J. Farm Sci., 33(4) : (531-535) 2020

RESEARCH PAPER

Development and evaluation of foxtail millet [*Setaria italica* (L.)] based custard powder mix

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(Received: October, 2020 ; Accepted: December, 2020)

Abstract: Millets are small seeded grains gaining prime importance because of their high nutritional value. Foxtail millet possess nutritional value higher than rice, two times rich in protein, three times rich in calcium and four times rich in minerals and fat. Millets have a renowned potential for processing, so the starch from foxtail millet grains extracted by three different methods namely chemical, sedimentation and traditional methods. The percent yield of the starch in chemical, sedimentation and traditional methods from foxtail millet were 44.5, 48.83 and 80.66 per cent, respectively, which was significantly higher in traditional method of starch extraction. Starch extracted from chemical method showed significantly higher volume (8.76 ml/5g) and lower bulk density (0.57 g/ml) compared to other two methods of starch extraction. The L*a*b* values for starch extracted from chemical, sedimentation and traditional methods were 71.82, -0.07 & 24.11, 69.28, 3.15 & 26.33 and 68.86, 3.20 & 30.13, respectively. Custard incorporated with 90 per cent of foxtail millet starch extracted from traditional method of starch extraction obtained highest score for appearance (7.75), colour (7.67), flavour (7.25), taste (7.50), texture (7.33) and overall acceptability (7.42) with acceptability index of 83.18 per cent. Among the custards prepared from the starch extracted from different methods of starch extraction, custard with starch obtained from traditional method scored 7.17 for appearance, 7.13 for colour, 7.24 for flavour, 7.25 for taste, 7.27 for consistency and 7.17 for overall acceptability. Computed nutrients of developed mix contained 13.07 g, 5.82 g, 7.2 g, 59.81 g and 3.34 g per 100 g of protein, fat, crude fibre, carbohydrate and ash respectively, it had energy value of 303 Kcal. The calcium content was 84.72 mg and iron content was 2.52 mg/100 g.

Key words: Foxtail millet, Custard powder mix, Siridhanya, Starch extraction

Introduction

Millets are small seeded grains which are cultivated as cereals. They are also called as coarse cereals, miscellaneous cereals, nutri-cereals and *siridhanya.* Millets are gaining key importance because of their high nutritional value. Millets are gluten-free and are non allergic (Wu *et al.,* 2014). The increased utilization of millets is due to various "rediscovered" health benefits and critical role in food security. Some of the promising health benefits of millets are helping in prevention of cardiovascular disease, cancer, risk of heart disease, delaying gastric emptying and managing diabetes (Saleh *et al.,* 2013). Millets are rich source of phytochemicals like polyphenols, phytosterols, phyto-oestrogens, lignans and phytocyanins which functions as antioxidants, immune modulators, detoxifying agents which protects against age related degenerative diseases (Rao *et al.,* 2011). Many products like cookies, biscuits, flakes and *laddos* are developed from foxtail millet.

Custard is a carbohydrate rich breakfast or dessert consumed by wide variety of population (Awoyale *et al.,* 2017). As it is rich in calories, can also serve as a supplement to the infants and as choice of food for sick. Custards are fine textured foods prepared from corn starch, salt, colouring and flavouring agents with or without the addition of egg yolk solids, vitamins and minerals (Okoye *et al.,* 2008). Many products like cookies, biscuits, flakes and *laddos* are developed from foxtail millet. Many non-corn starches like tubers, pulses and cereals were tried in the preparation of custard powder. Though few studies have been carried out to isolate starch from millets and using them in different preparations, custard powder mix from foxtail millets has not been investigated. Further, many housewives are in need of quick cooking products. Hence, the present investigation was carried out with the objective to develop and evaluate foxtail millet based custard powder mix.

Material and methods

Procurement of raw material

Foxtail millet and other ingredients were procured from local market of Dharwad. Care was taken to purchase ingredients of same brand and quality throughout the study.

Millet starch extraction

Chemical method

Foxtail millet was weighed and steeped in 0.2% NaOH solution (W/V) for 24 hours at 4-6^{0}C. Solution was decanted, grains were washed with distilled water and made into slurry. Slurry was sieved through different sized meshes and allowed for sedimentation at 4-6^{0}C for about 12 hours. Supernatant was discarded and sediments were washed with 0.2% NaOH and 0.5% sodium dodecyl sulfate. Obtained starch was dried in hot air oven at 40^{0}C until it was completely dried (Wu *et al.,* 2014).

Sedimentation method

Foxtail millet was soaked in water (1:2 W/V) overnight. Water was discarded and again washed with water and made into slurry and screened through 150 mesh standard sieve. Residue discarded and slurry was kept for sedimentation for three hours. The supernatant was decanted without disturbing starch and obtained starch was dried in hot air oven at 40^{0}C (Suma and Urooj, 2015).

Traditional method

Foxtail millet milled into fine flour in commercial electrical roller mill and sieved through 60 mesh sieve and fine flour rich in starch was obtained.

Physical properties of foxtail millet starch

Yield of starch

The starch obtained was weighed using electronic weighing balance to calculate the yield.

Starch yield was calculated using the formula

$$\text{Yield (\%)} = \frac{\text{Weight of dried starch}}{\text{Weight of grains}} \times 100$$

Color of starch

Colour of foxtail millet starches 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).

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.

Bulk density

Bulk density of starch was calculated from the weight and volume as follows,

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

Development of custard powder mix

The foxtail millet starch (FMS) extracted from traditional method mixed with corn starch (CS) and whole milk powder (MP) in different proportions (FMS:CS:MP = 45:45:10, 55:35:10, 65:25:10, 75:15:10, 85:05:10 and 90:00:10). Best accepted formulation was tried with starch extracted from different methods and final formulation was added with colouring and flavouring agents (vanilla) and mixed thoroughly.

Preparation of custard

Foxtail millet custard powder mix (10 g) was added to 50 ml of water and made into slurry. Prepared slurry was added to boiling milk (100 ml) slowly along with sugar (10 g) and stirred continuously to avoid formation of lumps. The mix was cooked for three min, to obtain required consistency. Prepared custard was rested in refrigerator for cooling and then served for sensory evaluation after cooling.

Sensory evaluation of custard mix

The prepared custard was subjected to sensory evaluation using trained panel of 12 judges using nine point hedonic scale. Acceptability index was calculated employing the formula

$$\text{Acceptability Index} = \frac{\text{Sum of scores of appearance, colour, flavour, taste, colour and overall acceptability}}{54} \times 100$$

Nutrient composition

The nutritive value was computed using the nutritive value of Indian foods by Gopalan *et al.* (1989)

Statistical analysis

Mean and Standard deviation was used for physical parameters of the starch. Data obtained for organoleptic evaluation of foxtail millet based custard powder mix was subjected to one way ANOVA using SPSS (version 23).

Results and discussion

Physical parameters of foxtail millet starches

The physical parameters of the foxtail millet starch obtained from different methods are presented in Table 1. The per cent yield of the starch in chemical, sedimentation and traditional methods from foxtail millet were 44.5, 48.83 and 80.66 per cent respectively. The yield of the starch was significantly higher in traditional method of extraction compared to other two methods. The variation in the purification and isolation of the starch (Suma and Urooj, 2015) and also reduced pre-treatments and processing methods while extracting the starch may be responsible for this higher yield in traditional method of starch extraction. Higher yield of the starch becomes main determinant in preference of starch in industrial level. Per cent volume of the foxtail millet starch was significantly higher when extracted with chemical (8.76 ml/5 g) and traditional methods (8.15 ml/5 g) and was significantly lower in sedimentation method (7.56 ml/5 g). The volume of the starches obtained from various methods were statistically different.

The bulk densities were 0.57, 0.66 and 0.61 g/ml for foxtail millet starch when extracted by chemical, sedimentation and traditional methods, respectively. The differences in bulk density for foxtail millet starches obtained from three methods were statistically significant. The variation in bulk density may be due to method of starch extraction, differences in moisture content, regularity in shape of starch granules and particle density.These results were in accordance with the bulk density of starch extracted by pearl millet (Abdalla *et al.,* 2009).

Table 1. Physical properties# of foxtail millet starch extracted by different methods

Parameters	Chemical method	Sedimentation method	Traditional method
Yield (%)	44.5± 0.50	48.83 ±0.28	80.66± 0.57
Volume (ml/5g)	8.76 ± 0.03	7.56± 0.02	8.15±0.02
Bulk density (g/ml)	0.57±0.00	0.66±0.00	0.61±0.00
Colour			
L*	71.82±0.14	69.28 ±1.39	68.86±0.31
a*	-0.07±0.52	3.15±0.37	3.20±0.36
b*	24.11±0.21	26.33±0.00	30.13±1.39

- Mean ± SD

Respective L* a* b* values for foxtail millet starch extracted from chemical, sedimentation and traditional methods were 71.82, -0.07 & 24.11; 69.28, 3.15 & 26.33 and 68.86, 3.20 & 30.13 indicating that starch extracted from chemical method was lighter and yellower than other two starches.This may be due to pure starch obtained from chemical method andstarches exhibit different colours owing to different treatments while extracting.

Sensory evaluation of foxtail millet based custard

Level of replacement of corn starch with foxtail millet starch in the custard powder was experimented and the results are presented in Table 2 and fig 1. Results showed that the control sample (commercial mix) received significantly higher sensory scores for all the parameters (8.25 for appearance and colour, 8.00 for flavour, 8.08 for taste, 7.83 for consistency and 8.17 for overall acceptability) with significantly higher acceptability index of 89.97 per cent (Fig 1). Custards with foxtail millet starch were accepted with slightly lower scores. The formulation with 90 per cent millet starch and 10 per cent milk powder received 7.75 for appearance, 7.67 for colour, 7.25 for flavour, 7.50 for taste, 7.33 for consistency and 7.42 for overall acceptability

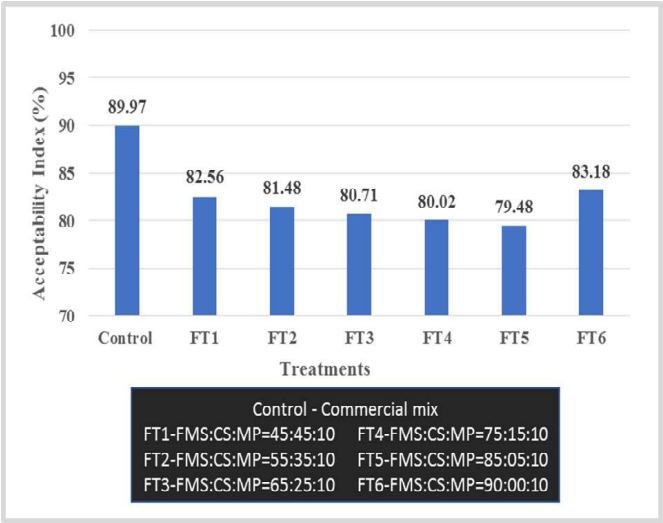

Fig 1. Acceptability indices of custards with variation in foxtail millet starch

Table 2. Sensory scores# of custard with variation in foxtail millet starch

Variations	Appearance	Colour	Flavour	Taste	Consistency	Overall acceptability
Control	8.25 ± 0.45^{a}	8.25 ± 0.45^{a}	8.00 ± 0.60^{a}	8.08 ± 0.51^{a}	7.83 ± 0.38^{a}	8.17 ± 0.57^{a}
FT_1	7.83 ± 0.83^{ab}	7.67 ± 0.88^{ab}	7.17 ± 1.19^{b}	7.08 ± 1.50^{b}	7.42 ± 0.79^{ab}	7.42 ± 0.99^{b}
FT_2	7.42 ± 0.90^{b}	7.42 ± 1.08^{b}	7.25 ± 0.96^{b}	7.33 ± 0.98^{b}	7.33 ± 0.77^{ab}	7.25 ± 0.96^{b}
FT_3	7.25 ± 0.62^{b}	7.58 ± 0.79^{b}	7.25 ± 0.75^{b}	7.08 ± 0.79^{b}	7.25 ± 0.62^{b}	7.17 ± 0.83^{b}
FT_4	7.42 ± 0.66^{b}	7.58 ± 0.79^{b}	7.17 ± 0.57^{b}	7.08 ± 0.51^{b}	7.25 ± 0.62^{b}	7.25 ± 0.75^{b}
FT_5	7.41 ± 0.79^{b}	7.58 ± 0.79^{b}	7.00 ± 0.95^{b}	6.92 ± 0.90^{b}	7.00 ± 0.85^{b}	7.00 ± 0.60^{b}
FT_6	7.75 ± 0.75^{ab}	7.67 ± 0.77^{ab}	7.25 ± 0.75^{b}	7.50 ± 0.79^{ab}	7.33 ± 0.65^{ab}	7.42 ± 0.79^{b}
F value	2.694	1.270	1.711	2.259	1.611	2.621
S.Em.	0.211	0.235	0.246	0.263	0.198	0.231
CD	0.594*	0.663*	0.693*	0.742*	0.559*	0.652*

- Mean ± SD ,S.Em- Standard error of mean, CD – Critical difference,

*- Significant at @ 5 %, NS - Non-significant. Values with the same superscripts (a, b, c) in the same column are not significantly different.

FMS –Foxtail Millet Starch CS – Corn Starch MP – Milk powder

FMS obtained from traditional method

Control – Commercial mix

FT_1 - FMS:CS:MP = 45:45:10; FT_2 - FMS:CS:MP = 55:35:10; FT_3 - FMS:CS:MP = 65:25:10;

FT_4 - FMS:CS:MP = 75:15:10 FT_5 - FMS:CS:MP = 85:05:10 FT_6 - FMS:CS:MP = 90:00:10

Table 3. Organoleptic scores# of foxtail millet based custard with starches obtained from different methods

Foxtail millet Starches	Appearance	Colour	Flavour	Taste	Consistency
OverallAcceptability					
Control	8.37 ± 0.57^{a}	8.28 ± 0.28^{a}	7.75 ± 0.45^{a}	7.83 ± 0.57^{a}	7.83 ± 0.38^{a}	7.92 ± 0.51^{a}
CM	7.25 ±0.45^{b}	7.17 ± 0.38^{b}	5.75 ± 0.62^{b}	5.33 ± 0.49^{c}	7.72 ± 0.66^{c}	6.25 ± 0.62^{c}
SM	7.25 ± 0.62^{b}	7.18 ± 0.79^{ab}	7.25 ± 0.75^{a}	7.45 ± 0.73^{b}	7.38 ± 0.51^{b}	7.28 ± 0.79^{b}
TM	7.17 ± 0.71^{b}	7.13 ± 0.88^{b}	7.24 ± 0.75^{a}	7.25 ±0.75^{b}	7.27 ± 0.71^{b}	7.17 ± 0.71^{b}
F value	7.488	4.642	20.842	32.671	22.081	12.423
S.Em.	0.173	0.185	0.189	0.187	0.169	0.193
C.D.	0.493*	0.528*	0.540*	0.534*	0.483*	0.551*

- Mean ± SD, S.Em- Standard error of mean, C.D. – Critical difference,

* Significant at @ 5 %, NS – Non-significant. Values with the same superscripts (a, b, c) in the same column are not significantly different.

FMS:CS:MP = 90:00:10

Control : Commercial mix CM : Chemical method

SM : Sedimentation method TM : Traditional method

and these scores were on par with those of control. The custard having 45 percent of millet starch and 45 per cent of corn starch also received nearly similar scores. Other formulations were on par with each other and lower than the control and mix with 90 per cent FMS. The scores of all the sensory parameters differed significantly as indicated by ANOVA. However, all the sensory parameters were scored between liked moderately to liked very much.

Studies were conducted to evaluate suitability of foxtail millet starch extracted by different methods in the preparation of custard powder mix. Organoleptic scores of foxtail millet custard prepared from starches obtained from chemical, sedimentation and traditional methods are presented in Table 3. Control sample (T_1) obtained highest scores for appearance (8.37), colour (8.28), flavour (7.75), taste (7.83), consistency (7.83) and overall acceptability (7.92). Among the experimental samples, starch obtained from the sedimentation method when used in the preparation of custard, received higher scores of 7.25 for appearance, 7.18 for colour, 7.25 for flavour, 7.45 for taste, 7.38 for consistency and 7.28 for overall acceptability with the acceptability index of 81.09 per cent (Fig 2). When the proportion of foxtail millet starch increased from 45 per cent to 90 per cent, the sensory scores decreased up to 85 per cent of FMS incorporation. However, 90 per cent incorporation of millet starch with zero per cent corn starch scored highest compared to other proportions. This indicates that millet starch cannot blend with corn starch as the structure, composition and purity of corn starch and millet starch differ (Nuvamanya *et al.,* 2011). It is noteworthy that complete replacement of corn starch with foxtail millet starch along with 10 per cent milk powder (T_6) was highly acceptable similar to control. Simi *et al.* (2016) also replaced corn starch with 100 per cent of Queensland arrowroot starch. There was no significant difference found between sensory scores obtained for custard prepared with sedimentation and traditional method of starch extraction, so keeping in mind to improve the nutritional quality custard with traditional method of starch extraction was selected.

Nutritional quality of foxtail millet based custard powder mix

Nutrient composition and mineral contents are presented in Table 3 and 4. Custard with different flavours and colours, looks like a unique dessert besides its higher consumer acceptance around the world. It is nutritious culinary food, sugar added for taste provides energy and milk makes it more nutritious. Foxtail millet based custard powder mix possessed 13.07 per cent of protein, the higher amount of protein may be due to significant quality of protein in milk powder. Good amount of carbohydrate *i.e* 59.81 per cent is provided by the foxtail millet based custard powder mix, which is lower than those reported for turmeric treated custard (84.39 %) by Odimegwu *et al.* (2019). Fat, crude fibre and ash obtained from developed mix was 5.82, 7.2 and 3.34, respectively. It provides 303 calories of energy which can be consumed as breakfast meal and also be a choice for sick. Foxtail millet custard powder mix contained good amount of calcium (84.72 mg) and iron (2.52 mg).

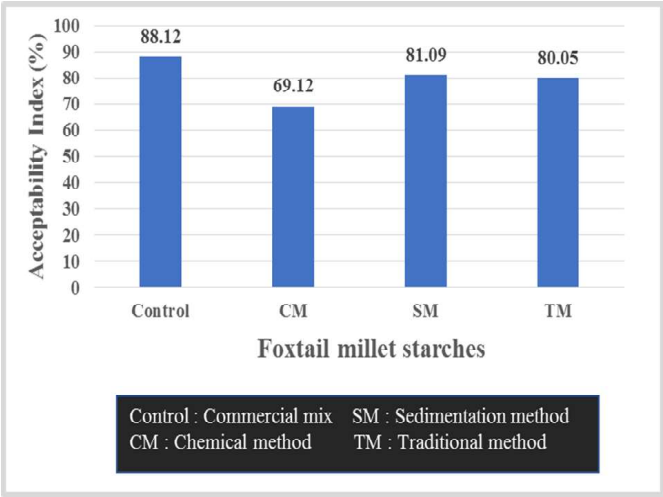

Fig 2. Acceptability indices of foxtail millet based custard with starches obtained from different methods

Table 3. Proximate composition of foxtail millet based custard powder mix

Nutrients	Per 100 g dry mix	Per serving*
Protein	13.07	4.51
Fat	5.82	4.68
Crude fibre	7.2	0.72
Carbohydrate	59.81	20.32
Ash	3.34	0.33
Energy (Kcal)	303	137

Table 4. Mineral content of foxtail millet based custard powder mix

Minerals (mg/100g)	Per 100 g dry mix	Per serving*
Calcium	84.72	128.47
Iron	2.52	0.46

* - 10 g dry mix + 100 ml milk + 10 g sugar

Conclusion

The study concluded that foxtail millet starches extracted from chemical, sedimentation and traditional methods had appreciable physical properties for the development of custard powder mix. Custard powder can be developed with 100 per cent replacement of corn starch with foxtail millet starch.

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