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Development of technology for bamboo seeds *payasam*- a traditional product of tribals in Wayanad district of Kerala

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The bamboo [*Bambusa bambos* (L.) Voss] seeds *payasam* is a light brown to dark brown coloured product, the dark colour is due to dark jaggery used in its preparation. The *payasam* has flowable consistency and possesses pleasant caramel taste with a typical bamboo seeds flavor along with a dash of coconut flavor. Various ingredients of bamboo seeds *payasam*, viz. amount of bamboo seeds, water, jaggery, fresh coconut extract and milk along with process for preparation were optimized. The standardized method of preparation involved cleaning and washing of bamboo seeds, soaking 100 g seeds in excess of water for 6 h at ambient temperature, draining the water, addition of 300 mL of fresh water and pressure cooking at 15 psi for 10 min. The cooked grains were then mixed with jaggery syrup, 125 g of fresh coconut extract and 125 g toned milk. Then the entire mixture was heated and desiccated to a final weight of about 1 kg. The bamboo seeds *payasam* had a composition of total solids 38.75 %, fat 7.8 %, protein 4.96 %, lactose 0.56 %, sucrose 20.25 %, ash 0.84 % and other carbohydrates 4.34 %. Based on the sensory evaluation and textural results, it was observed that the shelf life of the *payasam* was 1-2 days at 30 ^{o}C and more than 15 days at 5 ^{o}C.

Keywords: Bamboo seeds, *Payasam*, Jaggery, Packaging, Shelf life, Composition.

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Introduction

Payasam is a traditional sweet delicacy of South India, prepared during special occasions. The term *payasam* is derived from Sanskrit word *payasa*. It blends with the Hindu culture and this dessert has been an essential dish throughout the history of India, being usually prepared at ceremonies, feasts and celebrations. *Payasam* finds its place in literature around 400 BC through Buddhist and Jain canonical literature. In Bengal, a *payasam* like delicacy called *payesh* is made from rice, thickened milk and fruits like mango and is served at the end of festive meal. In Kannada literature of the 13th century, the *Sarvaligeya payasam* made with vermicelli and a baked like *payasam* are quoted. In Southern India, ancient traditions tell that wedding is not fully blessed if *payasam* is not served in the feast. It is offered as '*prasadam*' in many temples[1]. In Ambalappuzha temple, the famous *palpayasam* is served to devotees on payment basis[2]. Traditionally, *Thari kanchi* (*suji*) *payasam* is eaten while breaking the Ramzan fast in the evening. It also eases the cramps that arise from the sudden rush of food after a day of abstinence from any food and water[3]. Tribal people like Lambanis consume vermicelli *payasam* during pregnancy[4].

The traditional food preparations are held carefully by the people and passed by word of mouth from generation to generation[5]. The development of *payasam* making technology and preservation has recently started[6-10]. Varieties of *payasam* have been reported by Unnikrishnan *et al*[11] and Padmanabhan[12].

Mulayari (Malayalam word for bamboo seed) *payasam* is one of the traditional sweet desserts of Wayanad district of Kerala, mainly prepared by the tribal people using bamboo seeds, jaggery, coconut milk/milk, cardamom, cashew nut, raisins, etc. Bamboo is a flowering perennial evergreen plant in the grass family Poaceae, which also includes rice and wheat. It has the peculiarity of flowering and seeding only after a long vegetative phase and it varies from species to species. A single clump (*Mulamkkootatam)* on flowering yields 50 to 100 kg of seeds[13]. The husked bamboo seed comprises of moisture 10.0 %, crude protein 12.0 %, ether extractive 0.9 %, ash 1.1 %, fiber 2.6 % and carbohydrate 73.4 %[(Ref. 14)]. The protein content of the seeds is comparable with wheat but superior to rice[15]. The nutritive value of

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bamboo seed is slightly greater than that of rice and wheat as it contains minerals such as Ca, P, Fe, Mg and vitamins such as vit B_1, nicotinic acid, riboflavin and carotene[14].

So far, no work has been carried out on the utilization of bamboo products in Indian traditional dairy products. Hence, this work has been planned for characterization and standardization of this new variety of *payasam.*

Materials and Methods

Ingredients

Bamboo seeds [*Bambusa bambos* (L.) Voss or *Bambusa bambos* var. *spinosa*] were collected from Wayanad district, Kerala where there are several tracts of bamboo in forest region. Toned milk having 3 % fat and 8.5 % solids-not-fat (SNF) of Nandini brand, jaggery of golden yellow colour, coconut, ghee, cardamom, cashew nuts and raisins were procured from the local market.

Packaging material

Metalized thick Al pouch [320 gauge consisting of 50 gauge metalized polyethylene terephthalate (Met PET) / 270 gauge low density polyethylene (LDPE) with a size of 22.5 x 17.5 cm] was used as a high barrier, and LDPE pouch (350 gauge) was used as a low barrier packaging material for storage study of standardized bamboo seed *payasam.*

Characterization of traditional bamboo seed payasam

Information related to bamboo seed *payasam* was collected from various sources, viz. literature, recipe books, from the areas where bamboo seeds are grown in Wayanad district, etc. Market samples of *payasam* were collected from different regions of Wayanad district (Thirunelly, Ambalavayal and Manathawady). The collected samples were subjected to sensory attribute characterization and chemical composition. Characterization of sensory attributes was done using 9 point hedonic scale which included various parameters such as colour and appearance (CA), flavour, body and texture (BT), sweetness and overall acceptability. Chemical analyses included total solids (TS), proteins, fat, sucrose, ash and other carbohydrates. Other parameters such as pH, acidity, viscosity index, consistency, seed hardness and microbiological parameters were also analysed using standard methods.

Standardization of preparation method

Based on the information collected from Wayanad area, a basic method was devised for the preparation of bamboo seeds *payasam* (Fig 1).

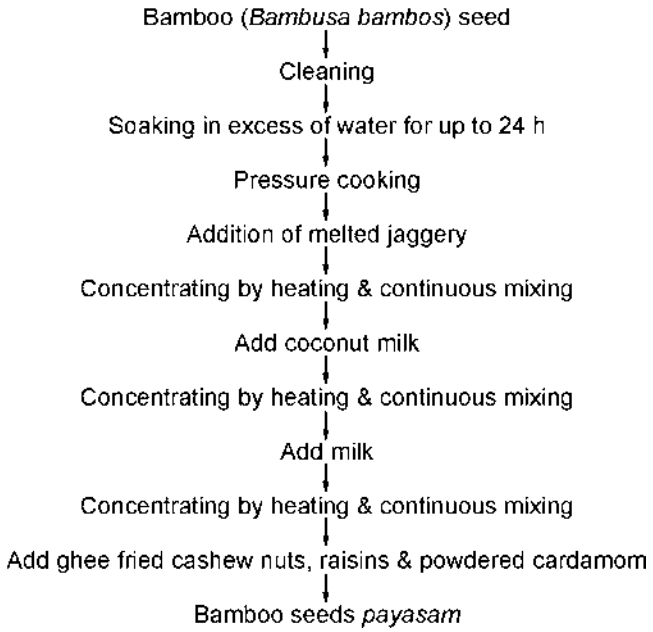

Fig. 1—Flow chart showing standardized method for preparing bamboo *payasam*

Parameters studied for standardization

Cooking pressure

The pressure required for cooking of bamboo seeds were optimised by trying steam pressures: 15, 10 and 5 psi and exposure time: 5, 10 and 15 min.

Milk

100, 125 and 150 g toned milk (taken per 100 g bamboo seeds) were tried to decide an optimum level.

Bamboo seeds

75, 100 and 125 g bamboo seeds taken per kg bamboo seed *payasam* were used to decide an optimum level.

Quantity of water

Quantities of water, viz. 200, 300 and 400 mL per 100 g bamboo seeds were tried for cooking purpose.

Coconut milk

The preparation of coconut milk was based on the method of Agarwal *et al*[16]. The raw coconuts were cut into small pieces and grated in the mixer without adding water. The grated coconut was squeezed in a cleaned dry muslin cloth to collect coconut milk. Three levels of coconut milk tried were 100, 125 and 150g (taken per 100 g bamboo seeds).

Jaggery

Three levels of jaggery were used, viz. 150, 200 and 250 g (taken per 100 g bamboo seeds) to decide an optimum level. About 150 to 250 mL of water was added to crushed jaggery and heated till all the

jaggery got melted on a low flame. The thin syrup was then filtered through a muslin cloth to remove all extraneous materials present in the jaggery.

During standardisation various sensory and rheological parameters of *payasam* samples such as viscosity and consistency were analysed. A final formulation of the *payasam* was developed based on the sensory acceptance and comments of the evaluators (10 No). Gross chemical composition and other characteristics of *payasam* prepared by the standardized method were also analysed.

Storage studies

The *payasam* was packed in LDPE and metalised polyester packages and stored at 30 and 5 °C. The product quality was evaluated every day at 30 °C and at three days interval at 5 °C. During storage sensory (CA, flavor, BT) and physico-chemical (pH, acidity, consistency and viscosity index) attribute were monitored. pH/acidity measurement indicates the overall chemical changes taking place in the product and consistency/viscosity index values are a reflection of texture related changes.

Methods of analysis

Proximate composition

Powdered seeds of *B. bambos* (L.) Voss used were analyzed for moisture, total ash, crude proteins, ether extract, nitrogen free extract and crude fibre according to AOAC[17].

Physico-chemical characteristics

Payasam was taken in a mixer and thoroughly ground into a smooth consistency fluid. This was used for all analyses. About 3 g of the *payasam* was accurately weighed into a previously dried and weighed flat bottomed aluminium dish. The TS & fat content were detremined by gravimetric and Mojonnier method, respectively as described in BIS[18]. The percent protein was determined by standard micro Kjeldahl method described in AOAC[19]. For determination of ash content, 3 g of *payasam* sample was accurately weighed into a silica crucible and procedure described in AOAC was followed[19]. The sucrose content of *payasam* was estimated using the procedure given in BIS for sweetened condensed milk[18].

Titratable acidity was determined by the procedure of BIS given for khoa[18]. Total hydroxymethyl furfural (HMF), which indicates extent of Maillard browning, was determined by the method recommended by Keeney and Bassette[20]. The pH was determined with a digital pH meter by dipping the electrode directly into the *payasam* taken in a 50 mL beaker. Water activity of the sample was determined using digital water activity meter[21]. Colour of the sample was measured in terms of reflectance by the method described by Shaunak[22] using reflectancemeter (Elico Make, Hyderabad).

Sensory evaluation

The organoleptic quality during storage was evaluated at regular intervals by a panel of judges on a 9 point hedonic scale under standard conditions of product evaluation[23]. The panelists rated each sensory attribute on 9-point hedonic scale, where 1 corresponded to “dislike extremely” and 9 corresponded to “like extremely”. The packets containing *payasam* were taken out from the incubator (30 °C) and fridge (5 °C), cut opened and poured into 250 mL beakers .The beakers were coded and served to judges in the sensory evaluation laboratory. The judges provided comments on the CA, BT, flavour and overall acceptance of the product.

Rheological characteristics

Consistency and viscosity index of the stored samples were determined using Texture Analyser by back extrusion method[24]. The instrument settings employed were mode: measure force in compression, option: return to start, pre-test speed: 1.0 mm/sec, test speed: 1.0 mm/sec, post-test speed: 10.0 mm/sec, distance: 30 mm, trigger type: auto 5 g, data acquisition rate: 200 pps; accessory used: back extrusion cell (A/BE) with 45 mm disc and extension bar using 50 kg load cell. From the force-time curve generated, consistency and viscosity index values were determined.

Hardness of the bamboo seed was determined using Texture Analyser[25]. The instrument settings employed were mode-measure force in compression, option-return to start, pre-test speed: 1 mm/min, test speed: 0.5 mm/min, post-test speed: 1 mm/min, distance: 2 mm, trigger type: Auto 5 g, data acquisition rate: 200 pps; accessory used: P/25 probe with 50 kg load cell. The cooked bamboo rice was drained of water completely using a strainer and surface moisture of the samples was blotted out. Then 2-3 bamboo rice samples from each lot were kept on the base of this instrument for testing, P/25 probe was used to compress 2–3 grains, with pre-test and post-test speeds of 1 mm/min and test speed of

0.5 mm/min. The hardness was indicated by highest peak value on the force – time curve generated.

Statistical analysis

The results of physico-chemical and sensory evaluation were statistically analyzed using SPSS 15.0 software (SPSS Inc, Chicago, IL, USA). The data were expressed as mean±SD. Tukey's Honest Significant Difference test was applied for mean comparison when analysis of variance showed significant differences at the 95 % confidence level.

Results and Discussion

Characterisation of the traditional bamboo seeds *payasam*

Samples of the *payasam* were procured from three regions of Wayanad district and evaluated for quality attributes. Their physico-chemical qualities were recorded. The samples were evaluated by the Section's panel of judges. Their observations are summarized in Table 1.

Sensory quality

The colour of the samples varied depending on the type of sweetener used. It was creamy brown when sugar or refined jaggery was used and dark brown when dark unrefined jaggery was used. The *payasam* had a thin to thick consistency and bamboo seeds were found dispersed in the liquid phase, which imparted consistency to the *payasam*. The bamboo seeds were chewy and soft, but in some samples they were hard and chewy. This may be because of excessive concentration during cooking, resulting in diffusion of moisture out of the seeds. The flavor was liked 'very much' by the panelists because of pleasant caramelized sugar taste coupled with typical bamboo seeds flavor which included a dash of bamboo taste as well. The bamboo seeds were observed to be in pieces indicating that broken seeds were also used for the preparation of the *payasam*. In case of rice based *payasam*, broken grains are also sometimes used **.** The broken grains may have the advantage of taking less time for cooking. All the samples of the bamboo seeds *payasam* were pleasantly sweet with jaggery taste. It was observed that the presence of chewy seeds is the characteristic of the bamboo seeds *payasam*. The sensory scores of market samples are presented in Table 1.

Table 1—Sensory quality characteristics of bamboo seed *payasam* samples collected from Wayanad district, Kerala

Attributes	Sample A	Sample B	Sample C
Appearance & colour	Creamy brown colour with dispersed bamboo seeds (7.57^{b})	Creamy brown colour with dispersed bamboo seeds (7.59^{b})	Dark brown colour with semi solid consistency, broken seeds (6.00^{a})
Body & texture	Thinner consistency, soft & chewy flakes (7.47^{b})	Soft & chewy flakes, medium consistency (8.04^{c})	Hard & chewy flakes, thicker consistency (6.18^{a})
Flavour	Pleasant sweet nutty aroma, caramelized sweet taste (7.78^{c})	Bland, less caramelized than 'A' (7.48^{b})	Sweet, jaggery taste & aroma (6.59^{a})
Sweetness	Pleasantly Sweet (7.84^{c})	Sweet (7.61^{b})	More sweet (6.95^{a})
Overall score	(7.98^{c})	(7.51^{b})	(6.38^{a})

Figures in parentheses are sensory scores (average of three replications); Note: Mean values with different superscripts in a row are significantly different from each other ($p<0.05$)

The overall acceptance of the samples ranged from 'like slightly' to 'like very much' range as indicated by scores, which were between 6 and 8.04. Among the three samples, sample A and B were liked more than sample C; the scores of all sensory attributes were significantly less than the other samples as indicated by statistical analysis ($P<0.05$). This could be probably because sample C contained dark jaggery and looked darker. The dark appearance along with thicker consistency might have influenced the sensory acceptance by the panelists.

Chemical composition

Table 2 presents information regarding the mean nutrient composition of *payasam* samples (per 100 g basis). Results showed that TS content of the samples varied from 29-38 %. Of this, sucrose was the major constituent (12-14 %) followed by carbohydrates (7-9 %), proteins (5-8 %) and fat (3-5 %). These

Table 2—Physico-chemical characteristics of bamboo seed *payasam* samples collected from Wayanad district, Kerala

Particulars	Percentage	Particulars	Percentage
	Physical		
Consistency (N.sec)	7.29-9.21	Hardness of bamboo seed grains in the *payasam* (N)	2.26 – 4.03
Viscosity index (N.sec)	0.184 – 0.432	Colour (Reflectance, %)	3.20 - 37.60
	Chemical		
Total Solid	29 – 38	Sucrose	12 – 14
Fat	3 – 5	Ash	0.9 – 1.2
Protein	5 – 8	Other carbohydrates	7 – 9.8

values are lower compared to bovine milk based *payasam* like *palada*, probably because of coconut milk used in bamboo seeds *payasam*. Asha *et al*[26] reported carbohydrate 22.98 %, protein 13.01 %, fat 5.12 % in moth bean *payasam*.

Physical characteristics

The *payasam* had a thin to thick consistency. Table 2 reveal that the consistency varied from 7.29-9.21 N.sec and the viscosity index varied from 0.184-0.432 N.sec. The sample 'A' though had more consistency value than 'B', it appeared thinner. The *payasam* samples are comparable to *kheer* in consistency because as in *kheer*, the starch from the seeds might have contributed to the viscosity. The hardness of individual grains / flakes in the *payasam* was also determined, which varied from 2.26-4.03 N. The grains in the sample 'C' were found to be more chewy than those in other samples as indicated by higher hardness values (4.03 N). The flakes in other samples were found to be soft and chewy. As for the colour, the reflectance values varied from 3.20-37.60 %. The higher the reflectance value, the lighter is the sample. Thus a value of 3.2 of sample 'C' indicates a very dark colour. This is because of dark jaggery and greater concentration used during the preparation. It is learnt that in Kerala, dark jaggery is commonly used for culinary purposes.

Microbiological quality of the samples was not analysed because the time gap between the manufacture of the product and the time the samples were brought to laboratory was long. Analyses of market samples of bamboo seeds *payasam* revealed that there were variations in the quality attributes and also the method of manufacture varied from manufacturer to manufacturer. Our enquiries elicited different versions for method of manufacture. Variations existed in use of coconut milk, type and quantity of sweetener used, product concentration, use of whole or broken seeds, etc. Therefore, a need was felt to standardize the method of preparation of bamboo seeds *payasam*.

Standardization of preparation method

On average, chemical composition of the bamboo seeds gave dry matter 90.2 %, crude protein 13.78 %, ether extract (EE) 1.21 %, crude fibre 1.95 %, ash 1.06 % and nitrogen free extract (NFE) 82 %, which is comparable with the result got by Rao *et al*[27] dry matter 92.2 %, crude protein 13.1 %, EE 1.20 %, crude fibre 0.95 %, ash 1.1 % and NFE 75.9 %.

Cooking of bamboo seeds

As bamboo seeds are harder than normal rice grains, it is better to pre-cook them before using in *payasam* preparation. The cleaned bamboo seeds were thoroughly washed in potable water and taken in a container. Potable water three times the quantity of the seeds was added and then pressure cooked at 121 ^{o}C for various periods of time. It was observed that even up to 10 & 15 min of exposure to 15 psi did not cook the seeds properly, however a holding period of 20 min resulted in properly cooked grains (Table 3). This was reflected in the hardness of grains, which at 5 min time was 25.66 N and the value remained above 10 N till 15 min of holding time at 15 psi (Table 3a). The hardness reduced to 4.25 N after 20 min holding time at 15 psi indicating that the grains were completely cooked. Thus hardness value of below 10 N is an indication of proper cooking of the grains. It is a common observation that the popularly used paddy rice is cooked within an exposure time of about 5 min under domestic conditions. This is because rice grains sold in the market are generally polished and the surface coat is scraped off making

Table 3—Effect of cooking time on cooking status and hardness of bamboo seeds

Cooking time (min) at 15 psi/121 ^{o}C	Cooking status	Hardness of grains (N)
(a) Raw bamboo seeds		
5	Not cooked	25.66
10	Not cooked	16.21
15	Less cooked	10.47
20	Properly cooked	4.25
(b) Raw bamboo seeds soaked for 6 h in potable water		
-	-	107.31
5	Not cooked	15.35
10	Cooked	6.67
(c) Raw bamboo seeds soaked for 6 h in hot potable water		
-	-	92.96
5	Less cooked	10.94
10	Cooked	4.37
(d) Raw bamboo seeds soaked for 12 h in potable water		
-	-	98.98
5	Less cooked	10.70
10	Cooked	6.77
(e) Raw bamboo seeds soaked for 24 h in potable water		
-	-	77.99
5	Less cooked	11.28
10	Cooked	5.64

the grains softer. In case of bamboo seeds procured from market, no such treatment was given to the seeds, hence it required prolonged exposure at 15 psi for proper cooking. The cooking time can be further reduced if the grains are soaked before pressure cooking. Hence, soaking of bamboo seeds was tried in potable water for 6, 12 and 24 h.

Initially, hardness of seeds after soaking for 6 h was 107.31 N, which reduced to 15.35 and 6.67 N, respectively after 5 and 10 min holding time at 15 psi (Table 3b). These values showed that the grains were cooked properly after 10 min holding at 15 psi as against 20 min holding for raw bamboo seeds. During soaking, the surface coat of the grains might have been hydrated thus facilitating entry of water into the grains during cooking process. When soaked in hot water (initial water temperature 90 ^{o}C), the hardness came down to 92.96 N and then to 10.94 and 4.37 N after an exposure of 5 and 10 min at 15 psi, respectively (Table 3c). The hardness was less than when the seeds were soaked in potable water at ambient temperature. This is because at high temperature water has less viscosity[28] and it might have entered into the grains resulting in faster hydration. However, when bamboo seeds were soaked in potable water for 12 h under ambient conditions, the hardness of the cooked grains was slightly more at 6.77 N though properly cooked. Under these conditions, the initial hardness of the grains was 98.98 N which reduced to 10.70 N after 5 min of holding at 15 psi; these grains were not properly cooked (Table 3d). The raw grains were also soaked for 24 h at ambient temperature before cooking and the hardness of the grains on an average was measured as 77.99 N, which decreased to 11.28 and 5.64 N, respectively after 5 and 10 min of cooking at 15 psi (Table 3e). Greater the period of soaking, softer the grains became, which could be possibly due to to more time given for hydration of surface coating as well as seed starch. The starch absorbs water and get hydrated attaining softer texture[29]. Soaking as well as cooking at high temperature accelerated this process.

The results indicated that cooking of raw bamboo seeds had taken more time (20 min) for cooking than the soaked grains. Soaking the grains for 6 h reduced the cooking time to 10 min at 15 psi. Soaking the grains in hot water or for more than 12 h did not much reduce the cooking time. Hence, for further trials the bamboo seeds soaked for 6 h in potable water under ambient conditions were used.

Effect of bamboo seeds-water ratio on cooking quality

For proper cooking and consistency, ratio of bamboo seeds and water is important. Less water results in improper cooking and harder grains, whereas more water results in textural inconsistencies. Hence, a suitable ratio of bamboo seeds and water for cooking purpose needs to be optimized. The grains remained hard and uncooked for 200 and 300 mL water levels, whereas 400 mL water ratio resulted in proper cooking of grains as indicated by subjective analysis as well as the instrumental hardness value of less than 10 N (Table 4a). In order to reduce the cooking time, the grains were soaked for 6 h at ambient temperature before pressure cooking. Cooking time of 10 min at 15 psi with 200, 250 and 300 mL resulted in hardness of the grains as 17.68, 11.41 and 6.32 N, respectively (Table 4b). A water:bamboo seeds ratio of 300:100 g yielded a properly cooked grain when the 6 h- soaked seeds were used.

Result indicated that 6 h soaked grains required a minimum time of 10 min at 15 psi for complete cooking. For paddy rice, double the quantity of water is taken in pressure cooker and cooked at the maximum pressure for about three minutes and then allowed to cool[12].

Effect of jaggery on sensory acceptance

Jaggery is commonly employed as sweetener in several culinary dishes and sweet products. It contains less sucrose than cane sugar and also contains other nutritionally beneficial ingredients, hence some consumers prefer jaggery instead of sugar[30,31]. However, use of jaggery affects the appearance of the product making it darker. In many regions of the country, people are used to consume dark jaggery,

Table 4—Effect of bamboo seeds-water ratio on cooking quality of the seeds

Quantity of water per 100 g bamboo seeds (mL)	Time for cooking (min)	Cooking status	Hardness (N)
(a) Bamboo seeds - without soaking			
200	20	Not cooked	20.72
300	20	Less cooked	13.18
400	20	Cooked properly	7.46
(b) Bamboo seeds, soaked for 6 h in potable water			
200	10	Not cooked	17.68
250	10	Less cooked	11.41
300	10	Cooked properly	6.32

which is obtained from sugar cane made by traditional process. Since sweetness is an important factor in acceptance of *payasam*, amount of jaggery to be added was optimized.

It was observed that a difference of 50 g significantly affected sensory acceptance of the *payasam* (P<0.05) (Table 5). As jaggery levels increased, the sensory attributes of the *payasam* also improved, maximum being at 250 g level. The jaggery also affected the rheological quality of the *payasam*. However, the instrumental readings showed that as jaggery level increased within the range of levels used, the consistency increased slightly (7.182 to 7.224 N.sec). Viscosity index (VI) value increased from 0.184 N.sec for 150 g jaggery level to 0.242 N.sec for 250 g level (Table 5) indicating that the *payasam* became slightly viscous with enhanced jaggery content. Based on the sensory acceptance scores, a jaggery level of 250 g per kg *payasam* was optimized for obtaining most acceptable sensory attributes.

Effect of coconut milk on sensory acceptance

Coconut milk is commonly employed in various culinary items, including sweet products, in Kerala. It is also used in bamboo seeds *payasam* for getting typical coconut flavor. The fresh coconut extract is known to contain 25 % fat, 2.92 % protein, 0.78 % ash, 6.68 % SNF and 2.98 % carbohydrate[32]. Since the extent of coconut milk used varies widely, the optimum level in the *payasam* making has been optimised. The sensory evaluation results indicated that all the coconut extracts yielded an acceptable quality *payasam*. Use of 125 g level yielded maximum CA score. Use of 150 g probably had dilution effect which gave a CA score of 7.10. There was little effect of coconut milk level on the BT of the *payasam*. This is because coconut extract proteins contribute little to the body of the *payasam*. Flavour of the *payasam* was however, enhanced significantly by coconut extract. Table 6 indicates that incorporation of 125 g resulted in maximum flavor, but thereafter showed no further improvement. The sweetness of the *payasam* was not much influenced by the coconut extract indicated by the sweetness score ranging from 7.80–8.00. Overall results suggested that 100 or 125 g coconut milk could be recommended. The statistical analysis showed almost no significant difference between 100 and 125 g coconut milk, but 150 g level differed significantly, though the difference in actual magnitude was very little. Regarding the instrumental rheological measurements, not much difference was observed for the three levels of coconut milk used. (Table 6).

Effect of cow's milk on sensory acceptance

Cow's milk (CM), typically imparts milky flavor and enhances the overall *payasam* flavor, besides an acceptable consistency. Toned milk was used at three levels, viz. 100, 125 and 150 g/kg final product in order to determine the acceptable level to be used. The scores indicate that the CA was not significantly affected by the level of CM used, however, sample containing 125 g CM secured highest score (P<0.05) (Table 7). The lower score at 150 g CM was probably because of lighter colour obtained in the final product.

Table 5—Effect of jaggery level on sensory acceptance score* (max. 9.0) and rheological attributes of bamboo seeds *payasam*

	Jaggery level (g per kg *payasam*)		
	150	200	250
Sensory attribute			
Colour & appearance	7.00^{a}	7.50^{b}	8.10^{c}
Body & texture	7.10^{a}	7.50^{b}	7.80^{c}
Flavour	7.10^{a}	7.60^{b}	8.00^{c}
Sweetness	7.00^{a}	7.50^{b}	8.10^{c}
Overall acceptance	7.00^{a}	7.60^{b}	8.10^{c}
Rheological attribute			
Consistency(N.Sec)	7.182	7.215	7.224
Viscosity index(N.sec)	0.184	0.221	0.242

*Average of three 'replications'; Note: Mean values with different superscripts in a row are significantly different from each other (p<0.05)

Table 6—Effect of coconut milk level on sensory acceptance score* and rheological characteristics (max 9.0) of bamboo seeds *payasam*

	Coconut milk level (g/kg *payasam*)		
	100	125	150
Sensory attribute			
Colour & appearance	7.50^{b}	8.00^{c}	7.10^{a}
Body & texture	7.50^{a}	7.70^{b}	7.70^{b}
Flavour	7.70^{a}	8.05^{b}	8.05^{b}
Sweetness	8.00^{b}	8.00^{b}	7.80^{a}
Overall acceptance	8.05^{b}	8.05^{b}	7.80^{a}
Rheological attribute			
Consistency (N.Sec)	7.199	7.224	7.295
Viscosity index (N.sec)	0.202	0.242	0.296

*Average of four replications; Note: Mean values with different superscripts in a row are significantly different from each other (p<0.05)

There was an improvement in BT as indicated by the higher score of 7.70 for 125 g CM level compared to 7.50 for 100 g CM level. This could be attributed to the water binding ability of caseins present in milk. These scores differed significantly at $P<0.05$. The changing CM levels did not have much impact on the sweetness score (Table 7). Overall, it was observed that CM level of 125 g was the most acceptable and use of low or high quantity affected the quality of the *payasam* whose overall acceptance (OAA) scores differed significantly from each other ($P<0.05$).

Use of CM also influenced, though slightly, the instrumentally measured rheological characteristics. Though milk proteins are known to stabilize food systems and enhance consistency and viscosity[33], in this study they had little influence probably because of small differences in the experimental levels tried.

Effect of bamboo seeds on sensory acceptance

Payasam is relished by consumers not only because of its typical pleasant flavor but also because of typical textural quality. For example in vermicelli *payasam*, consumers like the smooth, softly chewy nature of the vermicelli. In cereal based *payasam*s, consumers enjoy chewing of grains along with the fluid in which the grains are dispersed. The chewing action will satisfy consumer's palate and also more flavour is expressed during chewing action. This is true for many *paysams* like *ada*, rice, wheat and beaten rice based *payasam*s. Similarly, bamboo seeds *payasam* also contains dispersed flakes of bamboo seeds, which are chewed during consumption. However, when taken in mouth consumers prefer an optimum amount of seeds to be chewed along with the fluid; an excess of or too little seeds do not satisfy the consumer's palate. Moreover, the amount of the seeds influences the consistency of the *payasam*. Hence, amount of bamboo seeds in *payasam* was optimised by using three levels namely 75, 100 and 125 g per kg of *payasam* (final product).

Table 8 summarises sensory evaluation of *payasam* samples which indicated that the acceptance was affected by the amount of bamboo seeds used ($P<0.05$). 100 g gave an optimum consistency to the product, whereas lower (75g) or higher (125 g) level resulted in lower scores, though within acceptable range. However, it was found that the flavor and sweetness of the *payasam* was not affected by the amount of bamboo seeds level whose scores did not differ statistically from each other ($P>0.05$) (Table 8). 100 g yielded maximum OAA score of 8.10 which was significantly higher than either 75 or 125 g of bamboo seeds for which the OAA scores were 7.80 and 7.90, respectively. Hence, a bamboo seeds level of 100 g per kg *payasam* was optimized.

Because of their interfering action, the presence of seeds in *payasam* affects the rheological properties, the higher their content, the higher the consistency values. (Table 8). As the seeds level increased, the resistance of the *payasam* to flow also probably increased, hence more consistency values were observed. Similar are the observations with *kheer* when increasing amounts of rice grains were used[34]. This is also because of more starch content that

Table 7—Effect of cow's milk level on sensory acceptance score* and rheological characteristics (max. 9.0) of bamboo seeds *payasam*

	Cow's milk level (g/kg *payasam*)		
	100	125	150
Sensory attribute			
Colour & appearance	7.20[a]	8.00[b]	7.30[a]
Body & texture	7.50[a]	7.70[b]	7.80[b]
Flavour	7.70[a]	7.90[b]	7.60[a]
Sweetness	7.80[a]	8.00[b]	7.80[a]
Overall acceptance	7.50[a]	8.00[c]	7.70[b]
Rheological attribute			
Consistency (N.Sec)	7.212	7.224	7.345
Viscosity index (N.sec)	0.238	0.246	0.251

*Average of four replications; Note: Mean values with different superscripts in a row are significantly different from each other ($p<0.05$)

Table 8—Effect of bamboo seeds level on sensory acceptance score* and rheological characteristics (max. 9.0) of bamboo seeds *payasam*

	Bamboo seeds level (g/kg *payasam*)		
	75	100	125
Sensory attribute			
Colour & appearance	7.50[a]	8.20[c]	7.70[b]
Body & texture	7.50[a]	8.00[c]	7.80[b]
Flavour	8.00[a]	8.00[a]	8.00[a]
Sweetness	8.20[a]	8.20[a]	8.10[a]
Overall acceptance	7.80[a]	8.10[b]	7.90[a]
Rheological attribute			
Consistency (N.Sec)	6.143	7.244	7.545
Viscosity index (N.sec)	0.198	0.266	0.351

*Average of four replications; Note: Mean values with different superscripts in a row are significantly different from each other ($p<0.05$)

dissolves into the liquid. The values were higher at higher seed level. The VI values represent the overall pull applied by the surface of *payasam* on the returning probe during the measurement. This may be attributed to the starch content of the bamboo seeds. Mitra and Nayak[35] reported a starch content of 72.91 % starch in bamboo seeds.

Standardized method of bamboo seeds *payasam* preparation

Based on the optimized parameters, the standardized method of bamboo seeds *payasam* preparation involved cleaning and washing of bamboo seeds, soaking 100 g seeds in excess of water for 6 h at ambient temperature, draining the water, addition of 300 mL of fresh water and pressure cooking at 15 psi for 10 min. The cooked grains were then mixed with 125 g of fresh coconut extract and 125 g toned milk. The jaggery syrup (250 g of jaggery was dissolved in equal amount of water and heated to a liquid syrup) was then added and the entire mixture was heated and desiccated to a final weight of about 1 kg. After cooling, the *payasam* was evaluated and its characteristics recorded.

Characteristics of *payasam* prepared by standardized method

Sensory quality

Sensory attributes of the *payasam* prepared by standardized method is given in Table 9a. It was creamy brown in colour and possessed thin, flowable consistency (Plate 1). The bamboo seeds were dispersed uniformly which gave a pleasant mouthfeel during chewing. The *payasam* also possessed a pleasant jaggery flavor. The OAA score of the product was above 8.00 which was in 'like very much' range.

Physico-chemical quality

The *payasam* had water activity value a_w of 0.92 with an acidity of 0.12 % expressed as lactic acid. Its pH was 6.01 and HMF content was 468.90 µmol/kg (Table 9b), which is an indication of extent of Maillard browning that has taken place during heat desiccation[36]. The crude fibre content of the *payasam*, which was mainly derived from bamboo seeds was 2.44 %. The colour of the product was creamy brown (light brown), which was reflected in reflectance value of 36.5 %; this value was comparable to that of market samples in which sugar was used as sweetening agent. The chemical composition of the *payasam* is given in Table 9b, which is comparable to other *payasam* samples[8].

Shelf life evaluation

Bamboo seeds *payasam* had a sugar content of about 20 % and an a_w of 0.92. It also contained nutrients in amounts sufficient for the growth of spoilage microorganisms as well as occurrence of spoilage reactions. The shelf life of the *payasam* was evaluated at normal temperatures i.e. 30 °C as well as under refrigerated conditions (5 °C) using two packaging materials viz. LDPE and metalised polyester.

Table 9—Sensory and physico-chemical characteristics of bamboo seeds *payasam* prepared by standardized method

(a) Sensory

Attributes	Description
Colour	Creamy brown in colour
Appearance	Bamboo seeds are dispersed uniformly
Body	Thin, flowable consistency
Texture	Chewy flakes
Flavour	Pleasant sweet jaggery flavour

(b) Physico-chemical

Parameter	Value	Parameter	Value
Water activity (a_w)	0.92 at 30°C	Total solids	38.75
% Reflectance	36.5	Fat	7.80
pH	6.01	Protein	4.96
Acidity	0.12 % LA	Lactose	0.56
HMF	468.90 µmol/kg	Sucrose	20.25
Crude fiber	2.44 %	Ash	0.84
		Other carbohydrates	4.34

HMF- Hydroxymethyl furfural

Plate 1—Ready-to-eat bamboo seeds payasam

Storage at 30 ℃

The initial scores of CA, BT, flavor, sweetness and OAA of the *payasam* were 8.00, 8.00, 8.00, 8.20 and 8.00, respectively. These scores remained almost the same after one day of storage, which did not differ significantly from the scores on zero day ($p>0.05$) (Fig.2 a). However, on second day the scores drastically and significantly decreased ($p<0.05$). This was because the *payasam* appeared thicker and slightly viscous with a visually observable separation of some liquid. This drastically reduced the CA score to 5.10. The BT score was 4.60 on the second day. Typical pleasant smell was lacking and accordingly lowest score was registered (5.10). As a result, the OA drastically reduced to 4.80 which was in dislike range. Similar results were obtained when the *payasam* was packed in metalised polyester pouch (Fig. 2b).

The initial acidity value of the *payasam* was 0.12 % LA which increased to 0.23 % LA (Fig. 3a) indicating that the product had become slightly sour. This was also reflected in the pH value which decreased from an initial value of 6.02 to 5.87 at the end of two days. The consistency and viscosity index values considerably increased during the two day storage. The initial consistency of 7.232 N.sec increased to a final value of 11.453 N.sec. The VI value initially was 0.231 N.sec which increased to 0.563 N.sec at the end of two days. Similar changes were recorded in *payasam* sample stored in metalised polyester pouches (Fig. 3b). These changes decreased the acceptance of the *payasam* after one day of storage at 30 ℃.

The changes in the sensory quality of the *payasam* may be attributed to the growth of microorganisms mainly yeasts, and certain chemical reactions. Similar

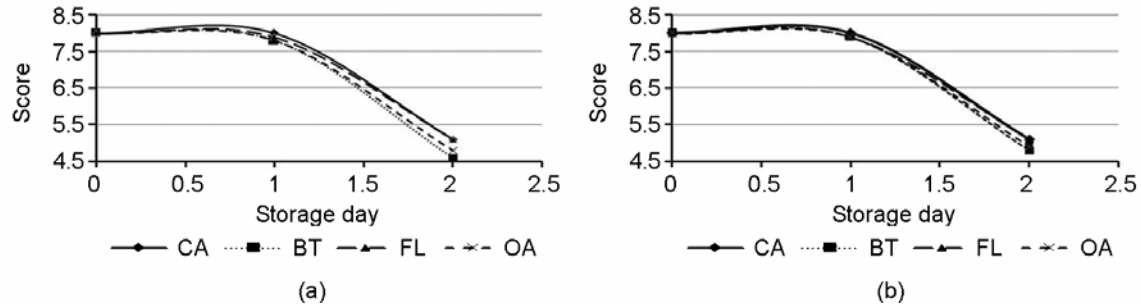

Fig. 2—Changes in sensory acceptance score of bamboo seeds payasam during storage at 30 °C (a) LDPE pouch (b) Metalised pouch (CA-Colour and appearance; BT-Body and texture; FL-Flavour; OA-Overall acceptance)

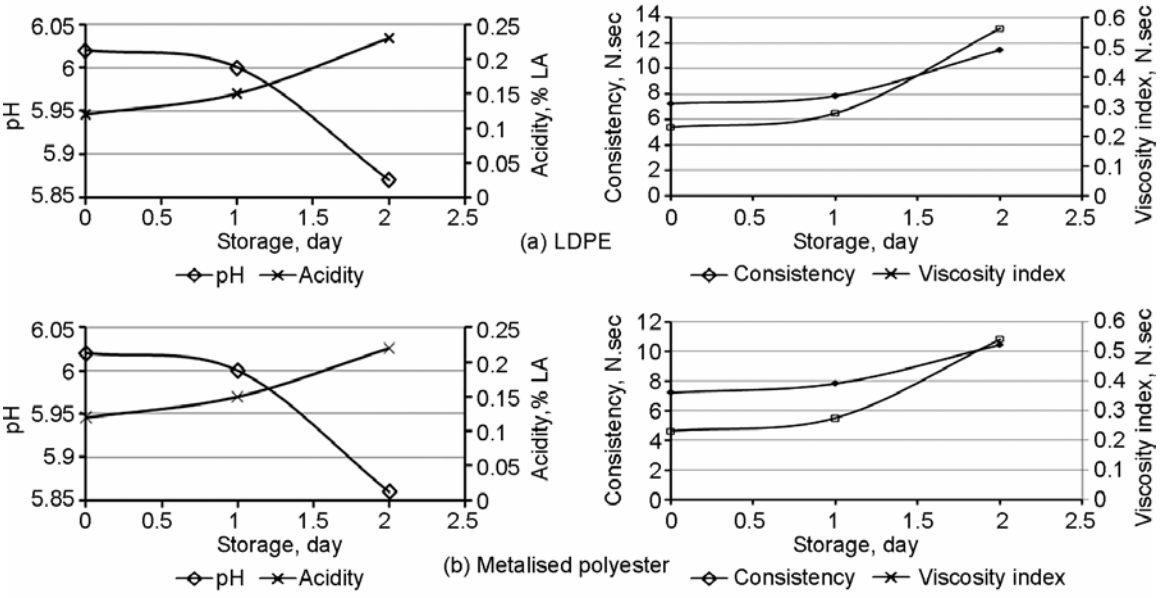

Fig. 3—Changes in physico-chemical characteristics of bamboo seeds *payasam* during storage at 30 °C

changes have been reported during the storage of other *payasam* varieties like poppy seeds *payasam*[37] and *palada paysam*[8]. It was observed that though the product did not display any offensive odor and flavor changes, there were physical changes like liquid separation, thickening and slight sliminess which drastically reduced the acceptance.

Storage at 5 °C

The results presented in Fig. 4a represent the changes in sensory score during storage at 5 °C in LDPE pouches. There was slight decrease in CA score from an initial value of 8.00 to 7.50 at the end of 15 days. However, till the end of 12 days, the decrease in CA score was not statistically significant (P>0.05), but thereafter there was a significant decrease, though within the acceptable range. Similar changes were noticed with body and texture of the product. This may be attributed to slightly thicker appearance and little liquid separation. There were also subtle changes noticed in BT quality, like viscosity related changes. With regard to flavor, it remained pleasant and acceptable till 12 days of storage (7.90-8.00), but thereafter registered a slight decrease (7.70) at the end of 15 days storage. Overall, there was no change in the score till a storage period of 9 days, but thereafter some change was perceived resulting in a minor slide in the score to 7.80, which further reduced to 7.70 that however was not statistically significant (P>0.05). The changes in the sensory acceptance scores were almost similar in the *payasam* that was packed and stored in metalised polyester (Fig. 4b). The range of scores demonstrated that there was no effect of type of packaging material

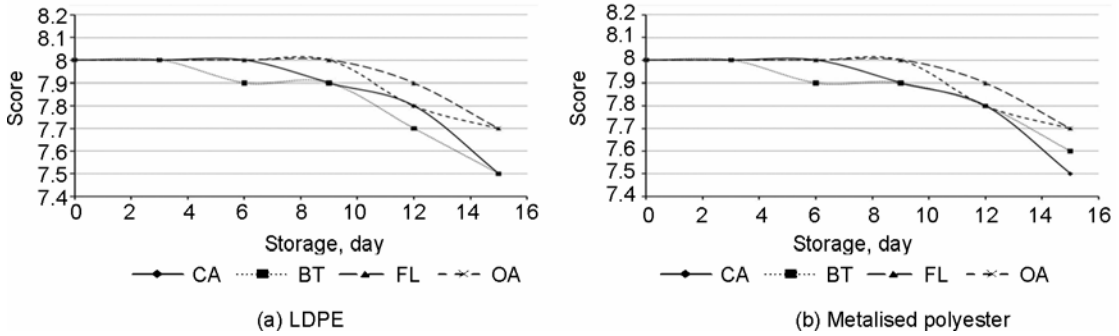

Fig. 4—Changes in sensory acceptance score of bamboo seeds payasam during storage at 5 °C (a) LDPE pouch (b) Metalised pouch (CA- Colour and appearance; BT-Body and texture; FL-Flavour; OA-Overall acceptance)

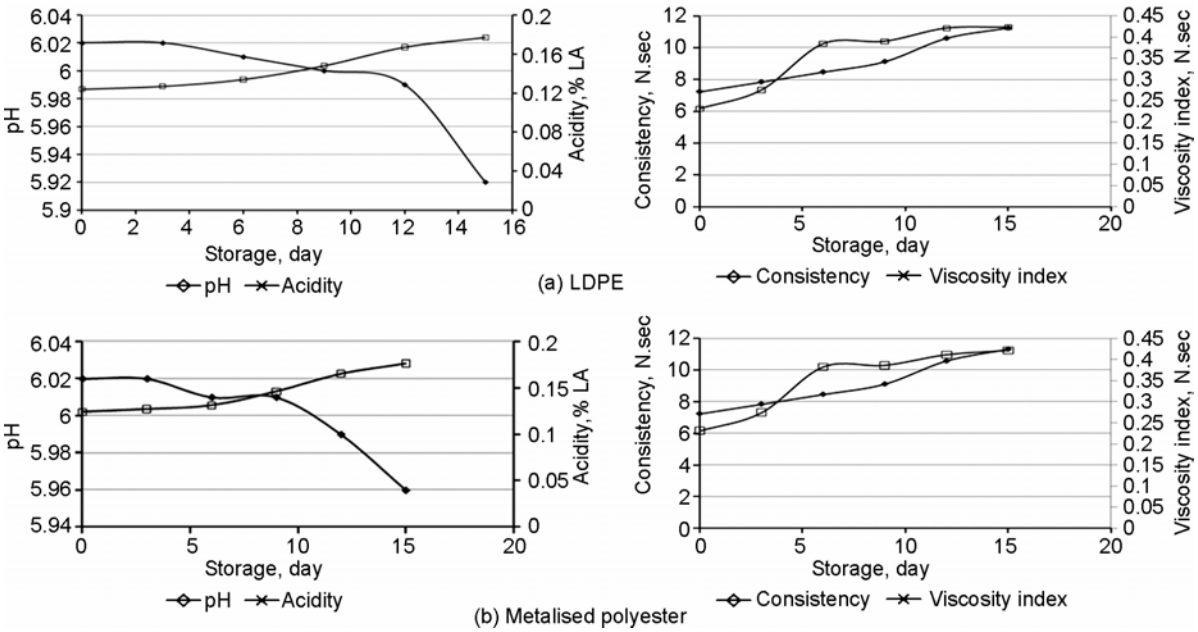

Fig. 5—Changes in physico-chemical characteristics of bamboo seeds *payasam* during storage at 5 °C

on the changes in sensory quality during storage period of up to at 30 or 5 °C. However, beyond 15 days of storage, significant changes may be expected to take place.

Concerning the physico-chemical quality, such changes were noticed in the product stored in LDPE as well as metalised polyester. The initial acidity was 0.124 % LA which increased to 0.177 % LA at the end of 15 days (Fig. 5a). pH of the *payasam* declined from zero day value of 6.02 to 5.92 at the end of the storage period. The storage however was not continued beyond 15 days at 5 °C. The rheological parameters indicated that the *payasam* became thicker and viscous during storage at 5 °C. The initial consistency value of the *payasam* was 7.232 N.sec which increased to 11.234 N.sec at the end of storage. Viscosity index increased from zero day value of 0.231 N.sec to a final value of 0.421 N.sec at the end of 15 days. These changes were similar to those observed at 30 °C storage. The changes were on similar lines even in metalized polyester packaging (Fig. 5b). It may be observed that the changes during storage at 5 °C were slower than at 30 °C. The results are in agreement with Geeta[37] who reported similar thickening and viscosity related changes in poppy seeds *payasam* which they attributed to chemical reactions and conformational changes in proteins.

Conclusion

A method of preparation of bamboo seeds *payasam* has been standardized which could be adopted by the industry for commercial purpose. Quantities of ingredients viz. bamboo seeds, jaggery, coconut extract, milk and water were also optimized. The shelf life of the *payasam* packed in metalized polyester pouch was observed to be 1-2 days at 30 °C and more than 15 days at 5 °C. There is a scope for enhancement of shelf life of bamboo seeds *payasam* by processes such as retort processing.

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