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RESEARCH PAPER

Development of proso millet (*Panicum miliaceum*) incorporated pudding mix

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Abstract: Pudding is a dessert mostly consumed after the main course of the meal, generally prepared with corn starch, sugar, milk and egg. The study was conducted to develop proso millet (*Panicum miliaceum*) based pudding mix. The proso millet grains were polished for 40 sec and starches were extracted by chemical, sedimentation and traditional methods. Physical properties of starches were determined. The pudding mix was prepared with variation in starch and milk powder.The results showed that polished proso millet grains showed lower thousand grain weight (3.69 g) and volume (5.00 ml) than raw. Starch extracted by traditional method yielded higher yield (88.50%) than other methods with color value of L* (69.008), a* (0.183) and b* (28.548). Pudding developed with proso millet starch and milk powder at the ratio of 50:50 received higher acceptability index of 85.74 per cent and was liked very much by panelist. Starch extracted with sedimentation method and milk powder in equal proportion was highly accepted than corn starch and other proso millet starches. Proso millet can be used for the preparation of pudding (dessert) with less processing. The acceptability of proso millet pudding was more than corn starch pudding.

Key words: Dessert, Proso millet, Pudding, Starch extraction

Introduction

Pudding is sweet dessert with relatively soft and thick textural characteristics. Various colors and flavors used and shaped in different patterns appeals large number of populations. Thus, it has been a popular dessert since many years in western countries. Traditionally pudding is considered as wholesome and nutritious food which results in improving nutritional status of the family and enables household to spend less on junk food. Pudding provides high calorie, which is helpful in malnourished population. Those with a desire of reducing their calorie intake, fat-free or sugar-free pudding presents better alternate with use of fat replacers. Low-fat or fat-free pudding yield same taste and texture as full-fat pudding (Weaver *et al.*,1987).

Millets are small sized grains having 1000 grain weight of 2.64 to 36.94 g. Small grains having huge benefits in terms of nutritional and health aspect, millets contain 50-70 g starch per 100 g (dry weight basis), with amylose content of 25- 30 per cent and amylopectin 70-75 per cent, respectively. Amylose and amylopectin in starch gel facilitate strength and viscosity respectively. Millets also contain phytochemicals, micronutrients and are rich source of dietary fiber and millets are easy to digest (Thilagavathi *et al.*, 2015). They help in preventing age-related lifestyle disorders like diabetes and cardiovascular disease, also beneficial in lowering blood pressure and cholesterol.

Millets have dual advantages of health and nutraceutical benefits besides utility in food preparations. Proso millet is oldest cultivated millet and important minor crop in India. Proso millet rich in iron (1.54 mg), calcium (14.76 mg), manganese (146.51 mg) provides protein and vitamins where the demand is high (Bora and Das, 2018). Proso millet contains comparable protein (11 g/100 g) as wheat but has higher share of essential amino acids *viz.* methionine, tryptophan, valine and phenylalanine (Das *etal.*, 2019). Proso millet energy value is as good as most exploited cereals like rice, barley and wheat.

Nowadays, it is the era of convenience, as women are working and involved in remunerative jobs, thus, not finding enough time to spend in the kitchen. At the same time, it is their concern to provide variety and healthy diet to their families. Due to westernization consumption of processed foods, bakery foods are escalating in India while traditional foods are occupying back seat. Under such circumstances, present study was attempted to replace corn starch used in pudding with proso millet starches. The study concentrated on the development of proso millet-based pudding mix so as to offer convenience to housewives and to provide healthy desserts to their families.

Material and methods

Procurement of proso millet and other ingredients

The proso millet (*Panicum miliaceum*) grains, skim milk powder and sugar were procured from local market of Dharwad. Care was taken to purchase ingredients in one lot in the year 2019.

Physical properties of proso millets

Thousand grain weight

Three sets of 1000 intact grains were selected randomly. Weight of selected grains was recorded in triplicates using electronic weighing balance (Semsung). The mean weight was expressed in g/1000 grains.

Volume

The volume of unpolished millet grains was measured by water displacement method (Mishra and Gupta, 1995).

Bulk density

Bulk density was calculated from weight and volume of unpolished millet grains as follows

$$\text{Bulk density (g/ml)} = \frac{Weight\ of\ unpolished\ grains\ (g)}{Volume\ of\ unpolished\ grains(ml)}$$

Color of proso millet grains

Unpolished millet samples were selected randomly in triplicates and were packed in transparent plastic pouches and subjected to color assessment separately in Konica Minolta spectrophotometer of model CM 2600/2500d. The color was assessed in chromatic components of L* (black to white), a* (redness to greenness) and b* (yellowness to blueness).

Polishing of grains

The proso millet grains were polished in grain polisher for 20, 40, 60 and 80 seconds separately to increase the yield of the extracted starch. After polishing of proso millet, the physical properties and color of selected polished grains were determined. For further processing the grains were washed under running water and dried at 60ºC for three hours.

Starch extraction

Starch was extracted by three different methods *viz.*, chemical, sedimentation and traditional method.

Chemical method

Starch was extracted with some modification in method given by Wu et al. (2014). Polished proso millet was weighed (200 g each) separately and were steeped in twice the volume of grains in 0.2 % NaOH solution (W/V) for 24 hours at 4-6 ºC. Soak solution was discarded and grains ground with distilled water. Slurry was sieved through 300 BSS Sieve and allowed for sedimentation at 4-6 ºC for 3 hours. Supernatant was discarded and sediments washed with 0.5 per cent SDS (Sodium Dodecyl Sulphate) and distilled water. The obtained starch was dried in hot air oven at 40 ºC.

Sedimentation Method

Starch isolation method given by Suma and Urooj (2015) was modified and used. Polished proso millet grains were weighed (150 g each), cleaned and washed. Millets were soaked overnight in 1:2 (W/V) ratio of water at 4-6 ºC. Soaked water was discarded and millets were made into slurry and passed through 150 BSS mesh sieve. The obtained slurry was kept for sedimentation for about three hours. Supernatant was discarded and obtained starch was dried in hot air oven at 40 ºC and powdered.

Traditional Method

Polished proso millet grains were milled in commercial electrical roller mill and made into flour. The flour was sieved through 60 and 85 BSS to obtain fine flour rich in starch.

Physical properties of starch extracted by different methods

Yield of starch

The starch obtained by all three methods (chemical, sedimentation and traditional) were weighed using digital weighing balance (accuracy of ±1 mg) to find out the yield. Starch yield was calculated as follows

$$\text{Per cent yield (\%)} = \frac{Weight\ of\ extracted\ dried\ starch\ (g)}{Weight\ of\ polished\ grains\ (g)} \times 100$$

Color of starch

The color of starch was assessed by following the procedures employed for estimating color of millet grains.

Volume

Volume of starch was measured by taking known weight of starch into a measuring cylinder and continuously tapping while pouring it into a measuring cylinder to avoid any empty space. The volume was measured after tapping sufficiently to settle the starch without any air spaces.

Bulk density

Bulk density of the starch was estimated using starch weight and volume.

Development of millet pudding mix

Trials were undertaken to prepare pudding mix with millet starch as a base ingredient and other ingredients like sweetener (sugar) and skim milk powder. Corn starch with other ingredients was used as control. Pudding mix was developed with proso millet starches extracted by three different methods.

Preparation of pudding

One serving (30 g) of pudding was prepared by adding proso millet pudding mix (11g) containing starch and milk powder; and sugar (12 g) in water (80 ml) and cooked for five minutes till desired consistency was obtained. The paste was poured into mold and refrigerated for 20-25 min., later unmolded for sensory evaluation.

Sensory evaluation

The sensory evaluation was carried out with ten trained panelists on a 9-point hedonic scale for parameters such as appearance, color, flavor, taste, texture and overall acceptability (Peryam and Girardot, 1952). Acceptability index was calculated totaling the scores obtained and converting to percentage.

Results and discussion

Physical parameters of millet grains

Physical parameters (thousand grain weight and volume) of unpolished proso millet were 3.72 g and 7.03 ml respectively with bulk density of 0.52 g/ml. Thousand grain weight and volume of polished proso millet were 3.69 g and 5.00 ml, respectively and bulk density was 0.75 g/ml. It is natural that dehulling and debranning results in removal of outer bran thus recording lower 1000 grain weight and volume than raw millet grains (Table 1). Bora and Das (2018) also reported that dehusked and polished grains had lower values than whole proso millet grains.

Color of millet grains

The color (L*a*b*) value of millets grains as raw unpolished grains and polished grains at various time of processing (20, 40, 60 and 80 seconds) are depicted in Table 2. The color value of raw, unpolished proso millet was L* (76.363) a* (5.403)

b* (32.300), respectively. After every polishing the color value for proso millet was lighter than first polished grains and was L* (76.743, 79.713, 81.523 & 80.426) a* (5.186, 5.313, 5.230 & 5.166) b* (31.243, 32.699, 34.326 & 32.933) i.e. lighter, and yellower than unpolished millet. As mentioned by Bora and Das (2018) and result obtained in present study, the lightness and yellowness observed were higher in polished grains compared to whole millet grains.

Physical parameters of millet starch

The physical properties of starches including weight, volume, color etc., indicates the characteristics of starches which helps to decide their usability. Table 3 indicates the physical properties of proso millet starches isolated from three different methods. Proso millet grains polished for 40 seconds were considered for starch extraction due to removal of outer layer of grains and high yield after polishing. Physical properties are supplementary factors which influence product processing. The starch yield from sedimentation (80.00 %) and traditional method (88.50 %) was significantly higher than chemical method (69.00 %). This may be reasoned to lower processing and more recovery of 'not so pure' starch in traditional method. Percent volume of proso millet starch in chemical, sedimentation and traditional methods was 56.00, 62.33 and 51.33 ml/100 g respectively. Bulk density for chemical, sedimentation and traditional methods were 1.78, 1.60 and 1.52 g/ml, respectively. The color values of proso millet starch were L* (72.537, 75.150 & 69.008) a* (-2.524, -12.522 & 0.183) and b* (25.934, -0.700 & 28.548) for chemical, sedimentation and traditional method respectively. Proso millet starch showed higher yellowness (Table 3) when extracted by chemical, sedimentation and traditional method due the presence of carotenoid pigments (lutein and zeaxanthin) and may be other non-starch compounds like fat, protein *etc.*

Table 1. Physical properties of raw and polished proso millets

Parameter	Raw	Polished	*t* test
Thousand grain weight (g)	3.72±0.01	3.69±0.01	5.19*
Thousand grain volume (ml)	7.03±0.05	5.00±1.00	NS
Bulk density (g/ml)	0.52±0.00	0.75±0.15	NS

*Significance at 5% level, NS- Non-significant,
Figures indicated mean ± SD.

Table 2. Effect of polishing on color of proso millet grains

Parameter	Polishing (Sec)							
	0	20	40	60	80	F value	SEm±	CD
L*	76.363±0.00	76.743±0.00	79.713±0.01	81.523±0.00	80.426±0.01	138609	0.00	0.01*
a*	4.736±0.01	5.186±0.00	5.313±0.00	5.230±0.01	5.166±0.00	0.55	0.30	NS
b*	32.300±0.01	31.243±0.01	32.699±0.00	34.326±0.00	32.993±0.00	56962	1.49	4.69*

*Significance at 5% level, NS- Non-significant, Figures indicated mean ± SD.

Table 3. Physical properties of millet starch extracted by different methods

Parameter	Chemical	Sedimentation	Traditional	F value	SEm±	CD
Yield of starch (%)	69.00±0.10	80.00±1.73	88.50±1.00 [a]	184.969	0.60	2.08*
Volume (ml/100 g)	56.00±1.00	62.33±0.57	51.33±0.57	122.6	0.43	1.48*
Bulk density (g/ml)	1.78±0.03	1.60±0.01	1.52±0.01	117.17	0.01	0.04*
Color of starch						
L*	72.537±0.11	75.150±0.28	69.008±0.37	1603	0.10	0.36*
a*	-2.524±0.02	-12.522±0.22	0.183±0.12	2430	0.11	0.38*
b*	25.934±0.01	-0.700±0.46	28.548±0.08	10666.4	0.15	0.54*

*Significance at 5% level, NS- Non-significant, Figures indicated mean ± SD.

Table 4. Organoleptic scores of proso millet puddings with 20 per cent milk powder[#]

CS:PMS:MP	Sensory parameters						
	Appearance	Color	Flavor	Taste	Texture	Overall acceptability	Acceptability Index
10:70:20	7.1±0.73	7.5±0.84	6.7±0.94	7.2±1.03	6.7±0.82	7.6±0.96 [a]	79.25
30:50:20	6.5±0.52	7.2±1.03	6.7±0.94	6.7±0.48	6.9±0.73	6.7±0.67 [b]	75.37
50:30:20	6.9±1.10	7.3±0.94	7.3±0.67	7.2±1.13	7.0±1.05	6.9±0.87 [ab]	78.88
70:10:20	7.2±0.91	7.5±1.08	7.1±0.99	7.4±0.84	6.8±1.03	7.5±1.08 [ab]	80.55
F value	1.33	0.23	1.11	1.08	0.19	2.35	
S.Em.±	0.26	0.30	0.28	0.28	0.29	0.28	
C.D.	NS	NS	NS	NS	NS	0.82	

#- Starch extracted employing traditional method, CS- Corn starch, PMS- Proso millet starch, MP- Milk powder. Sugar- 115 per cent of total mix.
NS- Non-significant, Figures indicated mean ± SD.

Development of millet pudding mix

Table 4, 5 and 6 shows different combinations of corn starch to proso millet starch with constant level of milk powder 20, 30 and 50 per cent, respectively.

In Table 4 with 20 per cent skim milk powder, there was no significant difference in sensory parameters except overall acceptability. Higher acceptability scores of 7.6 and 7.5 were received by 10:70:20 and 70:10:20 ratio of corn starch: proso millet starch: milk powder. The lower score of 6.7 was obtained by 30:50:20 of corn starch: proso millet starch: milk powder. At 20 per cent milk powder pudding showed tough texture and received lower scores. This may be due to the fact thatmilk protein and fat chains help to provide strong network in starch-milk system, 20 per cent level of dry milk was probably insufficient to create firm pudding and also may not have been sufficient to provide smooth rich creamy texture, taste and good mouthfeel. According to Dickson (2003) textural property of pudding mainly depends upon starch, having capacity to absorb large amounts of water; it acts as a gelling agent with water holding and thickening capacity. In pudding, texture plays important role in consumer acceptability (Elmore *et al.*, 1999) as retention of shape is a criteria in consumer preference.

Table 5 indicates higher and significant scores for appearance, taste and overall acceptability. Significantly higher scores for appearance (8.1) were received when proso millet starch was blended with skim milk powder in the ratio of 70:30. This combination registered higher acceptability index of 84.44 per cent. The combination of 35 per cent corn starch, 35 per cent proso millet starch with 30 per cent milk powder received significantly higher scores for taste (8.1). Whereas, 70 per cent corn starch and 30 per cent milk powder was least accepted with acceptability index of 79.07 per cent. At 30 per cent of milk powder the acceptability of pudding increased than puddings with 20 per cent of milk powder. This may be due to strong network between starch and milk system.

Table 6 shows the variation with 50 per cent milk powder. The sensory scores indicated that color, flavor, taste, texture and overall acceptability did not differ significantly with variation in starch. Acceptability indices were on par with each other. Surprisingly, 50 per cent milk powder with 50 per cent proso millet starch received better acceptance by panel of judges. The appearance of 50 per cent proso millet starch and 50 per cent milk powder pudding was scored between like very much and like extremely (8.3), which was significantly higher than 25:25:50 and 50:0:50 proportion of corn starch: proso millet starch: skim milk powder.This may be due to the fact that interactions between the food ingredients (corn starch, millet starch and skim milk powder) with different ratios plays important role in determining sensory parameters (Garcia *et al.*, 2015). Nevertheless, the acceptability index did not vary profusely and was above 80 per cent indicating that pudding with 50 per cent milk powder and either corn starch or proso millet starch was equally acceptable. Among the three levels of milk powder (Table 5, 6 and 7), 50 per cent was highly accepted with acceptability index of 85.74 per cent.

Hence, starches extracted with three different methods were tried for pudding mix preparation. Sensory scores of puddings prepared with different starches (corn starch and proso millet

Table 5. Organoleptic scores of proso millet puddings with 30 per cent milk powder#

CS:PMS:MP	Sensory parameters						
	Appearance	Color	Flavor	Taste	Texture	Overall acceptability	Acceptability Index
00:70:30	8.1±0.56[a]	7.6±1.42	7.2±1.22	7.6±0.69[ab]	7.4±1.34	7.7±0.82 [a]	84.44
35:35:30	7.0±0.94 [b]	7.6±1.17	7.4±1.34	8.1±0.87[a]	6.9±1.10	7.7±0.82 [a]	82.77
70:00:30	7.4±0.84 [ab]	7.3±0.67	7.0±0.66	7.0±0.66[b]	7.3±0.48	6.7±0.48 [b]	79.07
F value	4.83	0.23	0.31	5.35	0.64	6.29	
S.Em.±	0.25	0.35	0.35	0.23	0.32	0.23	
C.D.	0.73*	NS	NS	0.68*	NS	0.66**	

Table 6. Organoleptic scores of proso millet puddings with 50 per cent milk powder#

CS:PMS:MP	Sensory parameters						
	Appearance	Color	Flavor	Taste	Texture	Overall acceptability	Acceptability Index
00:50:50	8.3±0.67 [a]	8.1±1.28	7.1±1.52	7.5±1.64	7.6±1.17	7.7±1.05	85.74
25:25:50	7.9±0.87 [ab]	7.7±1.15	7.1±1.28	7.3±1.33	7.5±1.35	7.4±0.96	83.14
50:00:50	7.5±0.70 [b]	8.1±0.56	8.0±0.66	7.7±0.94	7.0±1.49	7.9±0.87	85.55
F value	2.78	0.48	1.83	0.22	0.57	0.67	
S.Em.±	0.23	0.33	0.38	0.42	0.42	0.30	
C.D.	0.69	NS	NS	NS	NS	NS	

#- Starch extracted employing traditional method, CS- Corn starch, PMS- Proso millet starch, MP- Milk powder. Sugar- 115 per cent of total mix.
NS- Non-significant, Figures indicated mean ± SD

Table 7. Organoleptic scores of puddings with starches extracted by different methods

CS:PMS:MP	Sensory parameters						
	Appearance	Color	Flavor	Taste	Texture	Overall acceptability	Acceptability Index
Corn starch	7.7 ± 0.67[a]	7.6 ± 0.84[a]	8.1 ± 0.87[a]	7.9 ± 0.87[a]	7.8 ± 1.03[a]	7.9 ± 0.73[a]	87.03
CM	6.7 ± 0.67[b]	6.8 ± 0.78[ab]	6.7 ± 0.67[b]	6.1 ± 0.56[c]	6.8 ± 0.78[b]	6.4 ± 0.84[c]	73.14
SM	7.3 ± 0.48[ab]	7.3 ± 0.94[a]	7.1 ± 1.19[b]	7.1 ± 0.87[ab]	7.5 ± 0.70[ab]	7.3 ± 0.48[ab]	80.74
TD	6.8 ± 1.13[b]	6.2 ± 1.39[b]	6.9 ± 0.99[b]	6.4 ± 1.17[bc]	6.9 ± 0.73[b]	6.9 ± 1.28[bc]	74.25
F value	3.54	3.58	4.24	7.94	3.36	5.12	
S.Em.±	0.45	0.59	0.55	0.51	0.47	0.51	
C.D.	0.45*	0.59*	0.55*	0.51**	0.47*	0.51**	

Starch:Milk powder-50:50, CM-Chemical method, SM-Sedimentation method,
TD-Traditional method. *Significant at 5% level, NS- Non-significant, Figures indicated mean ± SD.

starches isolated with chemical, sedimentation and traditional method) was given in Table 7. Pudding prepared with different starches indicated significant difference with higher values for appearance (7.7), color (7.6), flavor (8.1), taste (7.9), texture (7.8) and overall acceptability (7.9) of corn starch pudding. Proso millet possesses typical taste and nutty flavor (Brink and Belay, 2006) that probably is not accepted in pudding by Indian palate. Acceptability index of pudding prepared with corn starch was higher (87.03) and lowest was (73.14 %) in pudding with proso millet starch obtained by chemical method. Proso millet chemical method starch pudding tares apart from the middle, may be due to the syneresis of the pudding. This higher syneresis can be attributed to modification of starch during chemical treatment and probable leaching of fat and soluble proteins. However, the pudding prepared with proso millet starch extracted by sedimentation method was acceptable with acceptability index of 80 per cent.

Conclusion

The study indicated that different methods can be used to extract starch from minor millet i.e. proso millet depending on final use. Proso millet has potential for development of pudding mix with promising functionality and acceptability. The pudding with 50:50, proso millet starch: skim milk powder was prepared for children and can be consumed by adult and elderly persons. By using millet, novel products can be prepared such as pudding. The acceptance may further be improved by using additives, nuts, flavors and colors.

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