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Formulation and Evaluation of Ready-to-Reconstitute Smoothie Mix with Little Millet

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The urbanization, fast-paced lifestyle, improved income and globetrotting have spurred the adoption of convenience foods in India. Value addition to millets promotes their production, marketing and offers good opportunities to farmers for better income generation. Little millet is an indigenous nutricereal widely cultivated across India yet underutilised and often misquoted as poor man's crop. Till date not much research was done to develop a nourishing millet based smoothie mix. In the present investigation, a ready-to-reconstitute smoothie mix was developed with the most organoleptically acceptable formulation being 45% malted-pre-gelatinized little millet flour, 45% milk powder and 10% sugar. The developed mix possessed a good amount of protein (12.89 g/100 g) and exhibited improved dispersibility (88.97%), reduced sediment content (2.95 mL/10 mL) and reconstitution time (81.82 sec) compared to control. It can be readily reconstituted with fruit juices or pulps to prepare smoothies, which could serve as a healthy addition to one's daily diet. The mix was shelf-stable upto 45 days without much deterioration in physicochemical and microbial quality. The lower moisture content (4.81%) and water activity (0.48) indicate good shelf-stability of the developed mix. The developed smoothie mix could enhance the utilization of little millets, locally available seasonal fruits and promote dietary diversification.

Keywords: Convenience food, Little millet, Nutricereal, Protein, Value addition

In the present fast-paced era, where time and health are real assets, there is a need for consumers to make right food choices. However, food consumers often fail to choose the right food and end up consuming foods that are easily available but unhealthy resulting in the development of lifestyle diseases like cardiovascular diseases, obesity, diabetes, constipation, renal disorders, etc.[1] Convenience foods provide comfort to consumers with no requirement of any major processing or cooking before consumption. Rapid urbanization, industrialization and changes in the eating habits of people due to globalization led to the development of such foods.[2] They encompass a wide variety of processed and semi-processed foods broadly described as 'Ready-To-Eat (RTE)', 'Ready-To-Cook (RTC)' and 'Ready-To-Serve (RTS)' foods. The Ready-To-Reconstitute (RTR) mixes can be prepared in water or other liquids within 2–10 min.[3] The current situation of India suggests a shift towards the formulation of ready-to-consume nutrient-dense food products. In addition, with due consideration to the rising awareness among consumers regarding potential health benefits of millets, there is a need to meet the diversified demands of millet-based designer foods. Henceforth, provision of convenience foods with nutritious grains like millet would be more meaningful in modern times in the management of lifestyle disorders.[4] Further, germination or malting can be an effective way to enhance the quality and functionality of various RTE or RTR multi-nutrient mixes.[5]

Little millet as a nutri cereal provides bioactive components such as phenols, flavonoids, tannins and phytates in addition to macro and micronutrients. It has good amounts of protein (7.70–16.50%), fat (2.45–9.04%), carbohydrates (62.50–76.30%), dietary fibre (15.90–18.10%), magnesium (133.0 mg/100g), iron (9.30–20.00 mg/100g) and zinc (3.70 mg/100g).[6] Functionally it exhibits hypoglycemic, hypolipidemic and fecal bulking properties.[6] Further, considering its diverse adaptation to agronomic conditions it can be an alternate or supplement crop to widen the food basket ensuring food and nutritional security. Little millet is native to India and its cultivation is mainly observed in the states of Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh, Odisha, Chhattisgarh and Gujarat.[7] Currently, the area under

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little millet cultivation in India is about 0.3 to 0.4 million hectares with a production of around 0.1 million tonnes.[8] However, research and development activities of little millet are meagre as compared to other major cereals or millets. Hence, research on processing and value addition would pave the path for the commercialization of little millet.[9]

Smoothies are blended, thick, smooth, sweetened, chilled beverages combining fresh fruit or vegetable purees, milk and grain flours that serve as vehicles for stomach filling and nutrient supply. They are appealing for all age groups because of fresh fruit flavour, sweetness and balanced nutrition.[10] A smoothie can serve as a good breakfast replacer for those skipping breakfast for one or other reason in the morning. Till date not much research has been done to develop a millet based smoothie mix that can be readily reconstituted with fresh fruit pulps or juices. In light of these perspectives, the present investigation was undertaken to formulate a RTR smoothie mix with little millet and evaluate its physico-functional attributes, proximate composition and shelf life. It could be a novel value-added convenience food product and generate value to the misquoted 'poor man's crop' leading to market diversification. It could prove to be a nutritionally superior and convenient healthy food addition to consumers' daily diet.

Materials and Methods

The little millets used to develop smoothie mix are pooled grains procured from the farmers of Telangana State and supplied by Indian Institute of Millets Research, Hyderabad. All other ingredients were procured from the local markets of Hyderabad. The study was carried out in the Post Graduate & Research Centre, PJTSAU, Hyderabad. All the chemicals used were of analytical reagent grade.

Formulation of RTR Smoothie Mix

The raw little millets were soaked for 12 h at room temperature, germinated at 30°C for 24 h in a seed germinator (model: GA-240A) (Fig. 1a) and tray dried at 60°C to a moisture content of below 12%. Four types of little millet flours were prepared with and without heat treatments for utilization in RTR smoothie mix development (Fig. 2). The germinated and dried little millets were dehulled and pulverized without any heat treatment to prepare Germinated little Millet Flour (GMF). Dehulling was done using Indosaw dehuller cum pearler (model: 62077) and pulverization was done using Indosaw pulverizer (model: 62078). The germinated and dried little millets were subjected to mild pan-roasting till the sweet aroma developed, cooled, dehulled (Fig. 1b) and pulverized to prepare Malted little Millet Flour (MMF). In addition, both the germinated and malted little millets were pre-gelatinized to reduce the reconstitution time and increase the acceptability. This was done by pressure cooking the dehulled millet with an equal amount of water for 10 min without any loss in grain structure (Fig. 1c) followed by cooling, tray drying at 60°C to reduce the moisture content to below 12% and pulverizing to prepare the

Fig. 1 — Little millet smoothie preparation: (a) germinated little millet, (b) malted dehulled little millet, (c) pre-gelatinized little millet, (d) ready-to-reconstitute smoothie mix, (e) reconstituted little millet smoothies, and (f) fruit based little millet smoothies

Table 1 — Composition of ready to constitute smoothie mix

Composition	Little millet flour (g)	Milk powder (g)	Sugar powder (g)
C_1	90.00	—	10.00
C_2	60.00	30.00	10.00
C_3	45.00	45.00	10.00
C_4	30.00	60.00	10.00

Fig. 2 — Flow chart for treated little millet flours preparation

Germinated and Malted Pre-gelatinized little Millet Flours (GPMF and MPMF). All the developed little millet flours were sieved with a BSS (41/1969) sieve No. 150 to reduce the particle size to 105 µ and stored in heat-sealed High-Density Polyethylene (HDPE) pouches.

The developed little millet flours were substituted with milk powder in the proportions as given in Table 1 along with the addition of 10 g of sugar powder to formulate RTR smoothie mixes (Fig. 1d). The smoothie mixes were stored in heat-sealed HDPE pouches at ambient conditions (25 ± 1°C, 65% RH) until further investigation. They were added with 1.5 times water and mixed thoroughly to get the desired smoothie consistency (Fig. 1e). The reconstituted smoothies were evaluated for sensorial characteristics by 21 semi-trained panelists using a 9 point hedonic scale where 1 indicated disliked extremely and 9 indicated liked extremely.[11] Based on sensory properties the best formulation of the smoothie mix was determined.

Physico-Functional Parameters of Developed Smoothie Mix

The physical parameters analyzed for the smoothie mix were colour,[12] bulk density, tapped density,[13] viscosity, wheying off, sediment content[14] and total insoluble solids content.[15] The functional properties analyzed for the smoothie mix were flowability, cohesiveness, reconstitution time,[13] dispersibility[16] and water activity.[17]

Proximate Composition of Developed Smoothie Mix

The developed smoothie mix was analyzed for moisture, ash, protein, fat, crude fibre, carbohydrates and energy content following standard protocols.[18]

Shelf Stability of Developed Smoothie Mix

The developed smoothie mix was evaluated for physical parameters (titratable acidity, pH and total soluble solids),[18] sensory properties[11] and microbial quality (total bacterial and mold counts)[19] during the storage period of 45 days at an interval of once in 15 days.

Statistical Analysis

All the experiments were performed in replicates. The results obtained were statistically analyzed by analysis of variance and expressed as mean ± standard deviation of parallel measurements. The means were compared using the least significant difference (LSD) at 5% level.[20]

Results and Discussion

Sensory Attributes of Little Millet Smoothie Mix

The obtained scores for appearance, texture, flavour, taste and overall acceptability of smoothies prepared from different formulations of RTR mixes were given in Table 2. The best scores for appearance, texture, flavour, taste and overall acceptability of germinated little millet based smoothies (GLS) were for those made from C_4 mix with 8.13, 8.20, 7.27, 8.07 and 8.00 respectively due to lesser inclusion of little millet flour in formulation compared to smoothie mixes of other compositions. Similarly, other researchers[14] reported higher germinated sorghum flour level in smoothie imparted lumpy and thick appearance, beany flavour and adversely affected the colour, appearance, flavour, consistency and overall preference scores.

Several authors[5,21] have reported that the malting of millets has a profound effect in inactivating

Table 2 — Sensory scores for reconstituted little millet smoothies

Smoothie	Appearance				Texture				Flavour				Taste				Overall acceptability			
	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4
GLS	6.73 ± 0.46	7.13 ± 0.35	7.60 ± 0.51	8.13 ± 0.52	6.60 ± 0.51	7.33 ± 0.49	7.47 ± 0.52	8.20 ± 0.41	6.33 ± 0.49	7.27 ± 0.46	7.33 ± 0.49	8.07 ± 0.46	6.67 ± 0.49	7.20 ± 0.41	7.40 ± 0.51	8.07 ± 0.46	6.53 ± 0.52	7.33 ± 0.49	7.33 ± 0.49	8.00 ± 0.38
MLS	6.60 ± 0.51	7.40 ± 0.51	7.80 ± 0.41	7.87 ± 0.52	6.60 ± 0.51	7.07 ± 0.46	7.53 ± 0.52	7.67 ± 0.49	6.40 ± 0.51	7.27 ± 0.46	7.87 ± 0.35	7.67 ± 0.49	6.73 ± 0.46	7.33 ± 0.49	8.13 ± 0.35	7.87 ± 0.52	6.60 ± 0.51	7.33 ± 0.49	8.13 ± 0.35	7.73 ± 0.46
GPLS	6.53 ± 0.52	7.87 ± 0.52	8.20 ± 0.41	8.20 ± 0.41	6.60 ± 0.51	7.80 ± 0.41	8.10 ± 0.52	8.07 ± 0.46	6.53 ± 0.52	7.80 ± 0.41	8.27 ± 0.46	8.20 ± 0.41	6.67 ± 0.49	7.73 ± 0.46	8.27 ± 0.46	8.27 ± 0.46	6.67 ± 0.49	7.87 ± 0.52	8.27 ± 0.46	8.27 ± 0.46
MPLS	6.80 ± 0.41	7.80 ± 0.41	8.40 ± 0.51	8.07 ± 0.46	6.67 ± 0.49	7.87 ± 0.35	8.33 ± 0.49	7.93 ± 0.46	6.67 ± 0.49	7.73 ± 0.46	8.27 ± 0.46	7.93 ± 0.46	6.80 ± 0.41	7.60 ± 0.51	8.40 ± 0.51	7.87 ± 0.35	6.67 ± 0.49	7.73 ± 0.46	8.33 ± 0.49	8.07 ± 0.26
	F value		CD		F value		CD		F value		CD		F value		CD		F value		CD	
T	*		0.17		*		0.17		*		0.17		*		0.16		*		0.16	
C	*		0.17		*		0.17		*		0.17		*		0.16		*		0.16	
T*C	*		0.34		*		0.34		*		0.33		*		0.33		*		0.32	

Note: Values are expressed as mean ± standard deviation of twenty-one determinations. *Significant at $p < 0.05$. CD: Critical difference.
T: Treatment of little millets
GLS: Germinated little millet smoothie
MLS: Malted little millet smoothie
GPLS: Germinated pre-gelatinized little millet smoothie
MPLS: Malted pre-gelatinized little millet smoothie
C: Composition of smoothie mix
C_1: Smoothie mix with 90% little millet flour and 10% sugar
C_2: Smoothie mix with 60% little millet flour, 30% milk powder and 10% sugar
C_3: Smoothie mix with 45% little millet flour, 45% milk powder and 10% sugar
C_4: Smoothie mix with 30% little millet flour, 60% milk powder and 10% sugar

destructive enzymes, improving the digestibility, sensory, nutritional and storage quality and lowering antinutrients. Thus, malted flours can be utilised in the preparation of weaning foods, instant mixes and beverages.[21] Malting significantly enhanced the flavour, taste and overall acceptability of little millet flour resulting in best scores of 7.87, 8.13 and 8.13 respectively for malted little millet smoothie (MLS) made from C_3 mix rather than C_4 composition. Thus, it enhanced the scope for a greater amount of little millet flour substitution in the preparation of smoothies. Further, the MLS made from C_4 mix was less accepted due to over-sweetness. However, the best scores for appearance and texture were given for smoothies made from C_4 mix with 7.87 and 7.67 respectively probably due to slight browning of little millets resulting from roasting after germination.

Furthermore, the germinated little millets were pre-gelatinized to improve the acceptability of smoothies with decreased reconstitution time of mix. Several researchers have reported that pre-gelatinized starches exhibited better cold water swelling ability, solubility and water absorption capacity than natural starches.[22] This was due to the disruption of starch grains during pre-gelatinization, which would release amylopectin that is partially responsible for the swelling of starch.[23]

The best scores for appearance, taste and overall acceptability of germinated pre-gelatinized little millet based smoothies (GPLS) were given for those made from C_3 and C_4 compositions with the same score of 8.20, 8.27 and 8.27 respectively. While the best scores for texture and flavour were given for those prepared from C_3 composition with 8.13 and 8.27 respectively. The best scores for appearance, texture, flavour, taste and overall acceptability of malted, pre-gelatinized little millet based smoothies (MPLS) were given for those made from C_3 mix with 8.40, 8.33, 8.27, 8.40 and 8.33 respectively. A significant difference was observed between all samples for appearance, texture, flavour and taste while there was no significant difference between C_3 and C_4 smoothies for overall acceptability at 5% level.

Selection of Best RTR Little Millet Smoothie Mix

As the mean scores obtained for all sensory attributes of C_3 MPLS were superior to GLS, MLS and GPLS of all compositions, it was selected as the best accepted RTR smoothie mix. The control smoothie mix of 90% little millet flour, 10% sugar and test smoothie mix of 45% little millet flour, 45% milk powder, 10% sugar were further analysed for physico-functional properties, proximate composition and shelf stability.

Physico-Functional Attributes of RTR Little Millet Smoothie Mix

The physico-functional attributes of control and test smoothie mixes are described in Tables 3 and 4.

Colour

Colour changes gave information about degree of cooking, extent of browning reactions such as Maillard reaction and pigment degradation that took

Table 3 — Colour analysis of RTR little millet smoothie mix

Smoothie mix	L*	a*	b*	C*	h* (degrees)
Control	$16.04^{a} \pm 0.05$	$29.38^{b} \pm 0.04$	$2.29^{a} \pm 0.04$	$29.47^{b} \pm 0.04$	$4.46^{a} \pm 0.06$
Test	$22.28^{b} \pm 0.05$	$28.40^{a} \pm 0.04$	$4.06^{b} \pm 0.05$	$28.69^{a} \pm 0.04$	$8.14^{b} \pm 0.10$
Mean	19.16	28.89	3.18	29.08	6.30
SE_m	1.40	0.22	0.40	0.18	0.82
CD	0.20	0.10	0.17	0.10	0.30

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same column followed by different superscripts differed significantly at $p \leq 0.05$. SE_m: Standard error of the mean, CD: Critical difference

Table 4 — Physico-functional attributes of RTR little millet smoothie mix

Parameter	Control smoothie mix	Test smoothie mix	Mean	SE_m	CD
Bulk density (g/mL)	$0.48^{a} \pm 0.01$	$0.46^{a} \pm 0.01$	0.47	0.00	0.01
Tapped density (g/mL)	$0.71^{a} \pm 0.01$	$0.70^{a} \pm 0.01$	0.71	0.00	0.01
Wheying off (mL/10 mL sample)	$4.02^{b} \pm 0.03$	$1.18^{a} \pm 0.03$	2.60	0.63	1.57
Sediment content (mL/10 mL sample)	$5.98^{b} \pm 0.03$	$2.95^{a} \pm 0.05$	4.47	0.68	0.14
Total insoluble solids (%)	$63.91^{b} \pm 0.06$	$40.70^{a} \pm 0.06$	52.3	5.19	0.1
Viscosity (mPa.s)	$143.67^{b} \pm 0.58$	$139.67^{a} \pm 0.58$	141.67	0.92	2.48
Reconstitution time (sec)	$171.62^{b} \pm 0.04$	$81.82^{a} \pm 0.04$	126.72	20.08	0.01
Dispersibility (%)	$71.97^{a} \pm 0.06$	$88.97^{b} \pm 0.06$	80.47	3.8	0.25
Water activity	$0.50^{a} \pm 0.01$	$0.48^{a} \pm 0.00$	0.49	0.01	0.01

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same row followed by different superscripts differed significantly at $p \leq 0.05$. SE_m: Standard error of the mean, CD: Critical difference

place during tray drying and pre-gelatinization process.[24] The test smoothie mix had higher L*, b*, h* values and lower a*, C* values with 23.28, 4.06, 8.14, 28.40 and 28.69 respectively than the control mix with 16.04, 2.29, 4.46, 29.38 and 29.47 respectively indicating less redness, colour intensity and more yellowness as perceived by humans. This might be due to the lower proportion of pre-gelatinized flour in the test mix, which was slightly brown due to the Maillard reaction that occurred during the drying of partially cooked grains. The total colour difference (ΔE*) between test and control mixes was very distinct with 6.49. There was a significant difference between the samples for all colour values at 5% level.

Bulk and Tapped Densities

The test smoothie mix had comparatively less bulk and tapped densities with 0.46 and 0.70 g/mL than the control mix with 0.48 and 0.71 g/mL due to lesser degree of fineness of particles. Other researchers[16] have reported that bulk density was positively correlated with particle size. The lower bulk density of the test mix was advantageous as higher bulk density resulted in very thick smoothies. There was no significant difference between the samples for bulk and tapped densities at $p < 0.05$.

Viscosity

The viscosity is generally influenced by the presence of solid particles and their size.[25] The test smoothie had a lower viscosity of 139.67 mPa.s than the control (143.67 mPa.s) due to less bulk density of mix and less amount of millet flour resulting in less thick smoothie. Likewise, other researchers[14] also reported that the germinated sorghum flour had significantly ($p \leq 0.01$) increased the viscosity of the smoothie at linear levels. There was a significant difference between the samples at $p \leq 0.05$.

Wheying Off and Total Insoluble Solids

The test smoothie had less wheying off and total insoluble solids with 1.18 mL/10 mL sample and 40.70% respectively than the control with 4.02 mL/10 mL sample and 63.91% probably due to less amount of little millet flour that had poor dispersibility. There was a significant difference between samples for both parameters at $p \leq 0.05$.

Sediment Content

Reconstituted foods with low dispersibility tend to have high sediment content as both are opposite intrinsic parameters pertinent to instant smoothie or beverage mixes.[26] The test smoothie had lesser sediment content of 2.95 mL/10 mL sample than the control (5.98 mL/10 mL sample) due to better

dispersibility of smoothie mix. There was a significant difference between the samples at $p \leq 0.05$. Similarly, other researchers[14] reported that the germinated flour had increased the sedimentation of smoothie significantly ($p \leq 0.01$) at linear levels.

Reconstitution Time

The test smoothie mix had a better reconstitution time of 81.82 sec than the control (171.62 sec) probably due to less bulk density and a significant difference between the samples at $p \leq 0.05$ was observed. Likewise, other researchers[27] reported that reconstitution time of instant porridge mixes increased with the increase in bulk density. The reconstitution time was within the ideal range of reconstitution time for RTR mixes *i.e.* 2–10 min.[3]

Dispersibility

Dispersibility is the ease with which the mix becomes distributed as a single particle in the bulk liquid phase. The highly dispersible powders exhibit good wettability.[28] The test smoothie mix had better dispersibility of 88.97% than the control (71.97%) and a significant difference between the samples at $p \leq 0.05$ was observed. Both of them were within the ideal range of dispersibility of instant food powders *i.e.* 67.05–99.98%.[29]

Water Activity (a_w)

It is the amount of free water available that could greatly influence the chemical and microbial stability of foods rather than the total water content. Most of the enzymes are inactivated at a_w of < 0.85. At a_w of < 0.75 the bacterial growth is inhibited yet some yeast and molds may grow. At a_w of <0.6 growth of all microbes is inhibited. From the nutritional point of view, reduced a_w is associated with decreased loss of vitamins such as C, E, B_1.[30] Further, a_w affects the flow, caking and clumping properties of stored powders because of the ability of water to act as a solvent, reaction medium and reactant. Controlling the water activity of instant mixes below the critical levels is essential for maintaining texture, flowability and rehydration properties.[31] The test smoothie mix had comparatively high shelf stability due to less a_w with 0.48 than the control with 0.50 at 20°C. There was no significant difference between the samples at $p \leq 0.05$. The control of water activity was an effective method to control the growth of microorganisms that deteriorate foods.

Proximate Composition of RTR Little Millet Smoothie Mix

The proximate composition of control and test smoothie mixes is given in Table 5. The test smoothie mix exhibited higher ash (total mineral), protein, fat and lower moisture, crude fiber contents with 3.05 g, 12.89 g, 7.54 g and 4.81 g, 2.75 g respectively than the control with 1.21 g, 7.81 g, 1.37 g and 7.33 g, 6.26 g per 100 g respectively. The improvement might be due to substitution of flour with milk powder, which had fecund amounts of minerals, protein, fat and less fiber. The test mix had relatively higher ash, protein and fiber contents than the milk-sorghum based smoothie (0.31 g, 0.87 g, 1.68 g per 100 g respectively) developed by other researchers.[32] Further, it had a lesser carbohydrate content of 68.96 g/100 g than the control (76.02 g/100 g) probably due to increased ash, protein, fat and crude fiber contents. The energy content of the test little millet smoothie mix was augmented with 395.22 Kcal/100g than the control with 347.65 Kcal/100g due to enhanced protein and fat contents. There was a significant difference between the samples at $p \leq 0.05$ for proximate composition.

Shelf Stability of RTR Little Millet Smoothie Mix

Shelf life refers to the duration of consumers' acceptance of a foodstuff. Food products developed can undergo deterioration with storage associated with microbial contamination and auto-oxidation by

Table 5 — Proximate composition of RTR little millet smoothie mix

Nutrient (per 100 g)	Control smoothie mix	Test smoothie mix	Mean	SEm	CD
Moisture (g)	$7.33^b \pm 0.04$	$4.81^a \pm 0.05$	6.07	0.56	0.08
Ash (g)	$1.21^a \pm 0.03$	$3.05^b \pm 0.02$	2.13	0.41	0.16
Protein (g)	$7.81^a \pm 0.05$	$12.89^b \pm 0.04$	10.35	1.13	0.15
Fat (g)	$1.37^a \pm 0.03$	$7.54^b \pm 0.03$	4.45	1.38	0.15
Crude fiber (g)	$6.26^b \pm 0.04$	$2.75^a \pm 0.03$	4.51	0.78	0.18
Carbohydrates (g)	$76.02^b \pm 0.05$	$68.96^a \pm 0.03$	72.49	1.58	0.07
Energy (Kcal)	$347.65^a \pm 0.16$	$395.22^b \pm 0.25$	371.44	10.64	0.49

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same row followed by different superscripts differed significantly at $p \leq 0.05$. SE_m: Standard error of the mean, CD: Critical difference

intrinsic enzymes resulting in off-flavours and health hazards in consumers. Hence, safety of stored foods became an integral part of food processing and product development.[33]

Titratable Acidity and pH of Stored Mix

Storage resulted in an upsurge of titratable acidity and a gradual decline of pH of both control and test smoothie mixes representing deterioration of shelf stability as depicted in Fig. 3. The titratable acidity of the control mix ranged from 3.60 to 9.00 % lactic acid during 0^{th} to 45^{th} day of storage with a significant difference between samples at 5% level. While the titratable acidity of the test mix ranged from 21.90 to 28.50% lactic acid with a significant difference between samples at 5% level.

The pH of the control mix ranged from 7.18 to 6.39 during 0^{th} to 45^{th} day of storage with significant difference between samples at 5% level. While the pH of the test mix ranged from 7.32 to 7.01 with no significant difference between samples at 5% level. The test mix had comparatively higher titratable acidity (% lactic acid) than the control although it didn't exhibit low pH probably due to inclusion of higher quantity of milk powder in its composition.

The loss of quality millets and millet based products with storage was due to hydrolysis or oxidation of lipids and polymerization reactions. The lipoxygenase in millet kernels promotes oxidation of unsaturated fatty acids resulting in deterioration of flavour and quality. Though dried products with water activity < 0.60 are stable against microbial growth yet certain chemical and enzymatic reactions can occur contributing to quality deterioration and off-flavours development with storage.[34,35]

Total Soluble Solids Content of Stored Mix

There was a gradual increase in the total soluble solids content of both control and test smoothie mixes from 2.53 to 3.07 °Brix and 3.63 to 4.33 °Brix respectively as presented in Table 6. This might be due to the degradation of starch and other polysaccharides of mixes into soluble sugars by the amylolytic enzymes produced by storage microorganisms.[32] There was a significant difference between the control and test mixes for total soluble solids content at $p \leq 0.05$.

Sensory Parameters of Stored Mix

The scores obtained for appearance, texture, flavour, taste and overall acceptability of smoothie made from test mix were decreased significantly ($p \leq 0.05$) from 8.40 to 8.27, 8.33 to 8.20, 8.27 to 8.20, 8.40 to 8.13 and 8.33 to 8.13 respectively with the increase in storage duration to 45 days as depicted in Fig. 4. Likewise, other researchers[32] reported significant decline in scores obtained for flavour and sweetness of milk-sorghum based smoothie with the increase in storage duration to 60 days due to production of free fatty acids associated with the development of off-flavour. Further, the scores obtained for colour, appearance were decreased

Table 6 — Total soluble solids content of RTR little millet smoothie mix during storage

Sample	TSS (°Brix)	
	Control smoothie mix	Test smoothie mix
0^{th} day	$2.53^{a} \pm 0.06$	$3.63^{a} \pm 0.06$
15^{th} day	$2.63^{b} \pm 0.06$	$3.83^{b} \pm 0.06$
30^{th} day	$2.83^{c} \pm 0.06$	$4.17^{c} \pm 0.06$
45^{th} day	$3.07^{d} \pm 0.06$	$4.33^{d} \pm 0.06$
Mean	2.77	3.99
SE_m	0.06	0.08
CD	0.13	0.12

Note: Values are expressed as mean ± standard deviation of three determinations. Means within the same column followed by different superscripts differed significantly at $p \leq 0.05$. SE_m: Standard error of the mean, CD: Critical difference

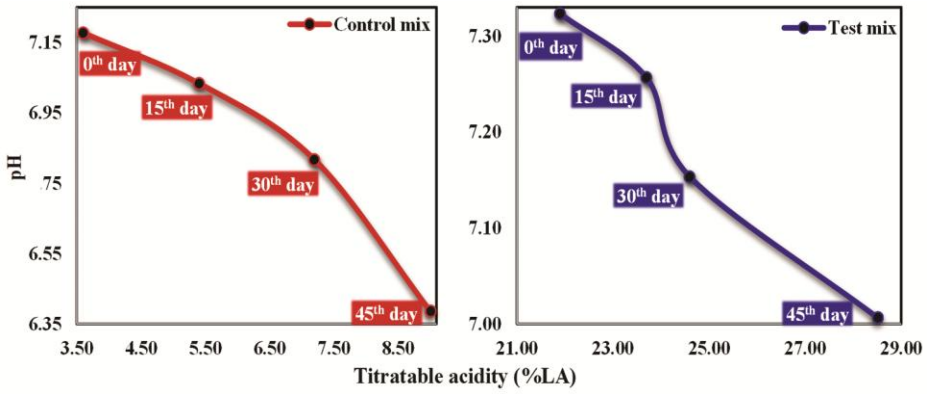

Fig. 3 — Titratable acidity and pH of RTR little millet smoothie mix during storage

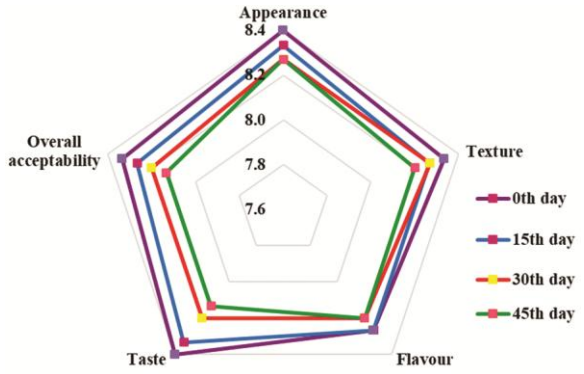

Fig. 4 — Sensory scores of reconstituted little millet smoothie from stored mix

Table 7 — Bacterial and molds population of test smoothie mix during storage

Day	Bacteria (CFU/g)	Molds (CFU/g)
0	ND	ND
15	2.33	ND
30	1.33×10^2	ND
45	0.33×10^3	ND

Note: Values are expressed as mean of three determinations. CFU: Colony forming units, ND: Not detected

significantly due to increase in browning index and separation of whey with storage. Also, the scores obtained for consistency and overall acceptability were decreased significantly due to reduction in viscosity associated with breakdown of carbohydrates to simpler compounds that are soluble in water. Although there was decline in the sensory scores with storage, they were above 7.0 that corresponds to 'liked moderately' on hedonic scale and thus safe for consumption.

Microbial Quality of Stored Mix

Microbiological activity has been widely recognized as a key factor influencing the changes that delineate spoilage in the food system. Other researchers[32] reported that milk and grain based food matrix served as an excellent substrate for proliferation of microorganisms, which produced hydrolytic enzymes associated with deterioration of product quality. Although there were no bacteria in the fresh sample, it gradually increased to 0.33×10^3 CFU/g during the 45th day of storage (Table 7). Molds were not detected in both the fresh and stored samples. The increase in microbial load was within the safer limit of bacterial count not more than 10,000 per gram and mold count absent in 0.1 g of sample as per FSSAI Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011 for milk-cereal based complementary food. Likewise, other researchers[33] reported an increment in the total bacterial count of fresh millet based diabetes mix from 1.86 to 5.97×10^3 CFU which was within the safer limit and no mold detection upon storage of 90 days.

Fruit-based Little Millet Smoothies

The suitability of test smoothie mix to blend with fruit juices and pulps and their acceptability was assessed by subjecting them to sensory evaluation in 1:1 and 1:2 combinations (Fig. 1f). The obtained sensory responses for all parameters of fruit-based little millet smoothies were in the acceptable range irrespective of addition of type of fruit pulps or juices and proportions added with not much percentage difference compared to the test smoothie.[36,37] The World Health Organisation (2003) recommended consumption of atleast 400 g of fruits and vegetables per day as they potentially contribute to maintaining health and nutrition of the human body by enhancing immunity and preventing chronic diseases. The developed smoothies with minimal processing, fewer calories and more protein content compared to energy-dense sweetened fruit drinks or smoothies available in the market help in preventing excess energy intake and dental caries. They could serve as a healthy and convenient between-meal snack providing nutrients from different foods to all age groups.

Conclusions

The consumption of smoothies has increased in recent years due to their perceived health benefits. A ready-to-reconstitute smoothie mix with 45% malted-pre-gelatinized little millet flour, 45% milk powder and 10% sugar yielded most organoleptically acceptable smoothies. The mix was found to be a good source of protein and was shelf stable upto 45 days without much deterioration in physicochemical and microbial quality. It can be readily reconstituted with fresh fruit pulps or juices within 1–2 min. The developed smoothie mix could enhance the utilization of little millets and locally available seasonal fruits, promote market diversification, widens food basket and serve as a healthy nourishing addition to one's daily diet. Thus, value addition to minor millets can be encouraged to enhance their production, promote income generation to farmers and combat prevailing lifestyle diseases.

Conflict of interest

There is no conflict of interest declared by the authors.

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