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Physico-chemical properties of instant *Kheer* mix

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Abstract – Certain cereal-based, traditional Indian desserts comprise a sweetened cooked mixture of partially concentrated milk and rice flour. However, such products have a very limited shelf life with the result that they cannot be commercially marketed. In order to render the product shelf-stable, it was converted into a reconstitutable powder by using a pilot-scale spray drying system with an integrated fluidized bed dryer and a provision for recycling of powder fines from the cyclone separator back into the drying chamber. The process involved standardization of buffalo milk followed by vacuum concentration, addition of ground rice flour and part sugar, pre-heating the slurry for gelatinization of starch, and finally spray-bed drying (inlet-air temperature 170 °C and outlet-air temperature 86 °C for the spray dryer and inlet-air temperature 88 °C and outlet-air temperature 80 °C for the fluidized bed dryer). The powder was then mixed with ground sugar through dry blending. The instant *kheer* mix thus obtained was analyzed for its physico-chemical properties. The freshly prepared powder had a good flowability (angle of repose, 40.09°) and fairly high loose and packed bulk densities (0.69 g·cm^{-3} and 0.81 g·cm^{-3}, respectively) corresponding to a particle density of 1.25 g·cm^{-3}, occluded air content of 6.63 cm^3·100 g^{-1}, interstitial air content of 45.00 cm^3·100 g^{-1} and porosity of 44.80%. It showed an insolubility index of 4.00 mL, wettability of 2.00 min, and dispersibility of 75.38%.

***Kheer* / shelf life / spray drying / fluidized bed drying / gelatinization / functional property**

Résumé – **Propriétés physicochimiques de mélange instantané de *Kheer*.** Certains desserts traditionnels indiens à base de céréales sont composés d'un mélange sucré et cuit de lait partiellement concentré et de farine de riz. Ces produits ont cependant une durée de vie limitée qui ne permet pas leur exploitation commerciale sur le marché. Dans le but d'obtenir un produit stable, il a été transformé en une poudre apte à la reconstitution à l'aide d'un équipement pilote de séchage par atomisation avec un lit fluidisé intégré et un système de recyclage des fines vers la chambre de séchage. Le procédé a impliqué la standardisation du lait de bufflesse suivie d'une concentration sous vide, l'addition de farine de riz broyé et d'une partie du sucre, le pré-chauffage du mélange pour gélifier l'amidon et

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finalement le séchage par atomisation (tour de séchage : température d'air d'entrée 170 °C et d'air de sortie 86 °C ; lit fluidisé: température d'air d'entrée 88 °C et température d'air de sortie 80 °C). La poudre était ensuite mélangée à sec avec le sucre en poudre. Le mélange instantané de *kheer* ainsi obtenu était analysé pour ses propriétés physicochimiques. Immédiatement après préparation, la poudre avait une bonne fluidité (angle de repos 40,09°) et des masses volumiques en vrac et tassée relativement élevées (0,69 $g \cdot cm^{-3}$ et 0,81 $g \cdot cm^{-3}$ respectivement) correspondant à une masse volumique particulaire de 1,25 $g \cdot cm^{-3}$, une teneur en air inclus de 6,63 $cm^3 \cdot 100\ g^{-1}$, une teneur en air interstitiel de 45,00 $cm^3 \cdot 100\ g^{-1}$ et une porosité de 44,80 %. Elle avait un index de solubilité de 4,00 mL, une mouillabilité de 2,00 min et une dispersibilité de 75,38 %.

***Kheer* / durée de conservation / séchage par atomisation / lit fluidisé / gélification / propriété fonctionnelle**

1. INTRODUCTION

The manufacture of indigenous milk products is confined mainly to the non-industrial sector in India. A major portion of the milk produced in the country is converted into sweets and desserts, which are deeply rooted in ancient traditions and have a strong cultural heritage. Centuries of tradition and culture have evolved firmly established consumption habits amongst the population. One such product, which is very popular and made almost daily as a matter of routine and also prepared to mark festivities and social functions, is called *kheer*. *Kheer* is a semi-solid to fluid product with partially disintegrated cooked rice grains dispersed in viscous liquid comprising soluble starch from rice grains. Conventionally prepared *kheer* has a dark creamish color as a result of prolonged cooking of rice grains in milk, which normally takes approximately 1 hour. As a result of the long cooking period, it has a sweet and cooked flavor, which is liked by consumers. References to *kheer* can even be found in ancient mythological texts such as the *Ramayana* and the *Mahabharata*. *Kheer* is made by concentrating milk with the simultaneous cooking of rice grains and addition of sugar during the process [10]. A variation of *kheer*, sometimes called *Firni*, is made by using rice flour instead of granular rice. The shelf life of *kheer* is very poor, and even under refrigeration it does not keep well for more than two days; this, coupled with a lack of technology, has hampered its organized manufacture and marketing.

It was envisaged that if a process was developed to render the product dry using the scientific principles of spray drying, then its shelf life could be enhanced. Not only was this achieved, but also a product was obtained which could resemble the conventional product upon reconstitution. The color and flavor of the reconstituted *kheer* was sensorily perceived to be better in comparison with conventional *kheer* because of less severe heat treatment. This paper describes the functional properties of ready-to-reconstitute *kheer* mix powder developed at this institute, and also the method of its reconstitution and sensory status.

2. MATERIALS AND METHODS

2.1. Materials

The process was developed for the production of instant *kheer* mix, which comprised separate preparation of the instantized liquid milk phase of the product and instantized rice grains, later to be mixed together to yield reconstitutable *kheer*. While the liquid phase was converted into an agglomerated powder in a two-stage spray dryer, pre-cooked rice was dried in a fluid bed dryer to give the particulate phase of the mix. For the manufacture of instant *kheer* mix, buffalo milk was obtained from the Experimental Dairy of the Institute. It was standardized to 5% fat and 9% solids not fat (SNF). Rice (Basmati, 3/4 broken; Chaman Lal Rice Exporters Ltd., Karnal, India) was ground into a fine powder in a local flour mill. Commercially-available cane sugar was, when required, obtained ground by a local commercial sugar grinder, for dry blending in the *kheer* powder. BHA anti-oxidant used for addition to the instant *kheer* mix was procured from Sigma Chemicals Co. (St-Louis, MO, USA). Metallized polyester low-density polyethylene pouches used for packaging of the instant *kheer* mix were obtained from the Experimental Dairy of the Institute. The specifications of this laminate were; water vapor transmission rate at 38 °C/90% RH/24h: 14–20 $g \cdot m^{-2}$; oxygen permeability (at atmospheric temperature (38 °C, 24 h): 85–95 $mL \cdot m^{-2}$; thickness: 350 gauge; grease resistance: very good; size of the pouches: 12 × 15 cm^2.

2.2. Equipment

Standardized milk was heated at 60 °C–15 min in the preheater of the triple effect evaporator (500 L water evaporation per hour: Jektron Ltd., Pune, India) and then concentrated to 35% total solids. A pilot-scale two-stage spray dryer (second stage integrated fluidized bed dryer) with water evaporation capacity of 40 $kg \cdot h^{-1}$ (SSP Ltd., Faridabad, India) was used with an inlet air temperature of 170 ± 2 °C and outlet air temperature of 86 ± 1 °C. The inlet air temperature for the 2nd stage, fluidized bed dryer was 88 °C and the outlet air temperature 80 °C. The integrated horizontal fluid bed consisted of a perforated stainless steel plate through which air was blown upwards, thereby fluidizing the powder. The feed pressure was 100 $kg \cdot cm^{-2}$ and feed rate 60 $kg \cdot h^{-1}$.

A pilot-scale fluidized bed dryer (SSP Ltd.) was used for instantization of rice, with an inlet air temperature of 75 °C. When the outlet air temperature became equal to the inlet air temperature, drying was considered complete. Steam pressure to heat the inlet air was maintained at 0.55 bar. The layer of rice grains placed on the stainless steel sieve was 10 cm. The rice was soaked in water for 10 min at 30 °C and then partially cooked in excess water in a stainless steel steam jacketed kettle. The rice (moisture content, 70%) was then removed from the kettle after draining the cooking water. The cooked grains were placed on a stainless steel sheet to remove any excess moisture for a period of 10 min. The grains were then transferred to a perforated stainless sheet in the fluidized bed dryer and dried with hot air (75 °C). These rice grains were packed separately and later used during reconstitution of the mix into *kheer*. A detailed flow chart with important process data is given in Figure 1.

2.3. Analytical methods

The instant *kheer* mix powder was analyzed for its proximate composition, viz., total solids, fat, protein and ash, using standard procedures for milk powders with suitable modifications [2]. The free fat of the instant *kheer* mix, consisting primarily of fat globules situated in the surface layer of the powder particles, reached directly by fat solvents, was determined by the method of Hall and Hedrick [8]. The free fat content was then calculated as per cent of total fat. The instant rice grains were also analyzed for their chemical composition.

Flowability, as the angle of repose (as a static measure for flowability), was determined by the method of Sjollema [22]. The wettability of the instant *kheer* mix was measured by the method given by Muers and House [16]. Both bulk and loose densities were estimated as described by Sjollema [22]. The method to measure the dispersibility as described by the American Dry Milk Institute (ADMI) [1] was followed. The insolubility index of the instant *kheer* mix was also determined by ADMI

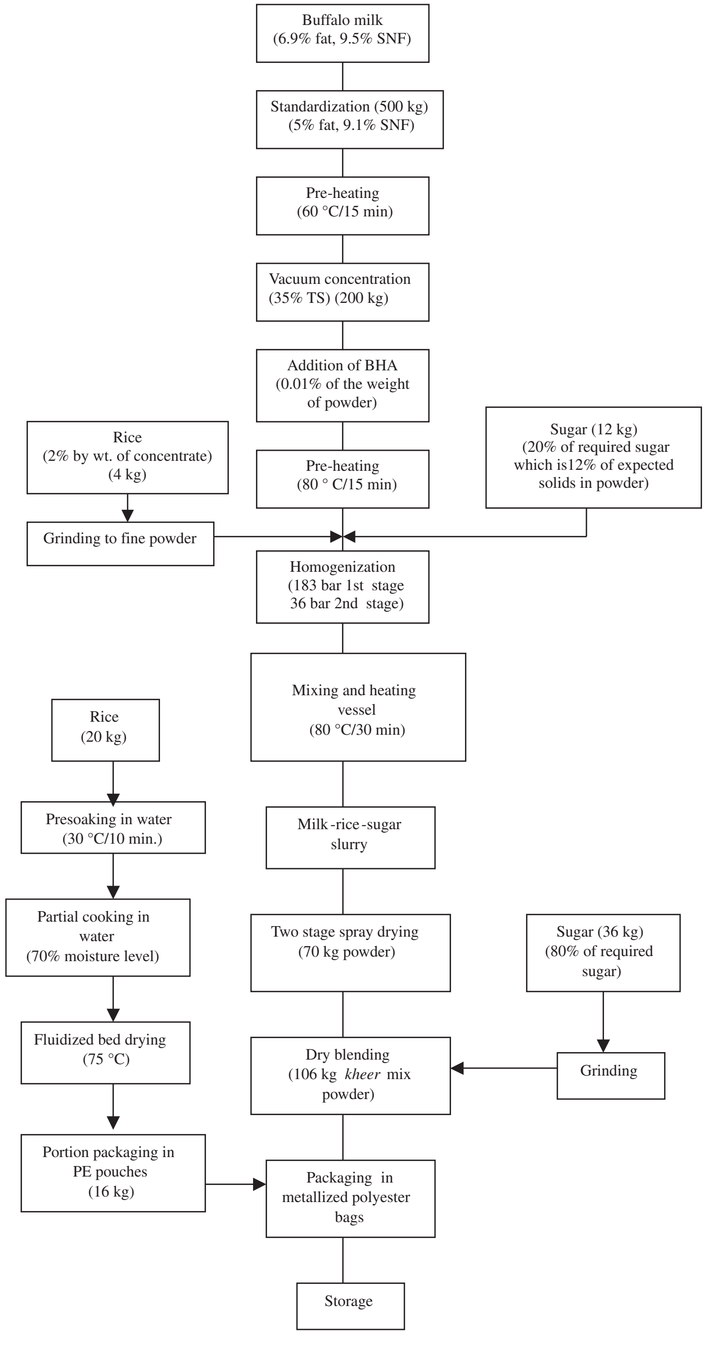

Figure 1. Flow chart for the manufacture of instant *kheer* mix.

[1] method with slight modification. 14 g of powder was reconstituted in 100 mL distilled water at 40 °C by blending in a solubility index mixer for 90 s. After allowing the mixture to stand for a while, the foam was removed and 50 mL of reconstituted liquid was centrifuged in a 50 mL conical graduated centrifuged tube for 5 min. The supernatant was decanted off and the residue washed by dispersing it in water and centrifuging again for 5 min. The volume of sediment in ml obtained at the bottom of the centrifuge tube was recorded and was designated as the insolubility index in mL. The particle density of the instant *kheer* mix powder was analyzed as per the method given by Niro Atomizer [17].

To calculate the occluded air content in the instant *kheer* mix powder, the procedure of Niro Atomizer [17] with the following formula was used.

$$v_{oa} = \frac{100}{D_{particle}} - \frac{100}{D_{solids}}$$

where,

v_{oa} = volume of occluded air in 100 g of powder expressed in cm^3;

$D_{particle}$ = mean particle density in $g{\cdot}cm^{-3}$;

D_{solids} = density of powder solids =

$$\frac{100}{\frac{\%F}{0.94} + \frac{\%SNF}{1.52} + \%W}$$

where,
% F = fat content in per cent;

% SNF = solids non-fat content in per cent (100 –% F –% W);

% W = moisture content in per cent.

To calculate the interstitial air content in the powder, the procedure given by Niro Atomizer [17] was used. The formula used to work out the interstitial air content was:

$$v_{ia} = \frac{100}{D_{powder}} - \frac{100}{D_{particle}}$$

where,

v_{ia} = volume of interstitial air in 100 g of powder expressed in cm^3;

D_{powder} = packed bulk density of powder;

$D_{particle}$ = mean particle density in $g{\cdot}cm^{-3}$.

Porosity, which is closely related to free-flowing characteristics of the powder, was measured by the method given by Sjollema [22]. The following formula was used:

$$P = \frac{100 \times (p - \gamma)}{p}$$

where,

γ = loose bulk density ($g{\cdot}cm^{-3}$)

P = porosity (% by volume)

p = particle density ($g{\cdot}cm^{-3}$).

The power law parameters, consistency coefficient (k) and flow behavior index (n) were measured using a Rheomat coaxial cylinder 108 E/R viscometer fitted with a measuring system 13 (shear rate range, 10–150 s^{-1}). The temperature of measurement was 25 °C.

2.4. Reconstitution

In preliminary studies, attempts were made to reconstitute the *kheer* mix by (a) dispersing the mixture of the instant *kheer* mix powder and instant rice grains in boiling water and then further cooking for the required period, or (b) first cooking the rice grains in boiling water for 10 min and then dispersing the powdered liquid phase in the rice-water mixture.

2.5. Sensory evaluation of reconstituted *kheer*

Sensory evaluation of reconstituted *kheer* was performed by a panel of 9 trained judges from the faculty of the Dairy Technology Division. A special laboratory with the necessary facilities viz., separate booths, provisions for adequate diffused light and an air-conditioned odor-free environment was employed for product evaluation. Hedonic rating (9-point scale) was used for color, texture, flavor and overall acceptability of the conventional as well as the reconstituted *kheer*. A proforma was devised for texture profile analysis, degree of brown discoloration and intensity of off-flavor attributes (10-cm long structured linear 100 points intensity rating scale).

3. RESULTS AND DISCUSSION

3.1. Proximate composition of instant rice grains

The chemical composition of instant rice was determined and the results are presented in Table I. The moisture content of instant rice was in the range of 5.32–5.44%. Moisture in quick-cooking rice has been reported to vary widely according to the method employed for manufacturing; with tray drying the range was 8.7 to 9.8% [7]. The fat content ranged from 1.38 to 1.49%, the protein content from 10.05 to 10.18%, the ash content from 4.73 to 4.76% and the total carbohydrate content from 78.28 to 78.47%. The higher ash content of instant rice as compared with raw rice could be due to the lower moisture content in the grains.

Table I. Chemical composition of instant rice*.

Constituent	Mean (Range) % by wt
Moisture	5.37 (5.32–5.44)
Fat	1.42 (1.38–1.49)
Protein	10.06 (10.05–10.18)
Ash	4.73 (4.72–4.76)
Carbohydrates (by difference)	78.36 (78.28–78.47)

* Means from triplicate experiments.

3.2. Proximate composition of instant *kheer* mix powder

Composition of the instant *kheer* mix powder is shown in Table II. Moisture in powders is an important property, which affects their shelf life and also flow properties. The moisture content of the *kheer* mix powder was less than 2%, on the lower side of the range, viz. 2–4% reported for whole milk powder (WMP) [28]. The fat content of the *kheer* mix powder (mean, 18.2%) was less than that of WMP but comparable to that of partially skimmed milk powder, and an appreciable portion of this fat was present as free fat. This was slightly higher than normal for spray dried milk powder [25]. The presence of free fat in dried milks is of great importance as it affects the wetting properties and oxidative stability [5]. Hols and van Mil [9] reported a free fat content of 1.1–2.1% in whole milk powder. The

Table II. Chemical composition of instant *kheer* mix*.

Constituent	Mean (Range) % by wt
Moisture	1.91 (1.86–1.98)
Fat	18.22 (17.58–18.61)
Protein (N×6.38)	15.31 (14.26–15.97)
Ash	2.51 (2.38–2.64)
Free fat (on fat basis)	21.02 (20.28–21.47)
Carbohydrates (by difference)	62.71 (61.03–65.82)

* Means from triplicate experiments.

protein content of the instant *kheer* mix powder was less than that reported for WMP, viz., 23.6–27.7% [14] and the ash content was appreciably lower than that reported by Tseng [24] for WMP (5.65%). Total carbohydrates in the *kheer* mix powder were higher as compared with both WMP and skim milk powder (SMP) on account of the added sugar and rice flour.

3.3. Functional properties of instant *kheer* mix powder

The physical nature of spray dried dairy products are vastly different from those of powders obtained by other drying methods such as drum drying, freeze drying, etc. However, within spray dried products, there are considerable variations in physical properties depending upon the type of feed and operating conditions. The results on various physical/functional properties of the instant *kheer* mix powder are presented in Table III.

3.3.1. Flowability

The flowability of the *kheer* mix powder measured in terms of the angle of repose (40.09°) was slightly higher than that of butter powder reported by Prasad [19]. The cotangent of the angle of repose (1.19) was appreciably higher than that of SMP (0.97) and WMP (0.45), which meant that *kheer* mix powder was more flowable than these powders, and that of instant SMP (0.75) too [25].

3.3.2. Wettability

The wettability, primarily a measure of hydrophilic properties, of fresh *kheer* mix powder was 2.00 min (Tab. III). It was lower than that of SMP or WMP, viz., 15–60 s [25]. Wettability of instant powders has been reported to be in the range of 0.026–0.119 min [23]. The longer wetting time in the case of the instant *kheer* mix powder could be due to the presence of rice solids.

3.3.3. Bulk density

The loose bulk density of fresh *kheer* mix powder was 0.69 $g \cdot cm^{-3}$ as compared to 0.35–0.65 $g \cdot cm^{-3}$ for spray dried powders [11]. Agglomerated powders have a low bulk density, viz., 0.45–0.55 $g \cdot cm^{-3}$ [12]. Bulk density of whey powders is in the

Table III. Functional properties of instant *kheer* mix powder*.

Property	Mean (Range)
Flowability (angle of repose °)	40.09 (38.30–42.64)
Wettability (min)	2.00 (2.00–2.00)
Dispersibility (%)	75.38 (69.73–86.51)
Insolubility index (mL)	4.00 (3.00–5.00)
Loose bulk density ($g \cdot cm^{-3}$)	0.69 (0.67–0.73)
Packed bulk density ($g \cdot cm^{-3}$)	0.81 (0.80–0.83)
Particle density ($g \cdot cm^{-3}$)	1.25 (1.25–1.25)
Occluded air content ($cm^3 \cdot 100\ g^{-1}$)	6.63 (5.90–7.00)
Interstitial air content ($cm^3 \cdot 100\ g^{-1}$)	45.00 (45.00–45.00)
Porosity (%)	44.80 (41.60–46.40)

* Means from triplicate experiments.

range of 0.6–0.7 [20] while Hols and van Mil [9] reported a loose bulk density of 0.38 $g \cdot cm^{-3}$ for spray dried powders. The packed bulk density of the instant *kheer* powder was found to be 0.81 $g \cdot cm^{-3}$ as against that of 0.41–0.43 reported for spray dried powders [9]. The relatively high bulk density of the *kheer* mix could be attributed again to the rice particles present in the powder.

3.3.4. Dispersibility

The dispersibility of the dried *kheer* mix was 75.38%. WMP has higher dispersibility, viz., 95–98% [12] and so has agglomerated SMP (90–98%). Dispersibility of instant skim milk powder was reported to be in the range of 86–99% [23]. The lower dispersibility of the *kheer* mix powder may be ascribed to its compositional characteristics.

3.3.5. Insolubility index

The insolubility index of fresh *kheer* mix powder was observed to be 4.0 mL, which was higher than what is normally found in SMP and WMP obtained by the spray process. A possible reason for this high insolubility index could be the presence of rice flour in the product.

3.3.6. Particle density

The particle density of fresh instant *kheer* mix was 1.25 $g \cdot cm^{-3}$, which was slightly higher than that of WMP (1.21–1.22 $g \cdot cm^{-3}$) [9]. Boersen [4] reported values of 1.20–1.25 $g \cdot cm^{-3}$ for WMP, 1.30–1.40 $g \cdot cm^{-3}$ for SMP and 1.40–1.50 $g \cdot cm^{-3}$ for whey powders. The usual range is 1.17–1.25 [25]. The value obtained for the *kheer* mix powder was on the higher side of this.

3.3.7. Occluded and interstitial air contents

The occluded air content of the instant *kheer* mix powder immediately after manufacture was found to be 6.63 $cm^3 \cdot 100\ g^{-1}$. The interstitial air content of the product was 45.0 $cm^3 \cdot 100\ g^{-1}$. In a study on the characterization of WMP, interstitial air content was found to be 125 $mL \cdot kg^{-1}$ [26]. Thus the low occluded and interstitial air contents of the *kheer* mix powder resulted in a high bulk density as observed above. The presence of air in the atomized droplets causes occluded air in dried powder particles [5]. Interstitial air in powder is related to the bulk density of powder [27]. The more interstitial air in a powder, the lower its bulk density. The greater the degree of agglomeration, the more interstitial air is contained in the powder and the lower the bulk density [18].

3.3.8. Porosity

The porosity of the instant *kheer* mix powder was observed to be 44.8%. Spray dried whole milk has been reported to have 42–77% porosity [6, 13]. Spray dried skim milk and spray dried whey appeared to have a very small or negligible particle porosity [15]. Smaller particles are more porous than the larger ones in the same powder. Porosity of powder may be caused by thermal or mechanical stress in the particle during drying or cooling, resulting in pores or cracks in particles caused by mechanical damage in a cyclone or in a pneumatic conveying system [6].

3.4. Reconstitution behavior of instant *kheer* mix

It was observed that in method "a" (powder-to-water ratio, 1:2; rice-to-powder ratio, 1:5), the rice grains did not cook properly even after 15 min of heating. During extended periods of cooking, there was excessive thickening of the product and it tended to show a burn-on. The grains remained undercooked or tough presumably because in a concentrated milk system, the viscosity of the system and a probable coating of rice particles with hydrated starch

Table IV. Reconstitution behavior* of instant *kheer* mix during indirect dispersion method.

Temperature of water	Ratio of powder to water	Dispersion behavior
25 ºC	1:2	No dissolution, powder lumps floating on the surface: Unsatisfactory reconstitution
25 ºC	1:4	No dissolution even after vigorous stirring: Unsatisfactory reconstitution
50 ºC	1:2	Extensive lumpiness: Dissolution is not satisfactory
50 ºC	1:4	do
75 ºC	1:2	Small lumps persist but generally disappear upon mixing
75 ºC	1:4	do
Boiling water	1:2	Initially large flakes which start dispersing quickly upon mixing: Reconstitution is complete
Boiling water	1:4	Reconstitution is satisfactory

* Observation from duplicate experiments.

and/or concentrated milk hindered diffusion of water into the grains.

Method "b" resulted in satisfactory cooking of the rice after 10 min heating. Depending on the method of manufacture, instant rice has been reported to have a wide range of reconstitution times. Tray dried instant rice had a reconstitution time of 12 to 15 min, whereas vacuum-tray dried rice could be fully cooked in 11–12 min [7]. A reconstitution time of only 5 min has also been reported for rice dried in a fluidized bed dryer with an air velocity of 914 m·min^{-1} (3000 ft·min^{-1}) and air temperature of 132 ºC [21]. Further studies were conducted in order to examine the dispersal of the instant *kheer* mix powder into water as a function of temperature using different powder-to-water ratios. The results are presented in Table IV. Reconstitution temperatures of 25 and 50 ºC were not at all satisfactory, powder dispersal and dissolution being very poor. At 75 ºC, the reconstitution behavior of the product improved, but still dispersal of the powder was incomplete. Reconstitution in boiling water was found to be satisfactory. Such a high water temperature for reconstitution could have been necessitated by the presence of rice starch in the *kheer* mix. The powder-to-water ratio did not seem to have any perceivable effect on the reconstitutability of the powder, although a ratio of 1:4 corresponding to a solids level of approx. 20% was slightly better.

Based on the studies discussed in the preceding section, the method "b" of two-stage reconstitution was selected for optimization of the rice-to-powder ratio in reconstituted *kheer*. In order to arrive at a satisfactory level of reconstitution in terms of grain-to-liquid proportion and overall product consistency, several ratios of instant rice to powder mix (from 1:11 down to 1:5 corresponding to 65–48% total solids in the product) were investigated for a constant powder-to-water ratio of 1:4. The results are presented in Table V. It can be seen from the table that with a rice-to-powder ratio of 1:11, the resulting product had too thick a consistency, as reflected by a very high value of k. As the ratio decreased, total solids also decreased and with that the consistency, the decrease being considerable for ratios 1:9 and 1:7 but of a smaller order for 1:5. The decreasing k was accompanied

Table V. Consistency characteristics of reconstituted kheer obtained by using different rice grains-to-powder ratios**♣.

Rice-to-powder ratio	Total solids (%, by wt)	Rheological properties**		Sensory attributes	
		k (mPa·s^n)	n	Hedonic texture score	Visual consistency rating
1:11	64.79	27296.75	0.40	_	_
1:9	60.99	19799.19	0.42	_	_
1:7	54.61	13593.18	0.43	6.16	80.22
1:5	48.12	12400.48	0.44	8.29	58.19

* Means from duplicate experiments.
** Measuring system 1–3, shear rate range 10–150 s^{-1}.
♣ Powder-to-water ratio, 1:4.

by an improving visual consistency score as well as hedonic texture score, the former (58.2 on a 100-point line scale) being close to optimum and the latter (8.3 corresponding to "like very much") for the product reconstituted at a rice-to-powder ratio of 1:5 (Tab. V).

It can be further seen from the tabulated data that while there was a remarkable decline in the consistency coefficient (k) as the total solids content decreased, there was a comparatively small change in the flow behavior index (n). This may be attributed to the increasing contribution of rice grains to the shear-thinning behavior of the system with increasing proportion (and level) of the grains in it. Bandyopadhyay [3] observed that with increasing concentration during conventional *kheer*-making, the dilatant flow behavior attributable to rice starch became more prominent as compared to the shear-thinning effect of milk solids.

3.5. Sensory properties of reconstituted *kheer*

As discussed in the preceding section, the instant *kheer* mix could be optimally reconstituted by using boiling water as the rice cooking medium followed by dispersal of the mix powder so as to have a powder-to-water ratio of 1:4 and rice-to-powder ratio of 1:5 in the product. *Kheer* reconstituted in this manner was subjected to sensory profiling in comparison with conventional *kheer*. The results are presented in Table VI.

As can be seen from the table, sensorily perceived browning (on an intensity rating scale of 0 to 100) of the reconstituted *kheer* was lower than that for the conventional product (17.1). The whiter appearance of the reconstituted *kheer* was also reflected in its hedonic color score (8.75) which was higher than that for the control (8.50), although both the products were in the "like extremely" category. This improved color may be on account of the less severe heat treatment involved in the production of the instant *kheer* mix.

The visual consistency of reconstituted *kheer* (51.56) was comparable to that of *kheer* prepared by the traditional method (50.0: "optimum"). The grain integrity in reconstituted *kheer* was perceptibly higher (74.76) as compared with traditional *kheer* (60.90). Thus the mechanical damage that

Table VI. Sensory properties of reconstituted *kheer* made from instant *kheer* mix*.

Properties	Conventional *kheer*	Reconstituted *kheer*
Color intensity of browning	17.07	0.33 (0.22–0.45)
Visual consistency	50.0	51.56 (51.38–51.74)
Grain integrity	60.9	74.76 (74.64–74.88)
Lumpiness	13.0	5.42 (4.88–5.96)
Relative amount of grains	48.8	50.68 (50.62–50.75)
Hardness of grains	45.52	60.45 (60.06–60.84)
Stickiness	8.13	25.67 (25.46–25.89)
Coarseness	11.38	24.50 (24.19–24.82)
Sweetness	50.00	50.14 (50.00–50.28)
Cooked flavor	35.00	22.47 (22.20–22.74)
Hedonic score (Color)	8.5	8.75 (8.75–8.75)
Hedonic score (Texture)	9.0	7.09 (7.06–7.13)
Hedonic score (Flavor)	8.5	8.25 (8.25–8.25)
Hedonic score (Overall acceptability)	8.5	8.37 (8.25–8.50)

* Means from triplicate experiments.
Figures in parentheses indicate range.

the rice grains suffered during reconstitution from the *kheer* mix production was far less than that in the traditional method. Lumpiness was also lower in reconstituted *kheer* (5.42) in comparison with conventional *kheer* (13.0), although it was of a small order in both the products.

The visually judged relative amount of grains in reconstituted *kheer* (50.68) was comparable to that of the traditional *kheer* (48.8), indicating that the level of rice in the *kheer* mix was optimal. The sensorily perceived hardness of the grains was more in reconstituted *kheer* (60.45) as compared with the control (45.52) because of the properties which the instant rice grains acquired upon cooking and subsequent drying. Stickiness was perceived to be slightly more (25.67) in reconstituted *kheer* than in the control (8.13). Likewise, coarseness was slightly more in reconstituted *kheer* (24.50) than in the control (11.38). The greater hardness, coarseness and stickiness caused the hedonic texture score of the reconstituted kheer to be smaller (7.09: “like very much”) as compared with the control (9:0: “like extremely”).

The sensory scores for sweetness of both the experimental sample and control were comparable and close to optimum (50.0), as can be seen from Table VI. However, the intensity of cooked flavor in the reconstituted product was somewhat lower than in the traditional product, which in turn resulted in a slightly lower hedonic rating of flavor in the former (8.25) as against the latter (8.50).

The overall acceptability rating was comparable for both the reconstituted product and control, viz., 8.37 and 8.50 (“like extremely”), respectively. It was thus evident that the reconstituted product had a very high sensory status.

4. CONCLUSION

Kheer, is a particulate product comprising both liquid and rice phases. It was the endeavour of this study to simulate the conventional product so that a new product not only with commercially useful shelf life but also with traditional taste and appearance could be developed. The study demonstrated that scientific principles of drying could be very well applied to enhance the self life of a popular traditional dairy dessert. The *kheer* mix powder had a good flowability and bulk density as compared to WMP and SMP. However because of the rice component, its wettability, dispersibility and insolubility index were poor. Upon reconstitution, it yielded a product, which was very much comparable to the traditional *kheer* as evidenced by sensory scores. Technology developed has not only resulted in value addition to farmers' milk but also provided dairy industry a scope for product diversification and export promotion. There was no objectionable deterioration in the product quality during storage for 6 months at 37 °C, which could have rendered it unacceptable. Such a shelf life would facilitate the wide-scale marketing of the product under the tropical conditions prevailing in the country.

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