PAPER

STUDY ON THE UTILIZATION OF PANEER WHEY AS FUNCTIONAL INGREDIENT FOR PAPAYA JAM

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ABSTRACT

The objective of the present study was to elaborate papaya jam by substituting 5% and 10% papaya pulp with same amount of paneer whey. Physico-chemical, sensory, microbial and texture analysis were performed on 0, 30th and 60th day of storage. Upon whey substitution in jams, protein content and texture of final products were significantly improved. Slight but not significant increase of acidity and decrease of pH were observed in all the formulations and during shelf life. Reducing sugar content in jam increased from16.20 to 37.49 and that of non-reducing sugar decreased from 45.18 to 26.23% during the storage period of 60 days. Absence of microbial growth was observed in all the jam formulations throughout the storage period. Taken together, whey can be efficiently substituted in papaya jam to improve nutritive value and texture of the product.

Keywords: jam, papaya pulp, protein, storage, substitution, texture, whey

1. INTRODUCTION

Jam is the most popular and shelf stable product made from fruits at household and commercial level. Fruit jams are good source of energy but poor source of protein (NAEEM *et al* 2015). Ingredients and fruit pulps used for preparing jams are commonly poor in protein content and ultimately results in less protein level in jam (NAEEM *et al* 2015). Commercially available jams are poor in protein content as reported by several workers i.e. apple jam - 0.04%, mango jam – 0.15%, jackfruit jam – 0.19%, papaya jam – 0.26%, blueberry jam – 0.31%, strawberry jam – 0.41%, grape jam – 0.27% and apricot jam – 0.43% pineapple jam – 0.46% and orange marmalade jam - 0.79% (AHMMED *et al*., 2015, TEANGPOOK and PAOSANTONG 2013, EKE-EJIOFOR and OWUNO, 2013 NAEEM *et al*., 2015). So there is a need to improve the protein content in jam to make it still a better nutritional food.

Whey is a valuable by-product obtained during manufacture of cheese, channa, casein paneer and shrikand as watery portion of milk after coagulation and removal of curd. Whey contains about 50% of milk solids together with 100% of lactose and 20% of protein. Lactose makes up about 75% of total whey solids (SISO, 1996). Whey represents about 80 to 90% of the volume of milk from which it is obtained (KHAMRUI and RAJORHIA, 1998). Whey protein is a complete, high quality source of protein with a rich amino acid profile. Whey has high protein efficiency ratio (3.6), biological value (104) and net protein utilization (95) is next only to egg protein in terms of nutritive value (RENNER, 1990). About 3 million tonnes of whey is produced annually in India containing about 2 lakh tonnes of valuable milk nutrients (NAIK *et al*., 2009). About 40% of total global production of whey is disposed as raw whey (REDDY *et al*., 1987) causing serious environmental pollution. The disposal of whey is problematic as the Biological Oxygen demand (BOD) of whey is 38,000 to 46,000 ppm (due to its high organic content) as compared to 200 ppm permissible limit for domestic sewage (MISHRA, 2008). Whey has to be treated appropriately to obtain commercial products (GUPTE and NAIR, 2010) or preheated before its discharge in inland water or rivers as per Environmental Protection Act (1986). So it is important to find alternative uses of whey to reduce the economic and environmental impact.

Whey is used in food industry for its high nutritional value, excellent functional properties and for reducing the cost of production of food products. Whey preparations are used in meat and meat products, reduced fat products, yoghurt, ice cream, cheese, bakery products, confectionary and pastry products, infant formula, whey beverage and for encapsulation of sensitive foods and edible coating of foods. The functional properties of whey proteins, mainly used in the production of food products are solubility, gelling, emulsifying, and water binding properties, antioxidant activity, flavour improvement and fat mimetics (Królczyk *et al*., 2016).

Papaya is considered as power house of nutrients as it is a rich source of carotenoids, Vitamin C, Vitamin E, niacin, riboflavin, Vitamin K, carbohydrate, folate, pantothenic acid and dietary fibre. It is also rich in Fe, Na, K, Ca, Mg, P, Cu, Zn and Mn (ARAVIND *et al*., 2013). Papaya is popularly used as dessert or processed into jam, puree or wine (MATSUURA *et al*., 2004).

In the present study, different percentages of papaya pulp were substituted with paneer whey in formulations for papaya jam. Upon substitution, its effects on functional and nutritional properties of jam were studied along with sensory and microbial analysis during storage period of two months.

2. MATERIALS AND METHODS

Plain condensed whey obtained from paneer (Dairy Plant, College of Veterinary and Animal Science, Thrissur) was utilized for study. Papaya used in the experiment was obtained from the local market. Pectin, Sugar (sucrose), citric acid (food grades) was purchased from local market.

2.1 Preparation of papaya jam

Three type's papaya jams were prepared by substituting papaya pulp with paneer whey. Control Jam group (T_0) served as control without whey substitution in papaya pulp (100 g papaya pulp + 0 g whey). Substitution of papaya pulp with condensed whey both for T_1 and T_2 are 5%(95 g papaya pulp + 5 g whey) and 10%(90 g papaya pulp + 10 g whey) respectively. Composition of prepared papaya jam was given in Table 1 and method of preparation was given in Fig. 1.

For substitution in jam, plain condensed whey (semi- solid form) was allowed for slow hydration for a period of 30 min by mixing with water at 60°C at the ratio of 1:2. Hydration was performed for optimal performance of whey protein during heat processing (ZHANG and ZHONG, 2010). The normal range pH range of jam was 2.5 to 3.5 (BROOMFIELD, 1996) and this pH range of jam helps in stability of whey protein.β-lactoglobulin in whey is heat stable at pH 3 (BOYE *et al.*, 1996). Heat stability of whey protein also further improved by presence of sucrose in jam (KULMYRZAEV *et al.*, 2000). According to DURANTI *et al*. (1989) heating to 85°C is critical for whey protein denaturation. So concentrated whey was substituted in the jam just 1 or 2 minutes before reaching end point of jam preparation (105.5ºC) to avoid denaturation. Prepared jams were stored in sterilized glass jars at room temperature (30ºC).

Table 1. Formulation of jam.

Composition	Control Jam (T_0)	T_1	T_2
Papaya Pulp (g)	100	95	90
Whey (g)	0	5	10
Sucrose (g)	75	75	75
Pectin (g)	1	1	1
Citric Acid (g)	0.6	0.6	0.6

2.2. Physical-chemical analysis

Physical-chemical analyses were performed in jam samples on 0^{th}, 30^{th} and 60^{th} days of storage and results were expressed as mean±standard error of mean. Following analysis were performed according to regulations and protocols described by Association of Official Analytical Chemists (2000): pH using a digital pH meter, total soluble solids (TSS,°Brix) by using an Abbe refractometer, water activity (Aw) using Aw Sprint - Novasina TH-500®, crude protein using micro Kjeldahl method,% acidity by titration with NaOH (0.1 M), ash by muffle furnace and moisture by drying in kiln. Estimation of fat in condensed whey was performed as per protocol described by AOAC (2000). Sugars in jams (total sugars, reducing sugar and non-reducing sugar) were determined as per Lane and Eynon method (1923).

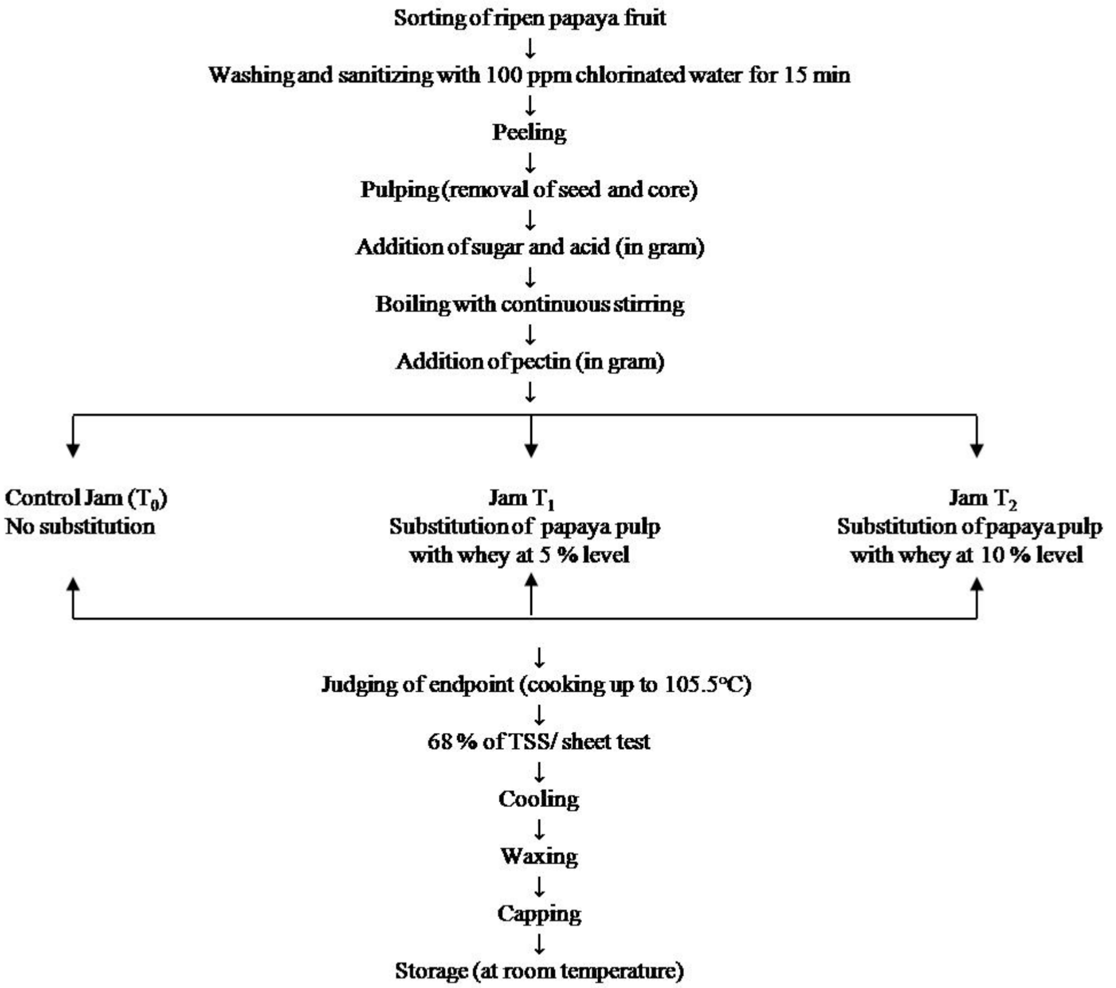

Figure 1. Flow chart for jam preparation.

2.3. Microbial analysis

Standard total plate count, spore count, coliform count, yeast and mould count of jams were performed as per RANGANNA (1986) on 0^{th}, 30^{th} and 60^{th} day of storage period for T_0, T_1 and T_2 jams.

2.4. Sensory evaluation

Jam for organoleptic evaluation was prepared aseptically in clean transparent disposable closed containers and served fresh on test day in a perfectly homogeneous way, i.e. identical conditions of preparation, conservation and presentation. Sixteen trained members of panel were selected from the university community among postgraduate students for evaluating sensory characteristics (color and appearance, taste, texture and overall acceptability) of the samples using a 9-point hedonic scale as per RANGANNA (2008). During product test, panel members were allowed to clean their mouth at intervals with water. The sensory evaluation of jams was performed on 0^{th}, 30^{th} and 60^{th} days of storage.

2.5. Texture analysis

Texture analysis was performed directly in jar containing jam at the ambient temperature with a Texture analyzer TA.XTplus® (Stable Micro System, United Kingdom), using back extrusion procedure. It was used to measure the force – time curve for a two cycle compression. A cylindrical probe (1 inch) was used to compress the samples. On the basis of the preliminary work, instrument working parameters were determined with test mode compression, pretest speed at 1.0 mm/s, test speed at 1.0 mm/s, post-test speed at 10.0 mm/s, distance 10.0 mm, trigger force at 10.0 g and data acquisition rate at 200 pp (YOUNIS *et al*., 2015). Data were analyzed using Texture expert Version 1.22® Software (Stable Micro System, United Kingdom) to measure hardness, consistency, cohesiveness and index of viscosity in the samples. All measurements were done in triplicates of jam samples.

2.6. Statistical analysis

ANOVA with Tukey's t-test, at the 5% level, was applied to data to establish significance of difference among the samples. Statistical analyses were performed using the statistical analysis package STATISTICA 7.0®.
The experiment was carried out with 6 replications

3. RESULTS AND DISCUSSIONS

The composition of plain condensed whey obtained from paneer is presented in Table 2. The papaya pulp had pH of 4.46, total soluble solid 10±0.56% and acidity 2.05±0.05% (Table 3). Similar findings were reported by ZAMAN *et al*. (2006) where pH of papaya fruit pulp ranged from 4.2 to 4.5, total soluble solids varied from 9.0 to 13.0%, the acidity (as citric acid) ranged between 2.00 to 2.30%, total sugar ranged from 6.96 to 10.5%, reducing sugar ranged from 3.42 to 6.92% and non-reducing sugar ranged from 3.17 to 3.58%. ARAVIND *et al*. (2013) reported that papaya pulp contain 0.61% crude protein. SARAN and CHOUDHARY (2013) reported that ash content of papaya pulp range from 0.31 to 0.66% and moisture from 85.9 to 92.6.

Table 2. Composition of plain condensed whey.

	Total solids%	Acidity%	Ash%	Fat%	Crude Protein%
Plain condensed	58.96±0.69	0.48±0.05	6.54±0.21	0.68±0.71	7.35±1.61

SEM – Standard error of mean

3.1. Physical-chemical analysis of jam

The physical chemical properties of jam are presented in Table 4. In this experiment, acidity values of all jams ranged from 0.55% to 0.59% during the storage period of two months). MAMEDE *et al*., 2013 reported that acidity of jam ranges between 0.5% and 0.8% of citric acid and jam with acidity above 1% shows syneresis as higher acidity value causes exudation of liquid from jam. Substitution with whey at 5% (T_1) and 10% (T_2) level did not affect significantly the acidity of jam; even if a slight but not significant rise in the acidity of all jams was observe during the storage period. TEANGPOOK and PAOSANTONG

(2013) reported that acidity of low sucrose lime juice papaya jam increased from 0.63 to 0.70% during the storage period of 6 months. Similarly SHAKIR *et al*. (2008) reported that there was increase in acidity from 0.6 to 0.78% in apple and pear mixed jam during the storage period of 3 months. Increase in acidity might be ascribed to rise in concentration of weakly ionized acids and their salts during storage. Further, rise in acidity might also be due to formation of acids by degradation of polysaccharides and oxidation of reducing sugars or by breakdown of pectic substances and uronic acid (HUSSAIN *et al*., 2008).

Table 3. Chemical Composition of fresh papaya pulp.

	pH	Total soluble solids %	Acidity %	Total sugar %	Reducing sugar %	Non-reducing sugar %	Crude Protein%	Ash %	Moisture %
Papaya pulp (Mean± SEM)	4.46±0.02	10±0.56	2.05±0.05	7.26±0.1	3.92±0.6	3.34±0.01	0.65±0.25	0.45±0.06	88.16±0.23

SEM – Standard error of mean

In jam, total soluble solids or °Brix is a measure of all soluble solids from natural fruit components, added sugar, acid, pectin and other ingredients. According to Food Safety and Standards Regulations (2011) total soluble solids of jam should be not less than 65%. For optimum gel formation in jam with good texture and sensory acceptance, the total soluble solids should range between 65 and 68% (MACRAE *et al*., 1993; DAMIANI *et al*., 2008). In current experiment, total soluble solids of all jams were > 65.0% without any significant differences among them. Substitution of papaya pulp with whey in jam at 5% (T_1) and 10% (T_2) level not caused any changes in total soluble solids level (Table 4). During storage period, all jams showed slight but not significant rise in TSS. TSS of T_1 increased from 66.25 to 67.06, T_2 from 67.52 to 68.01 and Jam C from 68.56 to 69.18. Similarly EHSAN *et al*. (2002 and2003) reported rise in TSS of watermelon lemon jam from 68.6 to 68.9 and grape fruit apple marmalade from 70.0 to 70.8 after 60 days of storage. SHAKIR *et al*. (2008) reported that there was increase in total soluble solids of apple and pear mixed fruit jam from 68.5 to 70.6 during the storage period of 90 days. Increase in TSS during storage might be due to acid hydrolysis of polysaccharides especially gums and pectin (LUH and WOODROOF, 1975).

Setting quality of jam can be improved by adequate pH maintenance. pH and titratable acidity are indicators for quantity of organic acids and their salts contained in a fruit. In our experiment pH value of all jams were ranged between 3.08and 3.36. This pH range was close to the optimal pH suggested by RAUCH (1965), which ranges from 2.5 (hard jam) to 3.45 (soft jam). Similarly, BROOMFIELD (1996) also reported that the pH range of 2.5 to 3.5 in jam was suggested for stable pectin-acid- sugar gel structure. The formation of gel structure in jam depends on the concentration of hydrogen ions and not that of the acidity. TEANGPOOK and PAOSANTONG (2013) reported that low sucrose lime juice papaya jam had pH of 3.22. There was slight decrease in pH of T_0 from 3.31 to 3.09, $T_1$from 3.36 to 3.15 andT_2 from327 to 3.08 during storage period of two month without any significant difference). KHAN *et al*. (2012) reported that pH value of the strawberry jam decreased from 3.20 to 2.91 during the storage period of 60 days.

Table 4. Physico-chemical analysis of jam.

		Control Jam (T_0)	T_1	T_2
Acidity	0^{th} day	0.55±0.017	0.58±0.03	0.58±0.02
	30^{th} day	0.57±0.04	0.58±1.25	0.59±1.28
	60^{th} day	0.57±0.05	0.59±0.56	0.59±1.58
Total soluble solids (^{0}brix)	0^{th} day	66.25±0.029	67.52±0.028	68.56±0.025
	30^{th} day	66.78±0.09	67.91±0.18	68.92±0.08
	60^{th} day	67.06±0.24	68.01±0.87	69.18±0.14
pH	0^{th} day	3.31±0.12	3.36±0.25	3.27±0.71
	30^{th} day	3.25±0.53	3.21 ±0.98	3.15±0.59
	60^{th} day	3.09±0.78	3.15±0.65	3.08±0.27
Ash (%)	0^{th} day	0.323±0.002	0.323±0.002	0.323±0.007
	30^{th} day	0.323±0.006	0.324±0.006	0.324±0.006
	60^{th} day	0.324±0.009	0.324±0.005	0.324±0.005
Moisture	0^{th} day	26.24±0.21^{Aa}	28.74±0.21^{Ba}	30.32±0.25^{Ca}
	30^{th} day	25.22±0.36^{Ab}	27.42±0.78^{Bb}	29.60±0.39^{Cb}
	60^{th} day	24.36±0.54^{Ac}	26.19±0.87^{Bc}	28.91±0.17^{Cc}
Crude protein	0^{th} day	0.92±0.028^{A}	3.15± 0.028^{B}	4.23±0.03^{C}
	30^{th} day	0.85±0.58^{A}	3.14±0.13^{B}	4.20±0.04^{C}
	60^{th} day	0.84±0.24^{A}	3.12±0.54^{B}	4.20±0.03^{C}
Reducing sugars	0^{th} day	16.20 ±0.06^{Aa}	19.54 ±0.02 ^{Ba}	22.17 ±0.01^{Ca}
	30^{th} day	18.47±0.03^{Ab}	25.63±0.01 ^{Bb}	29.35 ±0.05^{Cb}
	60^{th} day	24.30 ±0.18 ^{Ac}	32.44 ±0.01^{Bc}	37.49 ±0.02^{Cc}
Non reducing sugar	0^{th} day	45.18±0.01 ^{Ac}	43.16 ±0.01^{Bc}	40.28 ±0.02^{Cc}
	30^{th} day	43.19±0.12^{Ab}	37.24 ±0.01 ^{Bb}	32.50 ±0.02^{Cb}
	60^{th} day	38.54 ±0.29^{Aa}	31.55 ±0.08 ^{Ba}	26.23 ±0.03^{Ca}
Water Activity	0^{th} day	0.80±0.001^{C}	0.78±0.002 ^{B}	0.75±0.003^{A}
	30^{th} day	0.80±0.001^{C}	0.78±0.002 ^{B}	0.75±0.003^{A}
	60^{th} day	0.80±0.001^{C}	0.78±0.002 ^{B}	0.75±0.003^{A}
Microbial Analysis	0^{th} day	Nil	Nil	Nil
	30^{th} day	Nil	Nil	Nil
	60^{th} day	Nil	Nil	Nil

SEM – Standard Error of mean.

^{ABC} means on the same line without a common letter are significantly different at P < 0.05. (all samples at the same time).

^{abc} means on the same column without a common letter are significantly different at P < 0.05. (single sample during storage period).

jam significantly (P < 0.05) decreased with 5% whey substitution in T_1 (0.78) and with of 10% whey substitution in T_2 (0.75) substitution when compared to that of control jam T_0(0.80) TEANGPOOK and PAOSANTONG (2013) reported that low sucrose lime juice papaya jam had water activity of0.9. SANTOS *et al*. (2013) showed that water activity of gabiroba jams prepared with sucrose and sucralose were 0.78 and 0.80 respectively. In this study there was no change in water activity of all jams during the storage period of 60 days.

The decrease in pH of jam during storage may be attributed to formation of free acids by degradation of polysaccharides, oxidation of reducing sugar, ascorbic acid degradation and hydrolysis of pectin (HUSSAIN and SHAKIR, 2010).
There was no significant rise (P>0.05) in ash content of both T_1 and T_2due to whey substitution). Ash content of all jams ranged from 0.323% to 0.324% without any significant changes during storage. TEANGPOOK and PAOSANTONG (2013) reported low sucrose lime juice papaya jam had ash content of 0.51%. AHMED *et al*. (2011) reported ash content of sapota jam as 0.42%. VIDHYA and NARAIN (2011) reported that there was no change in ash content of wood apple jam during storage period of 90 days.
Statistical analyses revealed that addition of whey significantly (P<0.05) increased the moisture content of T_1 (28.74%) and T_2 (30.32%) when compared to that of control jam T_0 (26.24%). This may be due to higher water retention property of protein present in whey (VIDIGAL *et al*., 2012). T_2jam has significantly higher (P<0.05 moisture content than that of T_1. EKE-EJIOFOR and OWUNO (2013) reported that moisture content of jack fruit jam and pineapple jam in their experiments were 24.60% and 23.29% respectively. MAMEDE *et al*. (2013) observed that the moisture content of dietetic jam prepared from umbucaja fruit ranged from 26.7 to 31.98%.The moisture content of jam produced from dehydrated fruits (Tamarind Guava and Kumquarts) ranges normally between 28.6 – 30.1% (WINUS,2011). It is important to consider that the moisture content is directly related to the conservation of the product during storage. Reduction in moisture content of jam may decrease gel strength and thereby causes firmer jam with poor spreading ability (FASOGBON, 2013). In this experiment, there was significant reduction (P>0.05) in moisture content of all jams T_0 (from 26.24 to 24.36%), T_1 (from 28.74 to 26.19%), and T_2 (from 30.32 to 28.91%), during storage period of 60 days. Similarly, HUSSAIN and SHAKIR (2010) observed a decreasing trend in the moisture content of apricot and apple jam (from 16.08 to 4.3%) during the storage period of 60 days. ANJUM *et al.* (2000) observed decreased in% moisture from 79% to 77% after 60 days of storage in dried apricot diet jam. The loss of moisture in jam that is stored in sterilized glass container in room temperature is due to the exchange of moisture between the outside and inside of the glass by desorption, trapping the free water during gel formation in jam and due to Maillard reaction, which occurs at high temperatures (even at 25°C) in high-sugar products with low pH values by using the freely available water in jam (DAMIANI *et al* 2012).
Protein content of most fruit jam is very low due to the low protein content of most of fruit pulp and none of the ingredients used in jam preparation are an abundant source of protein (NAEEM *et al* 2015) In this experiment, T_2 contain significantly (P < 0.05) highest crude protein content (4.23%) due to 10% whey substitution. T_1 with 5% whey substitution contain crude protein content (3.15%) significantly (P < 0.05) higher than control T_0(0.92%). TEANGPOOK and PAOSANTONG (2013) reported that low sucrose lime juice papaya jam had protein content of only 0.26%. EKE-EJIOFOR and OWUNO (2013) prepared jackfruit jam using pineapple jam as control and reported that protein content ranged from 0.19% - 1.12% with pineapple jam had lowest and jackfruit jam had highest of the products. SALVADOR *et al*. (2012) reported that proteins were present in small amounts in yacon jams as yacon pulp had low protein content. CARVALHO *et al*. (2013) estimated that protein content of diet strawberry jam ranged between 1.31 and 1.35%. GEBHARDT and THOMAS (2002) reported that protein content present in one tablespoon (20 gram) of jam was in traces. CHAUDHARY and VERMA (2011) analysed the physicochemical properties of the processed fruits and vegetable products and found that protein content of jam was 0.48% which is least when compared to the protein content of other processed products (tomato sauce – 0.82%, pickle – 1.98 and orange juice – 1.97%). No significant change was observed in the value of protein content of all the jam samples during the storage period of two months.

Sugars that have high tendency to crystallize like pure dextrose (glucose) were not used in this study, in contrary refined sucrose is known to be a good sugar for addition to jam because of low tendency to recrystallization was used. Sucrose is partly inverted to glucose and fructose in the manufacturing process when the pH of the product is low. This fact was important because as it reduces tendency of sugar to form crystals (CANCELA *et al*., 2005). Statistical analyses revealed that substitution of whey significantly ($P<0.05$) increased the reducing sugar content in T_1 (19.54%) and T_2 (22.17%) when compared to control jam T_0 (16.20%). This increase in reducing sugar content in jam is due to the presence of lactose in whey and lactose itself is a reducing sugar (JENNESS AND PATTON, 1959). Presence of lactose may lead to formation of Maillard reaction products, which are known to have antioxidant properties in food systems (DE WIT 2001). The rise in reducing sugar by whey substitution has correspondingly significant decrease ($P > 0.05$) in non-reducing sugar content of jam T_1(43.16%) and T_2 (40.28%) when compared to T_0(45.18%). During storage period, there was significant ($P < 0.05$) rise in reducing sugar and decline in non-reducing sugar content of all jams. The results of reduction in non-reducing sugars in jams were in accordance with RIAZ *et al.* (1999) who reported reduction in non-reducing sugars from 44.64 to 32.35% in strawberry jam during storage period of 3 months. EHSAN *et al*. (2003) observed drop in non-reducing sugars of grape fruit apple marmalade during storage period of 60 days. Rise in reducing sugar may be due to inversion of non-reducing (sucrose) to reducing sugar (glucose + fructose) because of acid and high temperature during storage (MUHAMMAD *et al*., 2008). RIAZ *et al*. (1999) observed increasing trend in reducing sugars of strawberry jam during 3 months storage period. ANJUM *et al*. (2000) while working on apricot diet jam also observed similar increase in reducing sugars during storage period of 60 days. EHSAN *et al*. (2003) reported increasing trend in reducing sugars of grape fruit apple marmalade where reducing sugars increased from 16.55% to 31.36% after 60 days of storage.
Water activity (Aw) determines the lower limit of available water for microbial growth. Water activity for jams must be less than 0.95 in order to prevent the growth of pathogenic bacteria. In general, minimum Aw for most moulds were 0.8, yeasts - 0.85 and osmophillic yeasts- 0.6-0.7 (RAY and BHUNIA, 2014). Most yeasts, molds and bacteria do not survive at low water activities, which were directly correlated with a long shelf life (BEUCHAT, 1981) In this experiment water activity of papaya jam significantly ($P < 0.05$) decreased with 5% whey substitution in T_1 (0.78) and with of 10% whey substitution in T_2 (0.75) substitution when compared to that of control jam T_0 (0.80) TEANGPOOK and PAOSANTONG (2013) reported that low sucrose lime juice papaya jam had water activity of0.9. SANTOS *et al*. (2013) showed that water activity of gabiroba jams prepared with sucrose and sucralose were 0.78 and 0.80 respectively. In this study there was no change in water activity of all jams during the storage period of 60 days.

3.2. Microbial analysis

Microbial analysis of jam during 0^{th}, 30^{th} and 60^{th} day of storage revealed no bacterial or fungal growth in all three types of jam (T_0, T_1 and T_2). The presence of total soluble solids about 66 to 70% protects jam from microbial deterioration (TAUFIK and KARIM, 1992). In this experiment the total soluble solids of all jam ranges between 66.25 to 69.18%, which resulted in the absence of microbial growth during the storage period of two months. Jam was also prepared with hygienic measures during handling and storage to make it microbiologically safe.
The microbial results of this study were in agreement with findings of many authors like PARSI ROS (1976) who stated that papaya jam stored for 180 days at 29.4°C were found to be microbiologically safe. JOY and RANI (2013) reported that microbial analysis showed

no growth of any kind of bacteria or fungi in the plates of Aloe Vera strawberry jam, papaya jam and pineapple jam till the 60^{th} day of storage. KERDSUPA and NAKNEANA (2013) observed no bacteria, fungi and yeast growth in low-sugar mango jam over 6 weeks of storage.

3.3. Texture analysis

Textural properties of papaya jam were significantly (P<0.05) increased by whey substitution (Table 5). Water retention capacity and gelling properties of whey protein increased texture of jam by avoiding syneresis. ANTUNES *et al*. (2003) also reported that β- lactoglobulin in the whey act as a main gelling agent due to presence of free sulfhydryl group. Firmness of T_2jam (283.83 N) was significantly higher (P<0.05) than T_1 jam (209.92 N) and control jam T_0 (147.83 N). Firmness of T_1 jam was significantly higher (P<0.05) than control jam T_0. VIDIGAL *et al*. (2012) reported that addition of whey protein concentrate improved firmness but not adhesiveness and cohesiveness of ice cream. Adhesiveness of T_2jam (-1662.8 NS) was significantly higher (P<0.05) than T_1 jam (-1543.3NS) and control jam T_0 (-755.83 NS). Adhesiveness of T_1 jam was significantly higher (P<0.05) than control jam T_0. HERRERO and REQUENA (2006) showed that addition of whey protein concentrate enhanced textural characteristics of yoghurt prepared from goat milk by increasing its firmness, hardness and adhesiveness. Viscosity of T_2jam (10276.0 cP) was significantly higher (P<0.05) than T_1 jam (8739.20 cP) and control jam T_0 (5072.8 cP). Viscosity of T_1 jam was significantly higher (P<0.05) than control jam T_0. Increased viscosity is important in fruit jams as it gives better mouth feel, a greater sense of fruitiness and sweetness in final product (JAVANMARD and ENDAN, 2010).

Table 5. Texture analysis of jam.

Parameters		Control Jam (T_0) Mean±SEM	T_1Mean±SEM	T_2Mean±SEM
Firmness (N)	0^{th} day	147.83 ±1.51 ^{a}	209.92 ±0.75 ^{b}	283.83 ±0.87 ^{c}
	30^{th} day	153.3 ±0.49 ^{a}	210.60 ±0.91 ^{b}	285.50±1.33 ^{c}
	60^{th} day	155.5 ±0.56 ^{a}	221.1 ±0.47 ^{b}	291.5 ±0.67 ^{c}
Consistency (NS)	0^{th} day	1672.2 ±6.01 ^{a}	2021.8±3.96 ^{b}	2549.0±4.42 ^{c}
	30^{th} day	1679.0 ±2.85 ^{a}	2033.16 ±2.41 ^{b}	2561.16 ±2.77 ^{c}
	60^{th} day	1683.0 ±4.4 ^{a}	2048.66 ±2.02 ^{b}	2579.33 ±2.11 ^{c}
Adhesiveness (NS)	0^{th} day	-755.83±1.30 ^{a}	-1543.3±2.72 ^{b}	-1662.8±6.18 ^{c}
	30^{th} day	-764.66±0.88 ^{a}	-1558.66±2.62 ^{b}	-1671.33±1.23 ^{c}
	60^{th} day	-782.16±1.85 ^{a}	-1575.16±1.94 ^{b}	-1684.33±1.54 ^{c}
Viscosity (cP)	0^{th} day	5072.8±7.74 ^{a}	8739.20±9.60 ^{b}	10276.0±1.30 ^{c}
	30^{th} day	5119.33±3.45 ^{a}	8763.33±2.24 ^{b}	10313.66±1.87 ^{c}
	60^{th} day	5152.16±2.12 ^{a}	8787.16±1.68 ^{b}	10344.16±1.74 ^{c}
Cohesiveness (N)	0^{th} day	264.66±1.14 ^{a}	371.83±1.10 ^{b}	486.33±4.88 ^{c}
	30^{th} day	272.00±0.96 ^{a}	381.50±0.71 ^{b}	504.83±1.13 ^{c}
	60^{th} day	282.33±0.84 ^{a}	392.33±1.25 ^{b}	519.33±1.11 ^{c}

SEM – Standard Error of mean.

^{abc} means on the same line without a common letter are significantly different at P < 0.05. (all samples at the same time).

LI and GUO (2006) showed that incorporation of polymerized whey protein (prepared by thermal denaturation method) in yoghurt significantly improved viscosity. Consistency of T_2jam (2549.0 NS) was significantly higher (P<0.05) than T_1 jam (2021.8 NS) and control jam T_0 (1672.2 NS). Consistency of T_1 jam was significantly higher (P<0.05) than control jam T_0.Whey proteins were added to yoghurts to increase total solid content of milk in order to provide better consistency, texture and creaminess to the product (Martinez *et al*., 2002). Cohesiveness of T_2 jam (486.33 N) was significantly higher (P<0.05) than T_1 jam (371.83 N) and control jam T_0(264.66 N). Cohesiveness of T_1 jam was significantly higher (P<0.05) than control jam T_0.RAJU *et al*. (2007) substituted refined wheat flour with whey protein up to 30% in biscuit manufacture and observed increase in cohesiveness of biscuit dough which reduced the fracture stress of biscuit. Addition of whey protein increased hardness, adhesiveness, gumminess and chewiness of frankfurters prepared with 5% and 12% fat (HUGHES *et al*., 1998).
The results of textural parameters of jam from both sensory evaluation by sensory panel and instrument (texture analyzer) were in accordance to each other. Jam with 10% whey substitution (T_2) showed significantly higher value than other jams (T_0 and T_1) in textural parameters both through textural analyzer and sensory panel.

3.4. Organoleptic evaluation

Sensory scores of jam samples (Table 6) was performed based on 9 point hedonic scale to evaluate colour and appearance, taste, flavour, texture and overall acceptability with 9 = like extremely, 5= neither like nor dislike and 1= dislike extremely. Appearance and texture revealed that there was no crystallization of sugars in all jams. Presence of off flavor was not noticed in jam samples.

Table 6. Sensory Eevaluation of jam.

Parameters		Control Jam(T_0)	T_1	T_2
Color and appearance	0^{th} day	8.5 ± 0.03^{A}	7.12 ± 0.21^{B}	7.75 ± 0.11^{AB}
	30^{th} day	8.4 ± 0.16^{A}	7.11 ± 0.08^{B}	7.64 ± 0.17^{AB}
	60^{th} day	8.3 ± 0.03^{A}	7.08 ± 0.27^{B}	7.52 ± 0.11^{AB}
Taste	0^{th} day	8.3 ± 0.08^{A}	7.37 ± 0.03^{B}	7.37 ± 0.15^{B}
	30^{th} day	8.1 ± 0.07^{A}	7.14 ± 0.24^{B}	7.22 ± 0.19^{B}
	60^{th} day	8.0 ± 0.23^{A}	7.18 ± 0.31^{B}	7.18 ± 0.43^{B}
Flavor	0^{th} day	8.93 ± 0.05^{B}	7.06 ± 0.26^{A}	7.93 ± 0.38^{AB}
	30^{th} day	8.89 ± 0.17^{B}	7.18 ± 0.27^{A}	7.85 ± 0.19^{AB}
	60^{th} day	8.74 ± 0.05^{B}	7.29 ± 0.07^{A}	7.71 ± 0.22^{AB}
Texture	0^{th} day	7.32 ± 0.06^{A}	8.06 ± 0.28^{AB}	8.75 ± 0.03^{B}
	30^{th} day	7.44 ± 0.08^{A}	8.08 ± 0.34^{AB}	8.55 ± 0.11^{B}
	60^{th} day	7.62 ± 0.51^{A}	8.18 ± 0.44^{AB}	8.60 ± 0.18^{B}
Overall Acceptability	0^{th} day	8.37 ± 0.08^{A}	7.87 ± 0.01^{B}	7.75 ± 0.09^{B}
	30^{th} day	8.25 ± 0.31^{A}	7.78 ± 0.13^{B}	7.65 ± 0.21^{B}
	60^{th} day	8.19 ± 0.07^{A}	7.71 ± 0.04^{B}	7.64 ± 0.06^{B}

SEM – Standard Error of mean
ABC means on the same line without a common letter are significantly different at P < 0.05 (all samples at the same time).

The flavour, colour and appearance of control jam were significantly higher ($P < 0.05$) from that of Jam T_1. The taste and overall acceptability of control jam was significantly higher ($P < 0.05$) from that of Jam T_1 and Jam T_2. Texture of Jam T_2 was significantly higher ($P < 0.05$) than that of control jam. All the parameters of sensory evaluation were within liked limit (sensory score between 7.18 and 8.75) for the jam when substituted with whey both at 5% (T_1) and 10% (T_2). Thus sensory property of papaya jam is not affected by the substitution of whey up to 10% of papaya pulp.

4. CONCLUSIONS

Papaya jam with 10% whey substitution can be effectively assigned as best formulation as it has better textural property which is necessary for jam product, with normal range of pH, acidity, total solids and ash, with better water activity, reducing sugar and significant amount of protein content. The crude protein level in control jam (T_0), T_1, and T_2 jam are 0.92%, 3.15% and 4.23% respectively.

Further, it was substantially proved that whey can be efficiently substituted in jam with advantage of improving its nutritive, physico chemical and textural properties without any detrimental effect on sensory properties and also avoiding much denaturation of whey protein. Usually, fruit pulps incorporated in jam had less protein level, so whey can be used as economic protein source to improve its nutritive value. This experiment also paves a way for effective utilization of whey, which is produced abundantly as by product in dairy industry.

ACKNOWLEDGEMENTS

We would like to thank Department of Dairy Science and Dairy plant, College of Veterinary and Animal Sciences, Thrissur, Kerala, for kind support and facilities to conduct research. Further, thanks are due to Indian Council of Agricultural Research (ICAR), New Delhi, India for financial assistance to research.

REFERENCES

AOAC, 2000. Method 989.05. "Official Methods of Analysis" 17th Ed. Association of Official Analytical Chemists, Washington, DC.

Ahmed T., Burhanuddin M., Haque M.A. and Hossain M.A. 2011. Preparation of Jam from Sapota (*Achras zapota*). The Agriculturists 9(1-2): 1-7.Doi: 10.3329/agric.v9i1-2.9473.

Ahmmed L., Islam M.N., Islam M.S. and Ali M.S. 2015. Estimation of Protein in Jams, Jellies and Juices Available in Bangladesh. Science Journal of Analytical Chemistry. 3(4): 43-46.Anjum F.M., Maqam-ud-Din I. A., Ijazand Pasha A.R. 2000. Preparation and evaluation of dried apricot diet jam. Pak. J. Food Sci. 10(3-4):21-23.

Antunes A.E.C., Motta E.M.P. and Antunes A.J. 2003. Texture profile and water-holding capacity of whey protein concentrate acid gels. Food Science and Technology 23:183-189. Doi: 10.1590/S0101-20612003000400034.

Aravind G., Bhowmik D., Duraivel S. and Harish G. 2013. Traditional and Medicinal uses of *Carica papaya*. Journal of Medicinal Plant Studies 1(1):7-15.

Beuchat L.R. 1981.Microbial stability as affected by water activity. Cereal Foods World 26:345-349.

Boye J.I., Ismail A.A. and Alli I. 1996. Effects of physiochemical factors on the secondary structure of β- lactoglobulin. J. Dairy R. 63(1):97-109.

Broomfield R.W. 1996. The manufacture of preserves, flavourings and dried fruits. Ch. 7. In: "Fruit Processing", D. Artheyand P.R. Ashurt (Ed.), p.165-195. Blackie Academic & Professional Publishing Co, New York.

Cancela M.A., Ivarez E. and Maceiras R. 2005. Effects of Temperature and Carboxy methylcellulose with Sugar Rheology. J. Food Eng. 71:419-424.

de Carvalho A.C.G., de Oliveira R.C.G., Navacchi M.F.P., da Costa C.E.M., Mantovani D., Dacôme A.S., Seixas F.A.V. andda Costa S.C. 2013. Evaluation of the potential use of rebaudioside-A as sweetener for diet jam. Food Science and Technology 33(3):555-560. Doi: 10.1590/S0101-20612013005000080.

Chaudhary.M and Verma S.K. 2011. Analysis of the Physicochemical Properties of the Processed Fruits and Vegetable Products. International Journal of Pharma and Bio Sciences 2(4): 660-666.

Damiani C., Boas V.E.V.B., Junior S. M.S., Caliari M., Paula M.L., Pereira D.E.P. and Silva A.G.M. 2008. Physical, sensory and microbiological analysis of mango jams formulated with different levels of peels in substitution to pulp. Ciência Rural 38:1418-1423. Doi: 10.1590/S0103-84782008000500035.

Damiani C., Asquieri E.R., Lage M.E., Oliveira R.A., Silva F.A., Pereira D.E.P. and Boas V.E.V.B. 2012. Study of the shelf-life of a mixed araça (*Psidium guineensis* Sw.) and marolo (*Annona crassiflora* Mart.) jam. Ciênc. Tecnol. Aliment., Campinas 32(2):334-343. http://dx.doi.org/10.1590/S0101-20612012005000050

De Wit J.N. 2001. Lecturer's handbook on whey and whey products. European Whey Products Association. Brussels, Belgium. p. 50. http://ewpa.euromilk.org/publications.html.

Duranti M., Pagani S., Iametti S. and Carpen A.1989. Heat-induced changes of milk proteins rocket immuno electrophoretic detection of alpha lactalbumin.Milchwissenschaft 44(3):142-144.

Ehsan E.B., Naeem Z.P., Ghafoor A. and Bahtti M.S. 2002. Development, standardization and storage studies on watermelon lemon jam. Pak. J. Food Sci. 12(3-4):21-24.

Ehsan E.B., Naeem Z.P., Javed A. and Nazir. A. 2003. Development, standardization and storage studies on grape fruit apple marmalade. Pak. J. Food Sci. 13(3-4):11-15.

Eke-Ejiofor J. and Owuno F.2013. The physico-chemical and sensory properties of jackfruit (*Artocarpus heterophilus*) jam. International Journal of Nutrition and Food Sciences. 2(3): 149-152. Doi: 10.11648/j.ijnfs.20130203.19

Fasogbon B.M., Gbadamosi S.O. and Taiwo K.A. 2013. Studies on the chemical and sensory properties of jam from osmotically dehydrated pineapple slices. British Journal of Applied Science and Technology 3(4):1327-1335. Doi: 10.9734/BJAST/2013/3718

Food Safety and Standards (Food Products Standards and Food Additives) Regulations. 2011. The Gazette of India: Extraordinary (Part III-Sec. 4) p. 348-349.

Gebhardt S. E. and Thomas R.G. 2002. Nutritive Value of Foods. USDA-ARS, Home and Garden Bulletin 72, p.74. Nutrient Data Laboratory, Beltsville, Maryland.

Gupte A.M. and Nair J.S. 2010. β-galactosidase production and ethanol fermentation from whey using Kluyveromyces marxianus. Journal of Scientific and Industrial Research 69:855-859.

Herrero A. M. and Requena T. 2006. The effects of supplementing goat's milk with whey protein concentrate on textural properties of set-type yoghurt. International Journal of Food Science & Technology 41(1):87-92. Doi: 10.1111/j.1365-2621.2005.01045.x.

Hughes E., Mullen A. M. and Troy D.J. 1998. Effects of fat level, tapioca starch and whey protein on frankfurters formulated with 5% and 12% fat. Meat Science. 48(1-2):169-180. Doi: 10.1016/S0309-1740(97)00087-9.

Hussain I., Zeb A. Shakir I. and Shah A.S. 2008. Combined effect of potassium sorbate and sodium benzoate on individual and blended juices of apricot and apple fruits grown in Azad Jammu and Kashmir. Pakistan Journal of Nutrition. 7:181-185. Doi: 10.3923/pjn.2008.181.185

Hussain I. and Shakir I. 2010. Chemical and organoleptic characteristic of jam prepared from indigenious varieties of apricot and apple. World Journal of Dairy and Food Sciences 5(1):73-78.

Javanmard M. and Endan J. 2010. A Survey on Rheological Properties of Fruit Jams. International Journal of Chemical Engineering and Applications. 1(1):31-37. Doi: 10.7763/ IJCEA.2010.V1.6.

Jenness R. and Patton S. (Ed.). 1959. "Principles of Dairy Chemistry" Chapman and Hall Limited, London. p. 73-100.

Joy K.H.M. and Rani R.N.A. 2013. Formulation, sensory evaluation and nutrient analysis of products with aloe vera. World Journal of Pharmacy and Pharmaceutical Sciences 2(6):5321-5328.

Kerdsupa P. and Nakneana P. 2012. Effect of sorbitol substitution on physical, chemical and sensory properties of low-sugar mango jam. p. 12, presented at 4th International Science, Social Science, Engineering and Energy Conference, Petchburi, Thailand, December 11-14.

Khamrui K. and Rajorhia G.S.1998. Making profits from whey. Indian Dairyman. 50:13-18.

Khan R. U., Afridi S.R., Ilyas M., Sohail M. and Abid H. 2012. Development of strawberry jam and its quality evaluation during storage. Pakistan Journal of Biochemistry and Molecular Biology 45(1):23-25.

Królczyk J.B., Dawidziuk T., Turak E.J and Sołowiej B. 2016. Use of Whey and Whey Preparations in the Food Industry – a Review. Pol. J. Food Nutr. Sci. 66(3):157-165. doi: 10.1515/pjfns-2015-0052.

Kulmyrzaev A., Bryant C. and Mc Clemente D.J. 2000. Influence of sucrose on the thermal denaturation, gelation and emulsion stabilization of whey proteins. Journal of Agricultural and Food Chemistry 48:1593-1597. Doi: 10.1021/jf9911949.

Lane J. H. and Eynon L. 1923. Methods for determination of reducing and non-reducing sugars. Journal of Science 42:32-37.

Li J. and Guo M.R. 2006. Effects of Polymerized Whey Proteins on Consistency and Water-holding Properties of Goat's Milk Yogurt. J. Food Sci. 71(1):34-38. Doi: 10.1111/j.1365-2621.2006.tb12385.x.

Luh B.S. and Woodroof J.G. 1975. Commercial Vegetable Processing. AVI Publishing Co, Westport, Connecticut, USA, p. 649-650.

Macrae R., Robinson R.K. and Sadler M.J. 1993. Encyclopedia of Food Science, Food Technology and Nutrition. Academic Press Publication. Ltd., London, 3:2120-2123.

Mamede M.E.O., Carvalho L.D., Viana E.S., Oliveria L.A., Filho W.S.S. and Ritzinger R. 2013.Production of dietetic jam of Umbu- caja (*Spondia ssp*): Physical, physicochemical and sensorial evaluations. Food and Nutrition Sciences 4:461-468. Doi: 10.4236/fns.2013.44059.

Matsuura F.C.A.U., Folegatti M.I.D.S., Cardoso R.L. and Ferreira D.C. 2004. Sensory acceptance of mixed nectar of papaya, passion fruit and acerola. Science Agriculture 61:604- 608. Doi: 10.1590/S0103-90162004000600007.

Martinez G.C., Becerra M., Chafer M., Albors A., Carot J.M. and Chiralt A. 2002. Influence of substituting milk powder for whey powder on yoghurt quality. Trends Food Sci. Technol. 13:334-340.

Misra A.K. 2009. Whey management in Dairying. Diary Year Book. 4th Edn., p. 125.

Muhammad A., Durrani Y. Zeb A., Ayub M. And UllahJ.2008. Development of diet jams from apple grown in swat (NWFP). Sarhad Journal of Agriculture. 24(3):461-467.

Naeem M.M.N., Fairulnizal M.M.N., Norhayati M.K., Zaiton A., Norliza A.H., Syuriahti W.Z.W, Azerulazree M.J., Aswir A.R. and Rusidah S. 2015. The nutritional composition of fruit jams in the Malaysian market. Journal of the Saudi Society of Agricultural Sciences. In press. http://dx.doi.org/10.1016/j.jssas.2015.03.002

Naik Y.K., Khare A., Choudhary P.L., Goel B.K. and Shrivastava A. 2009. Studies on physico-chemical and sensory characteristics of whey based watermelon beverage. Asian Journal of Research in Chemistry 2:57-59.

Parsi Ros O. 1976. The preparation of papaya jam. Journal of Agricultural University 60(1):129-131.

Raju P.N., Rao K.H. and Devi N.L. 2007. Development and evaluation of high protein biscuits containing whey protein concentrate. Journal of Food Science and Technology 21:219-236.

Ranganna S. (Ed.). 1986. "Handbook of Analysis and quality control for fruits and vegetable products". 2nd ed. Tata Mc Graw Hill Publishing Co, New Delhi, India. p. 670-678.

Ranganna S. (Ed.) 2008. "Handbook of analysis and quality control for fruits and vegetable products". 15th ed. Tata Mc Graw Hill Publishing Co, New Delhi, India. p. 623-624.

Rauch G. H. 1965. Jam Manufacture. 2nd Ed. Leonard Hill Books, London. p. 78-82.

Ray B. and Bhunia A. 2014. Fundamental food microbiology. 5th Ed. CRC Press, Boca Raton, Florida p. 66.

Reddy G.L., Rao B.V.R., Reddy K.S.R. and Venkayya D. 1987. Development of a whey beverage. Indian Journal of Dairy Science 40(4):445-450.

Renner E.1990. Nutritional aspects. In: Whey and Lactose Processing J.G. Zadow (Ed.), Elsevier Appl.Sci., London, p. 449.

Riaz M. N., Mohyuddin G. and Al Haq M. I. 1999. Physical, chemical and sensory characteristics of jams made from fresh and frozen strawberries. Pakistan Journal of Arid Agriculture 2(1):51-60.

Saran P.L. and Choudhary R. 2013.Drug bioavailability and traditional medicaments of commercially available papaya: A review. Afr. J. Agric. Res. 8(25):3216-3223.

Salvador A.C., Dantas M.I.S., Vasconcelos C.M.,Vanetti M.C.D., Ribeiro S.M.R., Nery-Enes B., Nelson J.D. and Martino H.S.D. 2012. Development of a low calorie yacon jam: physico chemical, microbiological and sensory characterization. Revistachilena de nutrición 39(3):72-77. Doi: 10.4067/S0717-75182012000300011.

Santos M.S., de Lima J.J., Petkowicz C.L.O. and Candido L.M.B. 2013. Chemical characterization and evaluation of the antioxidant potential of gabiroba jam (*Campomanesia xanthocarpa Berg*). Acta Scientiarum Agronomy 35(19):73-82. Doi: 10.4025/actasciagron.v35i1.14389

Shakir I., Durrani Y., Hussain I., Qazi I.M. and Zeb A. 2008. Physicochemical analysis of apple and pear mixed fruit jam prepared from varieties grown in Azad Jammu and Kashmir. Pakistan journal of Nutrition 7(1):177-180. Doi: 10.3923/pjn.2008.177.18

Siso M.I.G. 1996. The biotechnological utilization of cheese whey: A review. Bio resource Technology 57:1-11. Doi: 10.1016/0960-8524(96)00036-3.

Taufik Y.C.M. and Karim M.N.A. 1992. Storage stability of ciku leather. ASEAN Food Journal 1(7): 53-55.

Teangpook C. and Paosantong U. 2013. Production and shelf-life of low sucrose lime juice papaya jam. Pakistan Journal of Nutrition 12 (9): 870-878. Doi: 10.3923/pjn.2013.870.878.

Vidhya R. and Narain A. 2011. Formulation and evaluation of preserved products utilizing under exploited fruit, wood apple (*Limonia acidissima*). American-Eurasian Journal of Agricultural and Environmental Science 10(1):112-118.

Vidigal, M.C.T.R., Minim V.P.R., Ramos A.M., Ceresino E.B., Diniz M.D.M.S., Camilloto G.P. and Minim L.A.2012.Effect of whey protein concentrate on texture of fat-free desserts: sensory and instrumental measurements. Food Science and Technology 32(2):412-418.Doi: 10.1590/S0101-20612012005000047.

Winus P. Studying on conditions and properties of gel in jam. Fund by Institution of Research and Product Development, Kasetsart University, Bangkok, Thailand; 10900. Accessed 23 July 2011. Available: http://www.ifr.ku.ac.th/staff/cc/cc244.pdf.

Younis K., Islam R. U., Jahan K., Yousuf B. and Ray A. 2015. Effect of addition of mosambi (*Citrus limetta*) peel powder on textural and sensory properties of papaya jam. Cogent Food & Agriculture 1:1023675. http://dx.doi.org/10.1080/23311932.2015.1023675

Zaman W., Biswas S. K., Helali M.O.H., Ibrahim M. and Parvez H. 2006. Physico-Chemical Composition of Four Papaya Varieties Grown at Rajshahi. Journal of Bio-Science 14:83-86. Doi: 10.3329/jbs.v14i0.448.

Zhang W. and Zhong Q. 2010. Microemulsions as nanoreactors to produce whey protein nanoparticles with enhanced heat stability by thermal pretreatment. Food Chemistry 119:1318-1325. Doi: 10.1016/j.foodchem.2009.08.043.

Paper Received April 23, 2016 Accepted October 15, 2016