was used in statistical analysis.

Table 3: Recipes for production of low fat mix-fruit yoghurt in the laboratory

Ingredients	Sample A with total solid 22.3%	Sample B with total solid 23%	Sample C with total solid 23.7%
Skimmed milk	450 ml	450ml	450ml
Full cream milk powder	30g	30g	30g
Sugar	50g	55g	60g
Gelatin	3.1ml	3.2ml	3.3g
Essence	0.2ml	0.18ml	0.18ml
Colouring	1ml	0.8ml	0.7ml
Culture	15ml	15ml	15ml
Mixed fruit pulp	80g	80g	80g

Results and Discussion

Sensory properties such as appearance, aroma, texture, sweetness, taste and general acceptability of the final three samples were compared and Table 4 shows the mean rank values of each sensory attribute for Cassava incorporated yoghurt. Table 5 and Table 6 show the mean rank values for low-fat Cereal mixture yoghurt and mix-fruit low-fat yoghurt, respectively.

Table 4: Estimated mean rank sums of sensory attributes for Cassava incorporated yoghurts

Product	Appearance	Smell	Taste	Mouth feel	Texture	Overall acceptability
A	54.15 * *	59.51 * *	58.838* *	52.61 * *	53.60 *	59.9 *
B	69.67 *	65.93 *	66.66 *	74.78 *	68.13 *	70.4 *
C	44.71 *	41.06 *	38.63 *	44.61 *	50.40 *	28.6 *
D	73.46 *	75.48 *	77.86 *	69.98 *	69.86 *	83.1 *

A - Cassava 3.25%, B - Cassava 4.0%, C - Cassava 4.2%, D - Commercial brand of yoghurt

*

** Means defined by the same letter are not significantly different according to DMNRT

Cassava yoghurts with cassava 4.0% showed significantly higher ($P<0.05$) overall acceptability compared to other cassava yoghurts. Therefore, out of prepared cassava yoghurts, the product

with 4.0% cassava was selected as the best product in keeping with it's significantly ($P<0.05$) higher sensory properties (Table 4).

Table 5: Estimated mean rank sums of sensory attributes for cereal yoghurts

Product	Appearance	Texture	Sweetness	Aroma	Mouth feel	Overall acceptability
A	58.767*	50.967*	52.350*	37.450*	56.717**	47.850*
B	76.700*	71.733*	79.800*	76.850*	76.200*	79.810*
C	32.733*	50.350*	33.450*	62.950*	65.883**	42.767*
Commercial yoghurt	73.800*	68.950*	76.400*	64.750*	43.200*	71.800*

A-cereal 8%, B-cereal 10%, C-cereal 12%

*

** Means defined by the same letter are not significantly different according to DMNRT

Cereal yoghurt with 10% Cereal mixture showed the highest overall acceptability compared to other cereal yoghurts and commercial yoghurt (Table 5). Moreover, sensory scores for taste and aroma of the same product were significantly ($P<0.05$) higher than those of other three products. Therefore, the cereal yoghurt with 10% cereal was selected as the best cereal yoghurt considering its highest sensory properties.

Table 6: Estimated mean rank sums of sensory attributes of different yoghurts mixed with fruit pulp

Product	Appęarance	Texture	Sweetness	Aroma	Taste	Overall acceptability
A	6.388*	6.333*	6.277*	5.888*	6.277*	6.222*
B	5.666*	5.555*	5.222*	5.222*	5.388*	5.611*
C	4.722*	4.555*	4.944*	5.111*	5.111*	5.222*

A - 12.71% fruit pulp, B -12.61% fruit pulp, C - 12.52% fruit pulp

*

** Means defined by the same letter are not significantly different according to DMNRT

The product with 12.71% fruit pulp showed significantly higher ($P<0.05$) sensory properties and can be selected as the best product considering its high sensory properties.

Therefore, cassava yoghurt (4 %; w/w), Cereal mixture yoghurt (10%; w/w) and mixed-fruit yoghurt (12.71%; w/w) appeared to be the best yoghurt products with high sensory properties. The acidity of Cassava yoghurt (with 4.0% cassava flour) stored at cold room (4°C) increased from 0.64% to 0.78% during storage period of 15 days (Figure 1). Therefore, formulated Cassava appeared not to have sour taste development comparing to the commercial yoghurt. It appears that lactic acid leads to syneresis during storage period. Further, production of acids could lead to compactness of yoghurt gel and the result is whey coming out from gel thereby increasing

sourness. It may not be a problem for cassava yoghurt because of its low acidity value. Therefore, cassava flour can be introduced to yoghurt to improve its sensory properties.

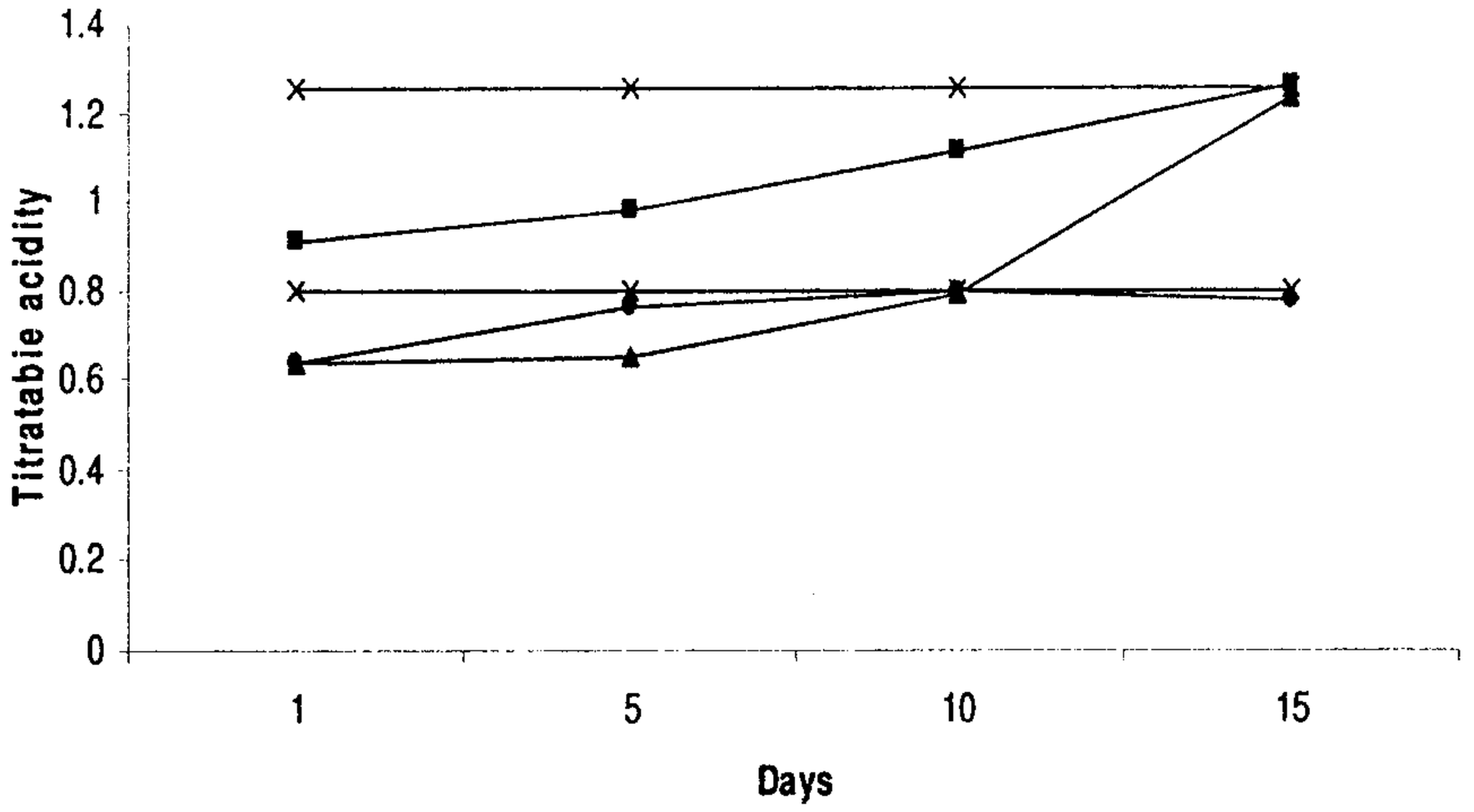

Figure 1: Development of acidity in three yoghurt products during cold storage at 4°C
■ - cereal yoghurt, ▲ - low-fat mixed-fruit yoghurt, ● - Cassava yoghurt, × - maximum and minimum recommended acidity of yoghurts according to SLSI standards

The acidity of Cereal mixture yoghurt (10% cereal mixed) stored at 4°C increased from 0.64% to 1.23% during cold storage period of 15 days and the acidity of mixed-fruit low-fat yoghurt (12.71% fruit pulp) stored at 4°C increased from 0.91% to 1.26% during cold storage period of 15 days, According to SLS standards, titratable acidity should be maintained between 0.8% and 1.25%. These results are in line with the findings of Tarakci and Erdogan (2003) where the acidity in yoghurts increased over the storage period. Guler and Mutlu (2005) also observed an increase in total titratable acidity during the storage period in yoghurts.

The *E. coli* was not detected in any of the yoghurt products during cold storage. The results of microbiological analysis of each product (Table 7) reflect that all the products are high in hygienic quality. According to SLS standards (*E. coli* not more than 1/g, Yeast not more than 1000/g and Moulds not more than 1/g) all the three products were high in their hygienic quality (SLSI, 1989).

Table 7: Yeast and mould populations in yoghurts during storage

Product	After 5 days	After 10 days	After 15 days
Mixed-fruit yoghurt	1.2×10^{3} CFU/g	2.1×10^{2} CFU/g	4.2×10^{2} CFU/g
Cereal yoghurt	< 10 CFU/g	2.1×10^{1} CFU/g	1.1×10^{3}CFU/g
Cassava yoghurt	< 10 CFU/g	1.4×10^{2}CFU/g	0.8×10^{3} CFU/g

Yeast and mould populations in yoghurts increased during storage over the time. According to the SLS standards the Yeast and Mould count should be <1000 CFU/g. Therefore, the observed population levels in the present study were well below the SLSI recommendations (SLSI, 1989).

Cereal mixture yoghurt contained high amount of crude protein (9.32 %) compared to commercial yoghurt (Table 8). Cassava flour incorporated yoghurt contained high amount of carbohydrate (18.71%) compared to the commercial yoghurt. Mixed-fruit yoghurt, cereal mixture yoghurt and Cassava yoghurt contained high amount of protein, fiber, carbohydrates, ash and total solids compared to the commercial yoghurt. Due to low-fat content in mixed-fruit, cereal mixture and cassava yoghurts, and the consumption of them appears to have comparative advantages on humans.

Table 8: Proximate composition of mixed-fruit, Cereal mixture and Cassava yoghurts

Nutrients	Mixed-fruit yoghurt	Cereal yoghurt	Cassava yoghurt	Commercial Yoghurt
Crude protein %	3.71	9.32	3.32	3.5
Crude fiber %	0.75	0.68	0.068	-
Total Carbohydrate %	15.56	11.94	18.71	15.04
Ash %	2.28	0.64	0.76	0.29
Total fat %	1.5	2.3	1.5	3
Total solids %	23.8	24.43	25.68	21.9

Therefore, it appears that the developed new yoghurts have high nutritive properties compared to the commercial brand of yoghurt.

Conclusion

Low-fat yoghurt mixed with fruit pulp (12.71%), (10%) and Cassava flour (4%) had the highest sensory properties in comparison to other yoghurts produced in the laboratory. The shelf-life of the low-fat yoghurts was approximately 15 days (4°C) considering the changes in physicochemical, microbiological and sensory properties. Therefore, it can be concluded that Cassava flour, Cereal mixture and mixed-fruit pulp can be introduced to the yoghurt industry successfully in order to develop novel value-added low-fat yoghurt with improved sensory and nutritional properties.

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