Development and Investigate of Palmyrah Fruit Pulp (PFP) Added Yoghurt

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Abstract

The present study was carried out to developed Palmyrah Fruit Pulp (PFP) added yoghurt and investigates the effects of physico-chemical attributes of yoghurt during storage. Result of this study revealed that the physico-chemical attributes like ash, dry matter, total sugar, reducing sugar, pH and titratable acidity were significantly (p<0.05) changed among yoghurt made from without PFP and PFP added yoghurt at day one. Further, the results has shown that ash, dry matter contents and titrable acidity were significantly (p<0.05) increased during the storage period whereas total sugar, reducing sugar and pH were (p<0.050 reduced with storage period. The values of titratable acidity and pH were 0.85±0.06 and 3.97±0.04, respectively at 4th week of storage in 2.5% PFP added yoghurt. Sensory attributes such as flavour, colour, taste and texture of yoghurt made from 2.5% PFP was superior to yoghurt made from all other types of yoghurt. Finally, concentration of 2.5% PFP added yoghurt had the highest overall acceptability compared to other all types of yoghurt.

Keywords: Yoghurt, physico-chemical attributes, titratable acidity, palmyrah fruit, pulp

1. Introduction

Dairy products have generally been considered an excellent source of high-quality protein, calcium, potassium, phosphorus, magnesium, zinc, and the B vitamins (Buttriss, 1997). There has been an unbelievable increase in the production of fermented milks in developed countries and most of the increase is attributed to the healthy image associated with yoghurt (Kamruzzaman *et al.,* 2002; Perdigon *et al.,* 2002; Valli and Traill, 2005). One of the most traditional cultured milk is the yoghurt, which is a product of the lactic acid fermentation of milk by addition of a starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (Tamine and Robinson, 1997; Kumar and Mishra, 2004).

Palmyrah palm (*Borrasus flabellifer)*is widespread in the arid tropic county like India, Sri Lanka and South-East Asia. It is features of the landscape of North- East Sri Lanka where it is called as wishing tree (Jansz *et al*., 2002). It is estimated that at present there about 11 million palms are available in Sri Lanka (Sangheetha *et al*., 2014). Palmyrah has a great capability to produce several products of economic importance, which means a palm that produces anything and everything (Sangheetha *et al*., 2014). Moreover, it was estimated in Sri Lanka that about 20,000 tons of palmyrah fruit pulp is available annually during fruit season but approximately 10000 tons of pulp is not utilized every year because its uses are limited mainly due to the presence of a bitter compound like flabelliferins and lack of trials are done to process into various consumer attractive value added products ((Jansz *et al* 2002; Janz *et al*., 1994; Sangheetha *et al*., 2014). Palmyrah fruit pulp has a yellow colour due to carotenoids which are precursors of vitamin A and therefore it has potential of being as a source of vitamin A. In addition to that, pulp is contained rich in vitamin C (ascorbic acid) and a good source of pectin which could be used to process the fruits into various products (Theivendrarajah, 2008). Further, pulp is mildly laxative, contains considerable amount of sugars such as sucrose, glucose and fructose (3.4, 3.5 and 3.4 g/100g, respectively) (Ariyasena *et al*., 2001).

Pulp has potential uses apart from traditional products. These include its use in jams and cordials and as a source of pro-vitamin A, pectin and portable alcohol (Balasubramaniam *et al.,* 1999). However the extensive use of PFP is detracted by presence of bitterness in the pulp (Janz *et al*., 1994). Debittering of pulp using naringinase enzyme resulted in a beverage with a pleasant mango cordial like colour, flavour and texture (Janz *et al.,* 1994). Pulp may be used for the production of special kind of fruit flavoured yoghurt as it has unique colour, flavour and texture. However there is lack of information available utilizing palmyrah fruit pulp for fruit flavoured yoghurt. Therefore, this experiment was designed to study the physico-chemical attributes of palmyrah fruit pulp added youghut.

2. Materials and Methods

2.1.Palmyrah fruit pulp (PFP)

Pulmyrah fruit was purchased from super market and brought laboratory. The fruit was heated for 5 minutes at 50^{o}C and cool down to room temperature. Then the washed and dried fruits were peeled, squeezed and palmyrah fruit pulp was obtained.

2.2. Preparation of yoghurt starter culture

Yoghurt culture containing freeze dried Lactic culture (direct vat set) Thermophillic Lactic culture (STI- 12,) was purchased and starter culture was prepared as prescribed by manufacturer. Then culture was stored at 4˚C for the usage.

2.3.Yoghurt preparation

Milks were standardized by using cream separator. The standardised milks were pasteurized at 65^{O}C for 30 minutes and cooled to 37^{0}C. Palmyrah fruit pulp added into the milk at the concentration of 2.5%, 5.0%, 7.5% and 10% at weight basis and sugar was used as a control.

Then the mixtures were mixed well and gelatin was added to the mixture at the level of 0.5% and mixed well. Then the mixtures were heated for 10 minutes at 95 ˚C in stainless steel containers while maintaining constant volume using distilled water. Heated mixtures were cooled to 42 ˚C under tap water. Starter culture (5%, w/v) was added for each mixture at 42 ˚C and equal volume of contents were transferred into the series of plastic container and incubated at 42˚C.

2.4.Proximate Analysis

The cheese samples were analysed in triplicate for moisture content using oven drying at 102^{o} C to get a constant weight according to AOAC method (AOAC, 1990) and percentage moisture was calculated as moisture (%) = 100 - total solid (%). Ash content was determined according to AOAC method (AOAC, 1990. The crude fat content was determined using the Gerber method (Anon, 1972).

2.5. Determination of sugar content

Lane and Eynon method described in Analytical chemistry of food by James (1999) was used to determine total sugar and reducing sugar content. Content was expressed in percentage on fresh weight basis.

2.6. Determination of titratable acidity of yoghurt

The titratable acidity was determined after mixing a yoghurt sample with 10 mL of distilled water and titrating with 0.1 N NaOH using 0.1% phenolphthalein indicator as described by Dave and Shah (1997).

2.7. pH Determination

The pH values of the yoghurt and milk samples were measured at 25°C using digital pH meter (Model -Delta 320, Mettler-Toledo Instruments Co., Ltd, Shanghai) after calibrating with fresh pH 4.0 and 7.0 standard buffers.

2.8. Determination of syneresis of yoghurt sample

Syneresis was defined as the volume of serum that was not retained within the structure on centrifugation. Tubes containing 20 g of yoghurt were centrifuged for 10 minutes at 25^{o}C at 5000 rpm. The amount of serum released from the coagulum was measured in a calibrated measuring flask as described by Domagała, (2009).

2.9. Storage of fermented yoghurt mixture

Starter culture was added for each mixture at 42 ˚C and equal volume of contents were transferred into the series of plastic container and incubated at 42˚C. Then samples were collected from 0 hour to 7th hour with the time interval of one hour during incubation. Before refrigeration of collected samples at 4 ˚C for titratable acidity and pH were measured. Then yoghurt samples were stored at 4 ˚C for further analysis at 1st, 2nd, 3rd and 4th week of storage.

2.10. Sensory analysis

The consumer acceptability studies were carried out using organeoleptic evaluation of yogurt by a jury of 10. The expert panel comprised nonsmokers who were very familiar with dairy products. Five parameters i.e. flavour, taste, color, texture a and overall acceptability were evaluated using a sensory rating scale of 1-7. The panels recognized the yogurt only by codes. Each panel was requested to rinse their mouth by drinking mineral water after assessing each yogurt.

2.11 Microbiological analysis

One gram of yoghurt sample was diluted with 9 mL of 0.15% peptone water diluent and mixed uniformly with a vortex mixer, subsequent serial dilutions were prepared and viable numbers enumerated using the pour plate technique. Counts of bacteria were enumerated on blood agar by incubating the plates aerobically at 37°C for 24 hours (Dave and Shah, 1996). Microbiological count data are expressed as colony forming units (cfu) per gram of yoghurt. Four dilutions were carried out to determine the number of bacteria during storage.

2.12. Statistical analysis

Theresults were analyzed statistically using a computer program ‘‘SAS system for windows Version 9.1.3 for analysis of variance (ANOVA) by one way and comparison of means by Duncan’s multiple comparison test where $P < 0.05$ was considered for significant difference.

3. Results and Discussions

3.1. Palmyrah fruit pulp and milk

The chemical parameters of palmyrah fruit pulp such as total sugar, sucrose and glucose contents were found to be 14.4± 0.5%, 6.3 ± 0.5% and 3.4 ± 0.1%,respectively. The pH and acidity were found to be 4.30 and 0.51%, respectively. Jeyaratnam (1986) has reports that the fresh palmyrah fruit pulp contains total sugars, sucrose and glucose in the rage of 14%-16%, 6.6% and 3.5%, respectively. Chemical composition of fresh milk namely milk fat, ash , dry matter content, titratable acidity, and pH were 3.5±0.06%, 0.75±0.06%, 12.6±0.06%, 0.23±0.01% and 6.7±0.04, respectively. These values were in line with the results of Gösta

Bylund (1995) who reported that cow milk contains of milk fat (4%), ash (0.80%), dry matter content (13.0%), titratable acidity (0.26±0.01%). These values are falling within normalcy.

3.2 Physical and chemical properties of palmyrah fruit pulp (PFP) added yoghurt at day One

3.2.1. Ash and dry matter

The study shows that there were differences ($p<0.05$) among the mean values of ash and dry matter content using different PFP added yoghurts. Ash and dry matter content of different concentrations of PFP added yoghurts has been shown in Table 1. Ash and dry matter content was the highest in 10% PFP added yoghurt and lowest in yoghurt made from without PFP. It could be an addition of PFP in youhurt increases the ash contents. The results were in accordance with Chougrani *et al.,* (2009), who reported similar trends in their study on physico-chemical analysis of fruit yoghurt. Whereas milk fat did not show any significant changes in yoghurt made from different concentrations of PFP.

3.2.2 Total sugar

Total sugar content of yoghurt in different concentrations of PFP has shown in Table 1. The mean value of total sugar content was ($p<0.05$) among the all types of yoghurt. The percentages of total sugar content of 2.5%, 5%, 7.5% and 10% of PFP added yoghurt were 13.14±0.07, 13.45±0.16, 14.09±0.04 and 14.77±0.08, respectively. The 10% PFP added yoghurt had highest mean value than yoghurt made from without PFP. The addition of PFP caused an increase in sugar content of yoghurt. Mean value of total sugar content of PFP added yoghurts were higher than yoghurt made from without PFP.

3.2.3. Reducing sugar

Reducing sugar contents of PFP added yoghurt and yoghurt made without PFP were significantly ($p<0.05$) varied among different types of youhurt. The 10% PFP added yoghurt had higher mean value (2.46±0.01) and the yoghurt made from without PFP had a least mean value (2.17±0.02). It could be indicating that PFP has higher reducing sugar content. Jayathilake and Wijeyaratne (1999) reported in his study that same trends were observed in fruit pulp added yoghurt.

3.2.4. Titratable acidity

The study shows that there was differences ($p<0.05$) among the mean value on the acidity of different PFP added yoghurt samples. The titratable acidity of the PFP added yoghurt was ($p<0.05$) increased from 0.58% to 0.80 % by adding of PFP from 2.5% to 10% as shown in Table 2 The acidity of yogurt was higher in PFP added yoghurt than yoghurt made from without PFP. The addition of PFP increased the acidity of yoghurt due to the PFP contain more sugar and it converted into acid by the fermentation process. These results confirm the results obtained by Rashid and Thakur (2012) who found that the titratable acidity values increase in yoghurt with adding of supplemented sugar.

3.2.5. pH

The pH reduced ($p<0.05$) with the increasing concentration of PFP. The effect of PFP on the pH values of fresh yoghurts is shown in Table 2. The pH was the highest in yoghurt made from without PFP (4.45±0.67) and lowest in 10% PFP added yoghurt (4.01±0.01). This might be increase in acidity, as acidity is inversely proportional to pH. The results generally showed that the higher acidity and lower pH in PFP added yoghurt. Rashid and Thakur (2012) found that there is a corresponding reduction in pH as the acidity increased in honey added yoghurt.

3.2.6. Syneresis

Syneresis percentage has decreased with the increasing level of PFP in yoghurt mixture (Figure 1). At day 1 yoghurt mixture without PFP had significantly ($P<0.05$) lower level of acidity where as mixture with 10% PFP had higher level of acidity. Increase of acidity was increased the curd stability because of the increase in water binding capacity of proteins (Langton, 1991). So that, higher the acidity in yoghurt was reduced the syneresis. Addition of fruit concentrates generally tends to change the consistency of products due to changes in water binding capacity of proteins (Ramaswamy and Basak, 1992). Therefore, this may be another possibility for decreasing syneresis in the yoghurt mixture with increasing level of PFP.

3.3. Fermentation of yoghurt mixture

Resulted values of titratable acidity and pH with time during the fermentation of prepared yoghurt mixtures have been plotted in Figure 2 and Figure 3. Statistically significant ($P<0.05$) model with higher correlation coefficient (R^2) was fixed for each type of yoghurt mixtures using resulted values. Polynomial regression type satisfied the requirements for of titratable acidity of all types of yoghurt mixtures and was selected for interpretation. Correlation coefficients (R^2) for each models selected are displayed Table 3. Rate of titratable acid production of 7.5% and 10% PFP added yoghurt increased with fermentation time and production was gradually reduced when reaching seventh hour. This pattern is exhibited because increasing level of titratable acid gradually inhibits the growth and metabolism of starter. On the other hand, without PFP added yoghurt (0% PFP) had shown lower value of titratable acid compare to other all types of yoghurt mixture. This was indicating that incorporation of PFP started the initial rate of titratable acid production in each yoghurt mixtures during fermentation is being increased with increasing level of PFP in the mixture. Although each type of yoghurt mixture showed the increasing rate of titratable acid production with fermentation time, increasing rate is increased with increasing level of PFP in the mixture. So ultimate result is that amount of total titratable acid produced at a particular time was high at higher level of PFP in the mixture. The pH changes of each mixture with fermentation time produced the pattern, which was the image of pattern produced depends on produced acid

3.4. Physical and chemical properties of palmyrah fruit pulp (PFP) added yoghurt during storage period

3.4.1. Ash

Ash is an indicator of total amount of minerals present in the yogurt and it presented in Table 4. At first week of storage 10% PFP added yoghurt exhibited ($p<0.05$) higher mean value (1.15±0.01%) than yoghurt made from without PFP (0.87±0.02%). At fourth week of storage 10% of PFP added yoghurt showed higher mean value (1.24±0.04%) and yoghurt made without PFP received lower mean value (0.91±0.01%). In this study, the range of ash content varied from 0.87±0.02% to 1.24±0.04% and it increased with storage period. This may due to higher minerals present in PFP.

3.4.2. Dry matter content in yoghurt during the storage period

The increasing trend of dry matter content was observed with increasing amount of PFP. Moreover, it was observed that the dry matter content of yoghurt made PFP were significantly ($p<0.05$) higher than yoghurt made without PFP (Table 4). In general, PFP (10%) added yoghurt obtained higher mean value (25.51±0.10%) than yoghurt made without PFP (19.80±0.10%) at 4th week of storage. The study revealed that the dry matter content of yogurt was increased during storage period is due to the evaporation rate of moisture content during storage at refrigerated condition. The results are in agreement with the results of Ayer (2014) who reported that increasing amount of fruits tend to decrease the dry matter content.

3.4.3. Fat content in yoghurt during the storage period

Fat contents of yoghurt not only during the storage but also different concentration of PFP added yoghurt did not show any ($p > 0.05$) significant changer among the yoghurt sample (Table 4).

3.4.4. Total sugar and reducing sugar

The result shows in Table 4 that the total sugar and reducing sugar were ($p< 0.05$) decreased throughout the storage period. It might be due to the conversion of lactose into lactic acid with time of storage. At fourth week of storage period, PFP (10%) added yoghurt has significantly ($p<0.05$) high amount of total sugar (12.02±0.16%) and reducing sugar (2.30±0.04%) compare to all other types of yoghurt. Similarly, Goodenought and Kleyn (1976) reported that sugar contents were decreased during storage of yoghurt. It might due to production of lactic acid by fermentation of starter cultures of sugars present in yoghurt (Wedad *et al.,* (2009).

3.4.5. Titratable acidity

Table 5 showed that the result of titratable acidity was ($p< 0.05$) increased throughout the storage period. While titratable acidity was observed at 4th week of storage period that the yoghurt made without PFP has highest ($p<0.05$) mean value (0.80±0.07%) than 10% PFP added yoghurt (1.23±0.07%). The changes in titratable acidity of yoghurt could be fermentation process by microorganism and degradation of lactose. The acidity further increased gradually during storage in all types of yoghurt (Salji and Ismail,1983), who reported significant increase in acidity during storage, it could due to conversion of lactose to lactic acid by lactic acid bacteria.

3.4.6. pH

The pH decreased with during the storage period of yoghurt. Yoghurt made without PFP received higher value (4.38±0.01) than 10% of PFP added yoghurt (3.97±0.01) at first week of storage (Table 5). At 4th week of storage 10% PFP added yoghurt received lowest value (3.62±0.03) compared to other treatments. The changes in pH might due to fermentation process of starter culture organism. During the first week of storage there was a ($p < 0.05$) change among different concentration PFP yoghurt. These results are agreed with results reported by Behrad *et al*. (2003) who mentioned that the pH for all yoghurts reduced from the initial values of 4.5 to 4.09 at 28 days of storage.

3.4.7. Effect of storage on sensorial attributes of different treated yoghurt samples

The sensory attributes analysis of yoghurt samples was evaluated in duplicate in 3 sessions presented in randomized order and coded with three digit numbers using friedman test and category can be graphically presented by a "spider web" in Figure 4 (a-e). Results showed that there were ($p<0.05$) significant differences between the treatments for all attributes of texture, colour, taste, flavour and overall acceptability. All attributes were decreased during the storage period in all kinds of yoghurt. Yoghurt with 2.5 % PFP added yoghurt received higher mean value and yoghurt made with 10% PFP added yoghurt received lowest mean value for texture, taste, colour, and flavour at 4th week of storage. PFP (2.5%) added yoghurt had higher degree of overall acceptability and gained highest scores for other sensory attributes such as taste, flavour, texture and colour. Yoghurt without added PFP yoghurt showed second highest mean value and lowest mean value was obtained in 10% PFP added yoghurt. Based on the sensory analysis, majority of panelist prefer yoghurt with 2.5% PFP followed by yoghurt without PFP added yoghurt. But more panelists did not prefer 10% PFP added yoghurt due to high concentration of unpleasant sensory attributes.

3.5. Microbiological analysis

It is evident from results (shown in Table. 6) that there was ($p<0.05$) decrease in total viable count (cfu/mg) during storage interval. Yoghurt made from without PFP showed higher bacterial colony count was 1.88×10^6 cfu/mg of 2 week of storage periods and it decreased to 1.30×10^6cfu/mg at 4 week of storage while there was significant ($p<0.05$) effect due to different concentrations of PFP. This result was consistent with the findings of Kailasapathy *et al.,* (2008). Total bacterial colony decreased during storage due to increasing acidity. These findings are in accordance with the results of Samadrita Sengupta *et al*., (2013) who observed that the bacterial colony in yoghurts decreased during the storage period.

4. Conclusion

At day one pH and syneresis decreased with increasing amount of PFP added in yoghurt. Titrable acidity, total sugar, reducing sugar, ash and dry matter contents increased with the increasing of PFP concentration in yoghurt. Nutritional parameters such as total sugar and reducing sugar were ($p<0.05$) decreased with storage period. Whereas, ash and dry matter content were increased in yoghurt during storage period. The titratable acidity was increased during the storage period while pH was decreasing thought out the storage period. Fat did not show any changes among all treatments. In sensory attributes such as taste, colour, texture, flavour and overall acceptability among the different types of yoghurt were differed amount the types of yoghurt. Finally, 2.5% PFP added yoghurt had more preferred than other concentration of PFP added yoghurt.

5. Reference

Anon. (1972). Determination of fat in cheese, evaporated and condensed milks by Gerber method. In *Manual in Dairy Chemistry.* Eighth Dairy Teachers' Workshop, ICAR Subcommittee on Daily Education, NDRI, Bangalore, India, p. 64

Ayar, A.,& Gürlin, E. (2014). Production and Sensory, Textural, Physico-Chemical Properties of Flavored Spreadable Yoghurt. Life Science Journal, 11(4), 58-65

AOAC. (1990). AOAC Official methods of analysis (15th ed., Vol. 2). Arlington, VA, USA: Association of Official Analytical Chemists

Ariyasena D.D., Jansz E.R., & Abeysekera A.M. (2001). Some studies directed at increasing the potential use of palmyrah (Borassus flabellifer L.) fruit pulp. Journal of Science of Food and Agriculture, 81,1347-1352

Balasubramaniam K., Janz E.R., & Ariyasena D.D. (1999). *"Palmyrah" Monograph*. International Program in Chemical Sciences, Uppsala University. pp. 1-34

Behrad, S., Yusof, M. Y., Goh, K. L., & Baba A. S. (2003).Manipulation of Probiotics Fermentation of Yogurt by Cinnamon and Licorice: Effects on Yogurt Formation and Inhibition of Helicobacter Pylori Growth in vitro. International Science Index,3(12),534-538

Buttriss, J. L. (1997). Food and nutrition: attitudes, beliefs, and knowledge in the United Kingdom. American Journal of Clinical Nutrition, 65(6), 1985–1995

Chougrani, F., Cheriguene, A., & Bensoltane, A. (2009). Physico-chemical and rheological properties of yoghurt manufactured with ewe's milk and skim milk. African Journal of Biotechnology, 8 (9), 1938-1942

Dave, R. I., & Shah, N. P. (1996) Evaluation of media for selective enumeration of *Streptococcus thermophilus, Lactobacillus delbrueckii* ssp. *bulgaricus, Lactobacillus acidophilus* and *Bifidobacterium* spp. Journal of Dairy Science, 79, 1529-1536.

Dave, R. I., & Shah, N. P. (1997). Effectiveness of ascorbic acid as an oxygen scavenger in improving viability of probiotic bacteria in yoghurts made with commercial starter cultures. International Dairy Journal, 7(6), 435-443

Domagała, J. (2009). Instrumental texture, syneresis and microstructure of yoghurts prepared from goat, cow and sheep milk. International Journal of Food Properties, 12(3), 605-615

Goodenought, E. R., & Kleyn, D. H. (1976). Qualitative and Quantitative Changesin Carbohydrates during the Manufacture of Yoghurt. Journal of Dairy Science, 59(1), 45-47

Gösta Bylund, M. Sc (1995). Chapter 15. Whey processing. In Tetra Pak dairy processing handbook. Lund, Sweden: Tetra Pak Processing Systems AB.

Jansz, E. R., Wickremasekara, N. T., & Sumuduni, K. A. V. (2002). A Review of the Chemistry and Biochemistry of seed shoot flour and fruit pulp of the Palmyrah palm (*Borassus flabellifer L.)*. Journal of National Science Foundation of Sri Lanka, 30(1&2), 61-87

James C.S. (1999). *Analytical Chemistry of Foods*. 2nd ed., Aspen Publishers Inc., Maryland, U.S.A

Jansz J.R., Nikawela J.K., Gooneratne J., & Theivendirarajah K. (1994). Studies on the bitter principle and debittering of palmyrah fruit pulp. Journal of Science of Food and Agriculture. 65,185-189

Jeyaratnam M. (1986). Chemistry and Biochemistry of palmyrah products. M. Phil. Thesis, University of Jaffna, Sri Lanka

Jayathilake, A.N., & Wijeyaratne, S.C.(1999). Biochemical and microbiological changes of *Caryota urens* (Kithul palm) phloem sap. Vidyodaya Journal of Science, 8, 91 -108

Kailasapathy, K., Harmstorf, I., & Phillips, M. (2008). Survival of *Lactobacillus acidophilus* and *Bifidobacteriumanimalis*ssp. Lactis in Stirred Fruit Yoghurts. LWT-Food Science and Technology, 41, 1317-1322.

Kamruzzaman, M., Islam, M .N., Rahman, M. M., Parvin,S.,& Rahman, M. F. (2002). Evaporation rate of moisture from dahi (yoghurt) during storage at refrigerated condition. Pakistan Journal of Nutrition, 1, 209-211

Kumar, P., & Mishra, H. N. (2004). Yoghurt powder—a review of process Technology, storage and utilization. Food and Bioproducts Processing, 82 (C2), 133–142

Martini, M. C., Bollweg, G. L., Levitt, M. D., & Savaiano, D. A. (1987). Lactose digestion by yogurt beta-galactosidase: influence of pH and microbial cell integrity. The American journal of clinical nutrition, 45(2), 432-436

Palmyrah Development Board. (2010). Annual Report of palmyrah, Jaffna

Perdigon, G., De leblanc A.M., Valdez J., & Rachid M. (2002). Role of yoghurt in the prevention of colon cancer. European Journal Clinical Nutrition, 56, 65-68

Ramaswamy H.S., & Basak S. (1992). Pectin and raspberry concentrate effects on the rheology of stirred commercial yoghurt. Journal of Food Science, 57(2), 357-360

Rashid, A., & Thakur, E. S. N. (2012). Studies on Quality Parameters of Set Yoghurt Prepared by the Addition of Honey. International Journal of Scientific and Research Publications, 2(9), 225-230

Samadrita, S., Jayati, B., & Bhatta, D. K. S. (2013). Development of New Kinds of Soy Yoghurt Containing Functional Lipids as Superior Quality Food. Annals of Biological Research, 4 (4),144-151.

Sangheetha, S., Wansapala, M. A. J., Gnanasharmala, A., & Srivijeindran S. (2014). Optimization of palmyrah (*borrasus flabellifer*) fruit pulp in different varieties of fruit yoghurts. International Journal of Multidisciplinary, 1 (1), 91-103

Salji, T. P., & Ismail, A. A. (1983). Effect of Initial Acidity of Plain Yoghurt on Acidity Changes during Refrigerated Storage. Journals of Food Science, 48(1), 258-259

Tamime, A.Y., & Robinson, R. K. (1999). Yoghurt, Science and Technology. *International* Journal of Dairy Technology, 61, 112–113

Theivendrarajah. K. (2008). *Palmyrah palm (Borrasus flabellifer)* – A Monograph, Scarborough, Ontario, Canada

Vali, C., & Traill, W.B. (2005). Culture and food: A model of yoghurt consumption in the EU. Food Quality and Preference, 16, 291-304

Wedad, A., Metry, K., & Owayss, A. A. (2009). Influence of Incorporating Honey and Royal Jelly on the Quality of Yoghurt during Storage. Egypt Journal of Food Science,3,115-131

Table 1: Chemical composition of yoghurt at day one

Yoghurt mixture	Ash content	Dry-matter content	Fat	Total sugar	Reducing sugar
0.0%	0.86±0.04[b]	17.22±0.10[d]	3.5 ±0.23 [a]	12.27± 0.08[e]	2.17±0.02[c]
2.5% PFP	0.93±0.02[b]	18.33±0.06[cd]	3.6 ±0.56 [a]	13.14±0.07[d]	2.26±0.05[b]
5% PFP	0.94±0.05[b]	19.53±0.08[c]	3.5 ±0.45 [a]	13.45±0.16[c]	2.41±0.04[ab]
7.5% PFP	1.05±0.05[a]	19.72±0.14[b]	3.7 ±0.32 [a]	14.09.04[b]	2.42±0.04[ab]
10% PFP	1.14±0.03[a]	21.66±0.10[a]	3.6 ±0.02 [a]	14.77±0.08[a]	2.46±0.01[a]

Values are means ± standard deviations of replicates. Mean with the same letters are not significantly different at ($p < 0.05$).

Table 2: Titratable acidity and pH at different mixture of yoghurt at day one

Yoghurt mixture	Titratable acidity	pH
0.0%	0.58 ± 0.01^{b}	4.45 ± 0.67^{a}
2.5% PFP	0.62 ± 0.03^{b}	4.19 ± 0.01^{b}
5% PFP	0.65 ± 0.01^{b}	4.15 ± 0.02^{bc}
7.5% PFP	0.66 ± 0.02^{b}	4.12 ± 0.01^{bc}
10% PFP	0.80 ± 0.08^{a}	4.01 ± 0.01^{c}

Values are means ± standard deviations of replicate determination. Mean with the same letters are not significantly different at ($p < 0.05$).

Table 3: Correlation coefficients (R^2) of selected models for production titratable acidity and pH changes of different yoghurt mixture

Yoghurt mixture	Titratable acidity Figure 2	pH Figure 3
0.0%	0.974	0.992
2.5% PFP	0.933	0.982
5% PFP	0.983	0.990
7.5% PFP	0.982	0.990
10% PFP	0.837	0.960

Table 4: Chemical composition in yoghurt during storage period

Treatments	Storage periods			
	Week 1	**Week 2**	**Week 3**	**Week 4**
Ash				
0.0%	0.87±0.02^{h}	0.88±0.01^{gh}	0.90±0.02^{gh}	0.91±0.01^{gh}
2.5% PFP	0.93±0.04^{gh}	0.94±0.03^{fg}	0.99±0.01^{def}	1.05±0.01^{de}
5% PFP	0.95±0.04^{ef}	0.96±0.08^{de}	1.08±0.01^{c}	1.12±0.02^{bc}
7.5% PFP	1.05±0.01^{d}	1.11±0.01^{ab}	1.19±0.01^{ab}	1.23±0.02^{a}
10% PFP	1.15±0.01^{bc}	1.19±0.01^{ab}	1.22±0.02^{a}	1.24±0.04^{a}
Dry matter				
0.0%	17.56±0.12^{j}	18.45±0.1^{j}	18.56±0.08^{hi}	19.80±0.10^{g}
2.5% PFP	18.61±0.01j	19.54±0.67^{hi}	19.64±0.06^{hi}	20.9±0.05^{g}
5% PFP	19.76±0.07^{j}	21.67±0.04^{h}	21.72±0.08^{g}	22.56±0.06^{f}
7.5% PFP	19.92±0.17^{hi}	22.62±0.17^{e}	24.43±0.10^{c}	24.92±0.09^{b}
10% PFP	21.65±0.04^{e}	21.56±0.06^{d}	24.43±0.06^{b}	25.51±0.10^{a}
Fat				
0.0%	3.07±0.06^{a}	2.93±0.15^{a}	2.93±0.15^{a}	2.90±0.00^{a}
2.5% PFP	3.03±0.15^{a}	3.03±0.06^{a}	2.87±0.12^{a}	2.87±0.12^{a}
5% PFP	2.97±0.15^{a}	2.87±0.06^{a}	2.93±0.06^{a}	2.90±0.10^{a}
7.5% PFP	2.97±0.15^{a}	3.07±0.15^{a}	2.97±0.06^{a}	2.90±0.10^{a}
10% PFP	2.87±0.15^{a}	3.03±0.12^{a}	2.87±0.15^{a}	2.90±0.17^{a}
Total sugar				
0.0%	11.88±0.16^{d}	11.67±0.2^{g}	10.87±0.16^{jk}	10.04 ±0.13^{k}
2.5% PFP	13.00±0.08^{b}	12.29±0.1^{g}	11.59±0.07^{j}	10.48±0.06^{i}
5% PFP	13.08±0.08^{b}	11.84±0.08^{ef}	10.75±0.18^{h}	10.67±0.04^{hi}
7.5% PFP	13.76±0.08^{a}	12.08±0.09^{d}	11.75±0.16^{f}	11.21±0.06^{g}
10% PFP	14.07±0.08^{a}	13.12±0.16^{b}	12.08±0.09^{d}	12.02±0.16^{de}
Reducing sugar				
0.0%	2.12±0.04^{ef}	2.08±0.04^{fgh}	2.01±0.1^{h}	1.95±0.06^{i}
2.5% PFP	2.19±0.04^{abc}	2.14±0.16^{de}	2.09±0.4^{gh}	2.04±0.03^{i}
5% PFP	2.38±0.04^{ab}	2.33±0.06^{bcd}	2.26±0.01^{efg}	2.23±0.07^{gh}
7.5% PFP	2.39±0.06^{ab}	2.35±0.06^{abc}	2.31±0.04^{bcd}	2.27±0.11^{e}
10% PFP	2.42±0.04^{a}	2.36±0.05^{ab}	2.32±0.08^{abc}	2.30±0.04^{cd}

Values are means ± standard deviations of replicate determination. Mean with the same letters are not significantly different at ($p < 0.05$).

Table 5 : Titratable acidity and pH in yoghurt during storage period

Treatments	Storage periods			
	Week 1	**Week 2**	**Week 3**	**Week 4**
Titratable acidity				
0.0%	0.68 ± 0.01^{h}	0.72 ± 0.03^{h}	0.75 ± 0.07^{gh}	0.8 ± 0.07^{fgh}
2.5% PFP	0.69±0.02gh	0.80 ± 0.02^{fgh}	0.82 ± 0.06^{fg}	$0.85\pm0.06e^{fg}$
5% PFP	0.76 ± 0.01^{fgh}	0.83 ± 0.01^{fgh}	$0.90\pm0.08d^{ef}$	1.11 ± 0.03^{b}
7.5% PFP	0.75 ± 0.03^{fgh}	0.86 ± 0.03^{efg}	0.91 ± 0.02^{def}	1.15 ± 0.07^{ab}
10% PFP	0.98 ± 0.07^{de}	1.03 ± 0.06^{cd}	1.07 ± 0.07^{bc}	1.23 ± 0.07^{a}
pH				
0.0%	4.38 ± 0.01^{a}	4.28 ± 0.02^{b}	4.13 ± 0.03^{c}	3.98 ± 0.05^{f}
2.5% PFP	4.12 ± 0.02^{c}	4.10 ± 0.01^{c}	4.07 ± 0.1^{de}	3.97 ± 0.04^{f}
5% PFP	4.08 ± 0.01^{cd}	4.03 ± 0.01^{cd}	3.95 ± 0.05^{fg}	3.87 ± 0.04^{gh}
7.5% PFP	4.05 ± 0.01^{cd}	4.00 ± 0.04^{ef}	3.85 ± 0.05^{h}	3.75 ± 0.04^{i}
10% PFP	3.97 ± 0.01^{ef}	3.94 ± 0.04^{fgh}	3.74 ± 0.03^{i}	3.62 ± 0.03^{j}

Values are means ± standard deviations of replicate determination. Mean with the same letters are not significantly different at ($p < 0.05$).

Table 6: Effect of "PPF" on the bacterial colony forming units of yoghurt during storage

Yoghurt mixture	Number of bacterial colony forming units per mg (cfu/mg)	
	Week 2	**Week 4**
0.0%	1.88×10^{6a}	1.30×10^{6e}
2.5% PFP	1.72×10^{6b}	1.12×10^{6f}
5% PFP	1.60×10^{6c}	1.00×10^{6g}
7.5% PFP	1.50×10^{6d}	0.90×10^{6h}
10% PFP	1.30×10^{6e}	0.80×10^{6l}

Values are means ± standard deviations of replicate determination. Mean with the same letters are not significantly different at ($p < 0.05$).

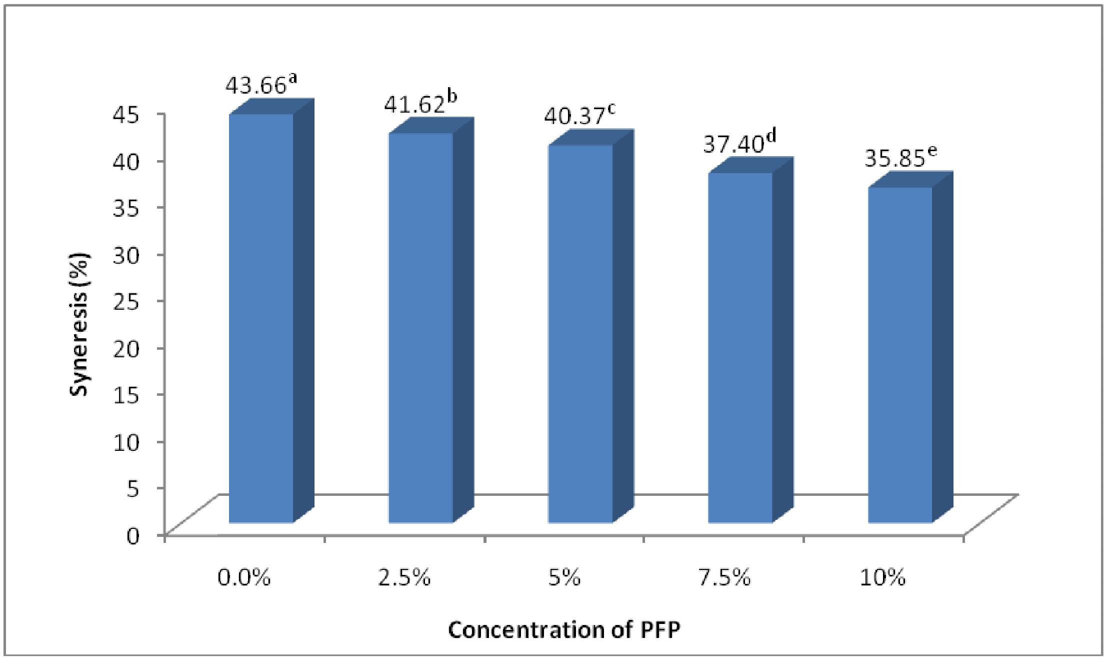

Figure 1 Syneresis of yoghurt mixture with different levels of PFP at days 1

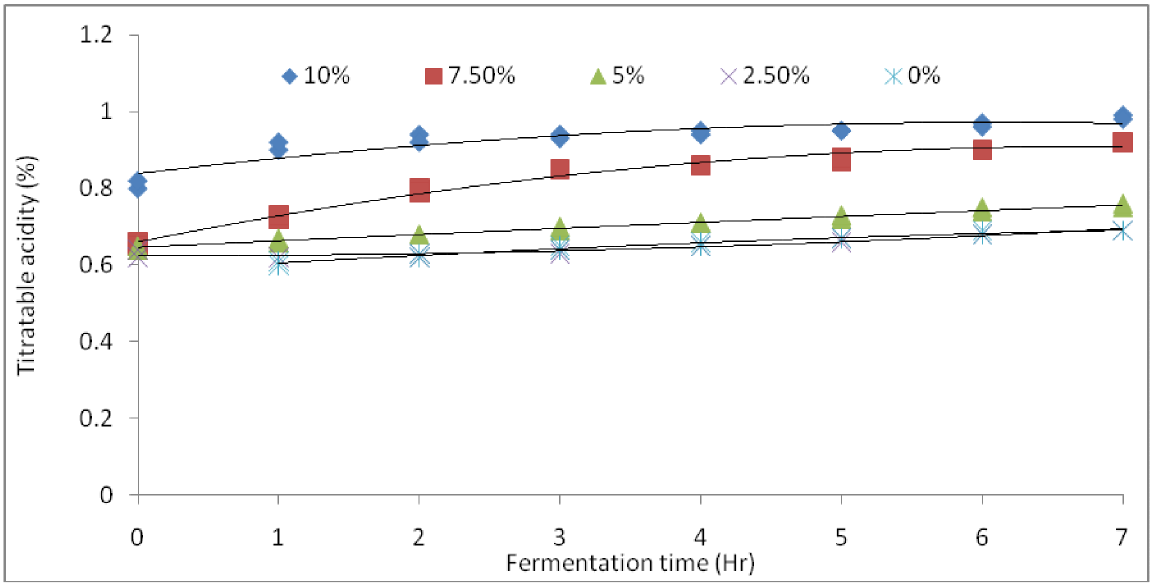

Figure 2 Titratable acidity productions with different levels of PFP in yoghurt during fermentation

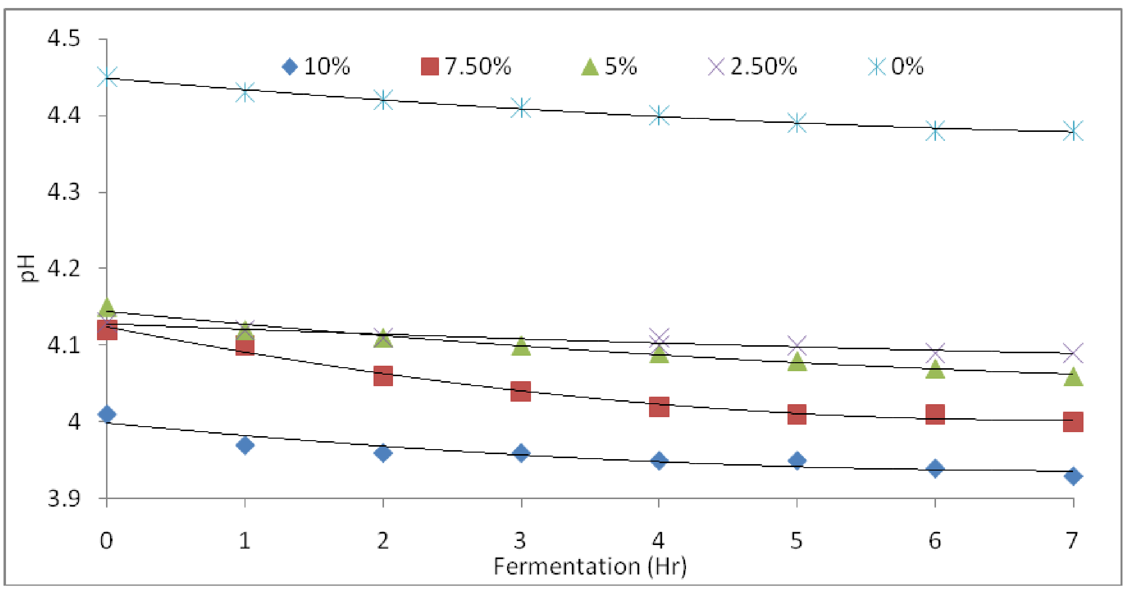

Figure 3 pH of different levels of PFP in yoghurt during fermentation

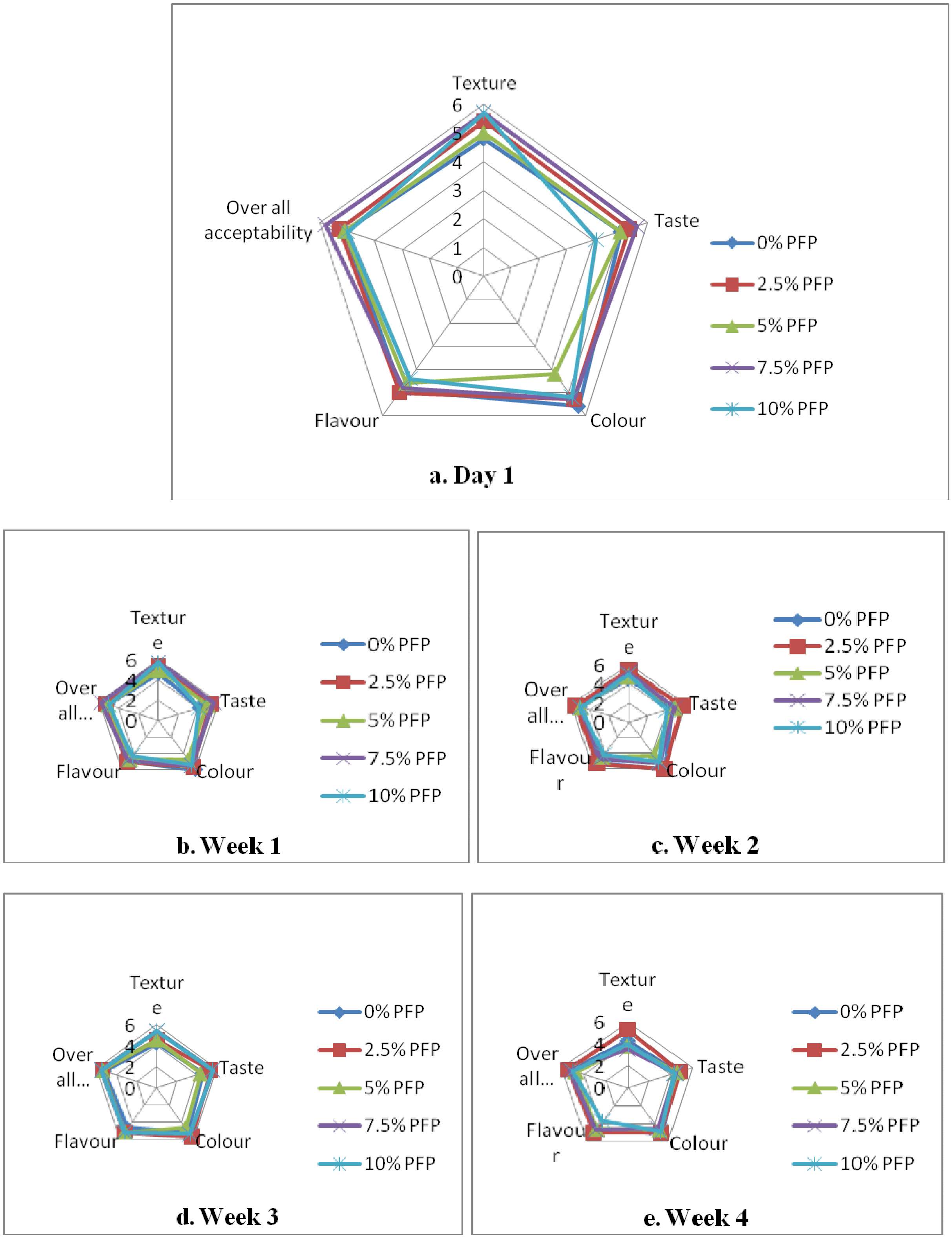

Figure 4: Sensory attributes of yoghurt samples during storage period presented by a "spider web (a-e)