Effect of fiber blends, total solids, heat treatment, whey protein concentrate and stage of sugar incorporation on dietary fiber-fortified *Kheer*

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Abstract Owing to the proven beneficial role of dietary fiber (DF) on human health, feasibility of incorporating commercially available soluble and insoluble DF preparations into rice-milk-pudding (*kheer*, a popular Indian delicacy) was studied through process modification. The novel approach of preparing reduced fat DF-fortified-*kheer* (DFFK) by developing liquid/cream phase and particulate/rice phase separately, and subsequently blending the two was developed. The major processing variables studied were total solids (TS) in the liquid phase, type of fiber blend, flavor-simulation through heat treatment or added whey protein, and the presence of sugar in water for pre-cooking of rice. Reduced fat DFFK made from three different pre-standardized fiber blends was quite acceptable to the sensory panel (overall rating 7.5). With increasing TS in milk up to 16.5%, sensory acceptability of DFFK increased. There was a small but perceivable improvement in the flavour of DFFK when pre-cooking of rice was carried out in sweetened water. Reduced fat DFFK from different fiber blends was found to be reasonably close to conventional *kheer*. DFFK prepared from Blend-I provided 3.31 g dietary fiber/100 kcal (suitable for the claim “High-in-Fiber”) with 38.71% Reduced-Fat. With the developed process of fortification of *kheer* with DF, it is possible to reduce fat (and thus calories) to cater to the needs of consumers seeking good health.

Keywords Dietary fiber fortification · Fat reduction · Fiber blends · Rice-kheer · Oat bran · Inulin

Introduction

Rice-pudding as called in Western culture is famous by the names of *Kheer*, *Payasam* and *Phirni* in India. Rice-*kheer*, a traditional Indian dairy dessert, is a viscous milk pudding prepared by cooking rice in milk using an open pan. It has cooked rice grains dispersed in a creamy liquid resulting from partial concentration of milk through evaporation and thickening effect of the soluble starch coming from the rice grains (Pant 2010). *Kheer* is very popular throughout India (De 1980). The richness of traditionally prepared *kheer* can be attributed to high content of fat (more than 6%) and protein, added sugar (nearly 9.0%), mostly in caramelized form by prolonged cooking at high temperature.

In some parts of North India, *kheer* is also made from *sevia*n (vermicelli), *makhana* (lotus puffs), *Sabudana kheer* (sago/tapioca) or *dalia* (semolina) with or without nuts (almonds, pistachio and cashewnuts) (Aneja et al. 2002) while in South India, it may include *kaddu* (pumpkin), poppy seeds (*khus-khus*), Bengal gram *dal*, green gram *dal*, rice, rice flour (*Phirni*), cooked rice dough (*ada*), beaten rice, mango and jack fruit. *Kheer* and its variants are acceptable to people of all ages and are particularly favourite of kids and elderly. Owing to its popularity, rice-*kheer* has been the theme of many scientific studies in the past. In 1989, Chaudhary standardized the method for production and preservation of conventional rice-*kheer*. In order to enhance convenience in use for consumers, Rao et al. (1994) used freeze drying process to develop rice-pudding (*kheer*) which could be rehydrated in 5–20 min. Later, Jha et al. (2011, 2014) developed a process for long-life *kheer* and *kheer* mix for

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possible commercial production on large scales and Bunkar et al. (2012) optimized the formulation and process of pearl millet based instant *kheer* mix powder. Recently, Kavimani et al. (2016) studied the influence of total solids on textural and sensory characteristics of *kheer*.

Besides convenience, urbanization and rapidly changing food habits have put an increasing demand for health foods. Because of various established beneficial effects on human health, dietary fiber (DF) has come to be recognized as an important ingredient of health foods. Diets lacking in fruits, vegetables, nuts, and whole grains do not provide sufficient fiber. Inadequate intake of DF was reported to increase the risk of constipation and bowel irregularities. DF has been found to reduce the risk of hyperlipidemia, heart disease, diabetes mellitus and obesity in susceptible genotypes (DeVries 2003 and Anderson et al. 2009). The role of fiber in cardiovascular diseases has been reviewed by Martos et al. (2010). DF also has a protective effect against mouth, throat, and esophageal cancers (Soler et al. 2001). In India, an estimated 600 000–700 000 deaths were caused by cancer in 2012 and slightly more than 1 million new cases of cancer are diagnosed every year in a population of 1.2 billion (Mohandas et al. 2014). However, the bile acid binding property of DF and butyric acid production due to the fermentation of DF by human gut microflora are considered to play preventive role against cancer. The relative in vitro bile acid binding of the cereal brans on an equal total DF was reported as rice bran (51%), wheat bran (31%), oat bran (26%) and corn bran (5%) by Kahlon and Chow (2000).

Various attempts have been made by several researchers to fortify DF into several milk-and-milk-based products, for example, Sekhon et al. (1997) studied the effect of addition of rice bran at 5–15% level to the semolina on the extrusion behavior and the use of the extruded rice bran-added-semolina to develop *kheer*/milk-porridge. It was found that the overall acceptability was not significantly affected with the blending of full-fat and defatted rice bran up to 10%. Soluble dietary fibers (SDF) are known to improve the texture and viscosity of the product without any addition of calories to the product. The physiological properties of grain fiber and some SDF (like inulin and polydextrose) have been reviewed by Raninen et al. (2011). Polydextrose, maltodextrin and pea fibers were reported to be used as a fat substitute at 1.5 per cent in yoghurt (Barrantes et al. 1994). These fat substitutes affected the viscosity of yoghurt. For decades food industry is using various soluble dietary fibers in milk desserts (for example, carrageenan, pectin, sodium alginates) as stabilizers at very low concentrations (normally less than 1.0%) to form gels, to prevent syneresis and to give body and mouthfeel. However, Arora and Patel (2015) developed “Rich/High-in-Fiber” Yoghurt containing 6.03% DF [FDA 2009, 21 CFR 101.13(j)(2)(iv)(A)]. A 200 g serving of which claims to provide 30% of Indian RDA values for DF.

While WHO recommends an intake of 27–40 g DF per day (Cho et al. 2000), Indian Council of Medical Research and National Institute of Nutrition, India advises Recommended Dietary Allowance (RDA 2009) of 40 g DF per day for Indians. Though DF could come from a variety of foods, it can also be fortified in dietary items containing little or no native fiber. In the present study, attempts were made to develop DF fortified rice-*kheer* with reduced fat and the effects of varying ingredients and process parameters were analyzed in terms of sensorial properties as compared with the traditional fat-rich rice-*kheer*.

Materials and methods

Source of materials

Vitacel wheat fiber (WF-200), Vitacel oat fiber (HF-600) and Vitacel microcrystalline cellulose (MCC-105) were procured from M/s J. Rettenmair and Sohne GmbH, Germany. Oat bran was obtained from Bagrry's Pvt. Ltd., India and psyllium (*Plantago ovata*) husk was sourced from ‘Sat Isabgol’, Palani Group, India. Inulin ‘Raftiline ST’ was sourced from ORAFTI, (Belgium). The compositional details of these DF are shown in the Table 1. Fresh, chilled, milk, and sugar of commercial grade were obtained locally. *Basmati* rice (three-fourth broken) was obtained from Setia Export, Karnal (Haryana, India). Whey protein concentrate (Procon 3700, 70% protein) was procured from Mahaan Proteins, Kosikalan (UP, India).

Development of fiber-fortified Rice-Kheer with reduced fat

Attempts were made to incorporate high levels of DF by incorporating a mix of various combinations of soluble and insoluble DF to milk rice-*kheer* so as to qualify for the claim of “High in Fiber” (FDA/CODEX Guidelines). DF were selected on the basis of physiological properties as well as the technological cum functional attributes of low calorific value and impact on textural and rheological properties with minimum/acceptable changes on the sensory quality of the *kheer*. Inulin, psyllium husk, pure oat fiber, oat bran, pure wheat fiber and MCC were dry blended into three fiber blends and were used with regard to thickening of sweetened milk (to serve as the liquid/cream phase of *kheer*). In the present study, we referred to the *Kheer* developed by Chaudhary (1989) as the appropriate comparison food.

A process was standardized to convert the fiber-added milk into development of fiber-fortified rice-*kheer* (Fig. 1) keeping texture and rheological implications in view. Milk added with different fiber blends (Table 2) and cane sugar

Table 1 Compositional characteristics of selected commercial fiber preparations

Sr. no.	Fiber	Moisture (%)	Protein (%)	Ash (%)	TS (%)	Soluble fiber (%)	Insoluble fiber (%)	Total dietary fiber (%)
1.	Wheat fiber (WF-200)	6.17 (8.0)	– (0.4)	1.10 (3.0)	93.83 (92.0)	0.13 (2.5)	– (94.5)	– (97.0)
2.	Oat fiber (HF-600)	8.98 (8.0)	– (0.25)	1.98 (2.6)	91.02 (92.0)	3.85 (3.0)	93.71 (93.0)	97.56 (96.0)
3.	Microcrystalline cellulose (MCC-105)	5.72 (5.0)	–	0.06 (0.05)	94.28 (95.0)	0.39	95.90	96.29
4.	Oat bran	7.44	– (17.0)	2.52	92.56	– (9.0)	– (6.0)	– (15.0)
5.	Psyllium husk	10.82		2.07	89.18	– (13.08)	– (68.08)	– (81.16)
6.	Inulin	2.42 (1.5)	–	0.23	97.58 (98.5)	– (94.7)	–	– (94.7)

Means of triplicate determinations. Figures in parentheses are the values given by the supplier

Fig. 1 Flow diagram for the preparation of DFFK **Table 2** Selected blends of soluble and insoluble fibers for use in *kheer*-fortification

Blend no.	Percent by weight					
	Psyllium	Inulin	Oat fiber	Oat bran	Wheat fiber	MCC
I	5.0	73.0	6.6	–	–	15.4
II	5.5	72.7	–	18.2	3.6	–
III	4.2	61.8	5.5	15.5	–	13.0

Table 3 Viscosity and hedonic rating of reduced-fat *kheer* prepared from milk^a (3% fat) added with different fiber formulations

Particulars	Fiber formulation			F ratio
	Blend-I (5.5% in milk)	Blend-II (5.5% in milk)	Blend-III (6.5% in milk)	
Appearance score	7.3	7.3	7.4	0.16 ^{NS}
Consistency of liquid phase	7.3	7.5	7.6	0.82 ^{NS}
Texture score	7.3	7.5	7.7	2.59 ^{NS}
Sweetness score	6.9	6.9	6.9	0.02 ^{NS}
Flavour score	7.4	7.3	7.5	0.21 ^{NS}
Overall rating	7.5	7.5	7.5	0.02 ^{NS}
Apparent viscosity at 20 °C (Pa.s) ^b	170.38	400.37	80.50	5.54

Means from duplicate experiments

NS Non-significant

^a TMS = 11.2% (Fat/SNF = 0.3), Sugar = 12%; milk-rice mixture heated at 90 °C for 5 min^b PD spindle, Heldal attachment, 1.5 rpm

(ground to a fine powder using Inalsa kitchen-grinder) was blended with precooked rice (2:1) and the mixture was heated followed by cooling to room temperature and overnight refrigerated storage. Attempts were made to simulate the sensory characteristics of traditional product while incorporating blends of DF. The effect of different type of the fiber blends (as shown in Table 3) and total solids (TS) in the liquid phase (12–18%) were studied on the apparent viscosity and sensory rating of DFFK. Blend-III was added at a higher level to match the total dietary fiber content in the DFFK as contributed by Blend-I or Blend-II (compare Table 1 with Table 2). Flavor-simulation through heat treatment of DFFK (milk was heated to either 90 °C/5 min or 121 °C/5 min either before blending or after blending with precooked rice) or added whey protein to DFFK in the form of whey protein concentrate (WPC) or the presence of sugar in water for pre-cooking of rice was tested. The DFFK was subjected to sensory evaluation by a laboratory panel of 7–10 trained judges using a 9-point hedonic scale (Score 9 means ‘Like Extremely’ and Score 1 means ‘Dislike Extremely’) for various sensory attributes like appearance, consistency of liquid phase, texture of rice grains, sweetness (low/high), flavor and over all acceptability. Samples were served in silence zone with three digit code numbers in random orders and RO water was served to rinse the mouth.

Analytical methods

The viscosity of DFFK was determined by taking 130 ml sample in a 150 ml glass beaker (dia. 5.3 cm; sample height, 6.0 cm) and using Viscostar Plus model L viscometer (Fungilab, Spain) fitted with Heldal unit with T-shaped (spindle PC or PD at rpm 10 or 1.5 rpm, respectively). The colour of DFFK was measured using a ColorFlex colour-meter (Hunterlab, USA) with a dual beam

xenon flash lamp. Before the test, the instrument was calibrated with standard black glass and white tile as specified by the manufacturer. Data were obtained in terms of L* [lightness, ranging from zero (black) to 100 (white)], a* [ranging from +60 (red) to –60 (green)] and b* [ranging from +60 (yellow) to –60 (blue)]. The TS content was determined gravimetrically (105 ± 2 °C) till a constant weight. The protein content was determined through nitrogen estimation by Kjeldahl method using 0.5 g of the ground sample (AOAC 2000). A factor of 6.25 was used to convert nitrogen to protein (because of the presence of DF in DFFK). The fat content of *kheer* was determined by the Rose-Gottlieb method as described by FSSAI (2016). The ash content was determined by charring approx. 3.0 g sample and then ashing the same (AOAC 2000). The total DF content of the powdered, oven-dried (105 ± 2 °C, overnight) DFFK was estimated by the AOAC (2000) method employing TDF-100A kit supplied by Sigma (USA). The data generated during the present investigation were subjected to analysis of variation (ANOVA) using MS Excel software.

Results and discussion

In order to incorporate commercially available soluble and insoluble DF preparations into rice-*kheer* process modifications were made in the traditional method of open pan cooking of rice in milk. DF-fortified *kheer* was prepared with a novel approach of preparing the liquid phase and the particulate (rice) phase separately, and subsequently blending the two at a lower time–temperature treatment than the conventional *kheer*. Here the added DF was utilized to develop desired consistency in the *kheer* which was otherwise thin due to the reduced fat in the milk used for the *kheer* preparation and also with almost no or less

evaporation at reduced time and temperature of processing than the conventional *kheer*.

Effect of the type of fiber blend on physical properties of reduced-fat *kheer*

In order to simulate the liquid phase consistency of rice-*kheer*, different fiber blends (vide Table 2) comprising different proportions of soluble DF contributing to the thickening of the product, and insoluble DF countering the latter effect were examined for their effects on sensory attributes. All three variants of DFFK were made from milk with reduced fat (3%). Table 3 indicates that reduced fat DFFK made from the different fiber blends was quite acceptable to the sensory panel as the mean sensory scores were lying between ‘Liked Moderately’ and ‘Liked Very Much’ on 9-point hedonic scale. SDF such as inulin and psyllium with proven health benefits serve as effective thickeners in the product whereas IDF such as microcrystalline cellulose, oat fiber, oat bran and wheat fiber not only help simulate the product texture and mouth-feel but also make the fiber content of the product more complete from the functionality point of view. The type of fiber blend did not make any significant difference in the sensory status of the product, though Blend-II and Blend-III gave a slightly improved consistency and texture as compared to Blend-I. This improved consistency corresponded with a slightly increased viscosity rating (on a 100-point linear intensity scale; rating ‘100’ for milk-like Very Thin and ‘0’ for gelly-like Extremely Thick viscosity) of the milk containing fiber Blend-III (score, 63.0 as against 69.8 and 69.0 for milk containing Blend-I and Blend-II, respectively). Similarly, the improved texture score of the *DF-Fortified kheer* coincided with a coarser (or, less slimy) mouth-feel of the fiber-added milk (intensity rating, 64.3 and 68.3 for milk containing Blend-II and Blend-III, respectively, as compared to 76.8 with Blend-I). It thus appeared that the use of oat bran in addition to oat fiber (Blend-III vis-à-vis Blend-I) could help overcome the ‘sliminess’ perceived due to the presence of psyllium in the product. The apparent viscosity of *kheer* made using milk added with fiber Blend-II was maximum on account of its high psyllium content while Blend-III with additional oat bran content yielded a product with lowest viscosity conceivably because of lower psyllium content and reduced gel formation also aided by the increased bran level along with oat fiber. As the effect of different types of fiber blends on the sensory properties of the product was same (statistically non-significant difference), all the three blends would be recommended to prepare DFFK. However Blend-III should be preferred as it could successfully overcome the slight sensorial difficulties posed in Blend-I and –II DFFK and also from the

functionality point of view, Blend-III comprised of varied sources of DF (five) than Blend I (four) and II (four).

Effect of the TS content of fiber-added milk on the properties of reduced-fat *kheer*

With increasing TS up to 16.5% in milk, the appearance score of the resulting product increased from 7.3 to 7.9 but further increase in TS was of no avail (Table 4). Consistency and texture scores also improved with increasing TS (from 7.1 to 7.9 and 7.4 to 7.8, respectively) but further increase in TS resulted in a slight decline. The increase in consistency was significant ($P < 0.05$) with every increment of 1.5% TS up to 15%. The increased consistency score was reflected in significantly increased apparent viscosity of the product (from 2.70 to 6.39 Pa.s) ($P < 0.01$). Kavimani et al. (2016) also reported the similar effect on the consistency of *kheer* with increased TS. However, they increased the TS with the increased cooking time and with the evaporation of water. In this study, the highest TS level of 18%, corresponding to 0.38% psyllium, made the product slightly thick though no significant difference was observed in the liquid phase consistency score for DFFK made from 15.0 and 16.5% TS. While there was no perceivable impact of TS on the sweetness of the product, the flavour score slightly increased (from 7.1 to 7.5) owing to increasing TS. Overall sensory rating of DFFK also registered an increase from 7.1 to 7.6 as the TS increased to 16.5% although the increase was non-significant. This effect could be attributed to improved consistency and flavour scores with increased TS. The pH of DFFK was neutral over the entire TS range. Also, the instrumental colour parameters L^* and a^* values did not vary appreciably with increasing TS in milk. The studied levels of DF addition in the prepared samples was quite broad (5.5–7.4%) but surprisingly the overall acceptability rating was statistically non-significantly different which could be attributed to increase in total milk solids (TMS) with respect to increase in DF content such that the ratio between the fiber solids to milk solids was 0.73. The increased TMS were able to hold or disperse the increased DF in the pudding such that only perceivable difference could be seen for the consistency scores in conjunction with the significantly different values of apparent viscosity. Overall, all the samples of DFFK made with different TS and fiber contents were quite acceptable to the sensory panel as the mean sensory scores were between ‘Liked Moderately’ and ‘Liked Very Much’. However, on the basis of consistency scores, milk with TS (including fiber) either 15 or 16.5% should be preferred to develop DFFK. Such DFFK would be high in milk solids-not-fat along with rich content of beneficial DF (6.4 and 7.2%, respectively)

Table 4 Effect of TS in the milk/liquid phase^a added with fiber Blend-I on the physical and sensory properties of reduced-fat DFFK^b

Particulars	TS (including fiber) in the milk phase with 3% fat					F ratio (LSD)
	12.0%	13.5%	15.0%	16.5%	18.0%	
Appearance score [@]	7.3	7.7	7.8	7.9	7.9	1.28 ^{NS}
Liquid phase consistency score [@]	7.1 ^a	7.3 ^b	7.8 ^d	7.9 ^d	7.7 ^c	3.21 (0.18)
Texture score [@]	7.4	7.5	7.5	7.8	7.7	0.40 ^{NS}
Sweetness score [@]	7.8	7.8	7.8	7.7	7.8	0.20 ^{NS}
Flavour score [@]	7.1	7.1	7.3	7.3	7.5	1.19 ^{NS}
Overall rating [@]	7.1	7.2	7.5	7.6	7.5	1.15 ^{NS}
pH at 20 °C	7.0	7.0	7.0	7.0	7.0	–
Apparent viscosity (Pa.s) [#]	2.7 ^a	4.9 ^b	5.9 ^c	6.4 ^{c,d}	6.6 ^d	11.86 (0.65)
Hunter L* value	87.0	87.1	87.3	87.1	87.4	–
Hunter a* value	–1.9	–2.0	–2.1	–2.0	–2.0	–
Hunter b* value	7.5	8.2	8.5	8.9	8.7	–

^a Milk containing 7.1–10.6% total milk solids to which 5.5–7.4% total fiber (corresponding to a fiber solids-to-milk solids ratio of 0.73) and 9.0% sugar

^b *kheer* obtained by blending the milk phase with precooked rice (2:1)

[#] PC spindle, Heldal attachment, 20 °C, 10 rpm

[@] On a 9-point hedonic scale

Means with the same superscript in a row do not differ significantly ($P < 0.05$)

and reduced content of milk fat but with no compromise to taste and other sensory properties.

Effect of different heat treatment on the fiber-added reduced-fat *kheer*

The rice-pudding obtained by blending of fiber-added milk and precooked rice did not have the desired intensity of the ‘cooked’ flavour found in conventional *kheer*. Apparently, the brief heat treatment at 90 °C for 5 min used in the experiments was inadequate in developing the desired flavour. This finding is in agreement with the findings of Chaudhary (1989) who reported that *kheer* obtained by blending of precooked rice and sweetened condensed milk followed by boiling for 5 min was inferior to the conventional product in terms of flavour and other attributes. The higher heat treatment (121 °C/5 min, achieved in an autoclave) of the milk before blending or after blending with precooked rice was compared with regard to the flavour and other sensory attributes of the product prepared by heat treating at 90 °C for 5 min in a water bath. The higher heat treatment was considered equivalent to the conventional heat treatment of approximately 40 min at 100 °C giving rise to an HMF content of 16 µmol/L (Kessler 1996). It was, however found that the high intense heat treatment failed to show any improvement in flavour. In fact, the flavour scores were lower for reduced fat DFFK prepared by heating milk at 121 °C for 5 min before blending (7.2) and after blending (7.4) with precooked rice

as compared to the lower heat treatment (90 °C/5 min: score, 7.9). The major criticism in terms of flavour was ‘staleness/sterilization taste’, developed in the high heat treated *kheer* which could probably be attributed to high heat treatment (121 °C for 5 min) of milk proteins. The high heat treatment (121 °C for 5 min) of milk proteins might had caused either excessive denaturation of proteins leading to the formation of n-methyl ketones and o-aminoacetophenone responsible for stale flavour (Chandan et al. 2015) and/or might be the reaction of proteins with sugar leading to Maillard reaction (Mai 2012). The overall sensory rating (7.8 vs. 7.3 for before blending and 7.4 for after blending) as also appearance score (7.9 vs. 7.6 and 7.2, respectively) of the product was found to be better with the lower heat treatment than the higher heat treatment, respectively as the higher heat treatment had caused brownish appearance which might be due to Maillard reaction (Mai 2012). Therefore, the lower heat treatment was selected and other means of developing cooked flavor was evaluated as below.

Effect of the addition of whey protein concentrate (WPC) to fiber-added milk on the properties of the reduced-fat *kheer*

Whey protein in a heated milk system is a major source of cooked flavour attributable to the sulfhydryl groups becoming exposed upon denaturation of this protein (Fox and Condon 1982). In order to develop the desired cooked-

flavour intensity in the DFFK, the milk solids level of the mixture was raised by adding 2% whey protein concentrate (WPC, 70% protein) along with 2% whole milk powder (WMP) and compared with DFFK prepared with SMP (@ 2%) along with 2% WMP. The fiber-added and MSNF-fortified milk mixed with precooked rice was heat-treated in different sets of experiments to 90 °C for 5 min, 90 °C for 10 min, or by boiling for 5 min so as to effect extensive denaturation of whey proteins. It was found that irrespective of the type of fiber blend used and the heat treatment, DFFK obtained using WPC or SMP scored nearly the same in respect of flavour score or other sensory attributes. The product containing fiber Blend-I and SMP was overall, slightly better than the rest, though the difference being non-significant (data not shown here). Also, viscosity-wise and colour-wise, the product obtained with the use of added WPC was essentially similar to that with added SMP, although the colour parameter (a^* value) showed a slightly reduced greenness (−1.32 vs. −1.42 and −1.01 versus −1.17 for fiber Blend-I and Blend-II, respectively) corresponding to a slightly increased redness, whereas the b^* value suggested an increased yellowness (8.74 vs. 8.52 and 8.93 vs. 8.72 for fiber Blend-I and Blend-II, respectively). However, the flavour changes in the product with or without WPC were not significant. As the addition of WPC (@ 2% level) was not found to suitably enhance the flavour of DFFK therefore, another innovative idea of performing precooking of rice in sweetened water was tested so as to bring the desired flavour.

Effect of precooking of rice in sweetened water on reduced-fat *kheer*

Kheer making by the traditional method of cooking rice in milk over an extended period might result in diffusion of soluble solids, particularly sugar into the swollen rice grains undergoing gelatinization. Therefore, use of sweetened water for precooking of rice was considered to potentially give an improved taste perception of the rice grains in DFFK. Comparison of the products obtained from rice precooked in water and that from precooked in sugared water (sugar @ 14%) (Table 5) showed that there was a small but perceivable improvement in the flavour of the product when precooking was carried out in sweetened water (scores 8.0 vs. 7.7 and 7.7 vs. 7.6 for Blends-I and II, respectively) while other sensory attributes did not show any noticeable impact except the texture score which tended to slightly decline with precooking in sweetened water (probably, the osmotic forces increased the toughness of rice grains), however the difference in the scores were non-significant statistically. The overall sensory rating exhibited a slight improvement (7.9 vs. 7.8 and 7.8 vs. 7.7). Presumably, the diffusion of sugar which increased the

sweetness of the rice grains was responsible for the slightly improved flavour and overall acceptability of DFFK. Also, the apparent viscosity measured instrumentally was significantly affected by this treatment; the DFFK samples prepared from precooking of rice in sweetened water was rather close to the conventional *kheer*. Thus, it is recommended that the precooking of rice in the sweetened water should be followed while preparing DFFK.

Nutritive value and claims for DFFK in comparison to the conventional *kheer*

DFFK obtained from Blend-I had on an average 4.75% protein ($\%N \times 6.25$), 3.91% fat, 0.59% total ash, 18.90% carbohydrates (including DF content of 4.03%) and 28.15% TS. The conventional product, on the other hand, had 5.44% protein, 6.38% fat, 0.74% total ash, 25.68% carbohydrates (without any added DF) and 38.23% TS (Chaudhary 1989). The DF content of the fiber-enriched *kheer* [4.03 g for 113.67 kcal (assumed no calories from DF) i.e., 3.55 g DF/100 kcal; 4.03 g for 121.73 kcal (assumed 2 kcal/g DF as recommended by FAO 1998) i.e., 3.31 g DF/100 kcal; 4.03 g for 129.8 kcal (assumed 4 kcal/g DF by Atwater general factor system) i.e., 3.1 g DF/100 kcal] was sufficiently high for it to be termed as ‘High in Fiber’ (European Commission 2006) which requires at least 3 g of fiber per 100 kcal. It corresponds to 37.51, 33.1 and 28.57% reduction in energy respectively, in comparison to conventional *kheer*. The 38.71% reduction in fat content in DFFK (3.91% vs 6.38%) makes it eligible for the claim for “Reduced Fat” which requires at least 25% less fat per reference amount than appropriate comparison food (Federal Register 1993; FDA 2009 and Jones and Russell 2004).

The fortification with DF enabled the development of “Reduced fat” *kheer*. It is vital to communicate and educate the consumer via means of authentic claims in solving the purpose of such food product development in actualizing the health benefits to the public. One of the studies found that the milk desserts enriched with fiber with health claims showed the highest willingness to purchase scores by consumer Ares et al. (2010).

Conclusion

The different fiber blends (I, II & III) with different combinations of soluble and insoluble fibers were tested in the present study for incorporation as non-conventional ingredients in milk-rice *kheer*. The present study reveals the effect of different level of total solids, low and high heat treatment, stage of sugar incorporation and addition of WPC on the physical and sensory acceptability of DFFK

Table 5 Properties of reduced fat *kheer* obtained from fiber-added milk^a and rice pre-cooked in plain water or sweetened water

Particulars	Blend-I		Blend-II		Conventional kheer	F ratio (LSD)
	Precooking in water	Precooking in sweetened water ^b	Precooking in water	Precooking in sweetened water ^b		
Appearance	8.13	7.90	7.84	7.66	7.60	0.90 ^{NS}
Consistency of liquid phase	7.91	7.90	7.97	7.84	7.95	0.09 ^{NS}
Texture	7.86	7.82	7.79	7.66	7.80	0.20 ^{NS}
Sweetness	7.79	7.89	7.82	7.97	7.90	0.13 ^{NS}
Flavour	7.66	7.98	7.61	7.74	7.60	0.48 ^{NS}
Overall rating	7.75	7.90	7.69	7.78	7.67	0.16 ^{NS}
pH at 20 °C	7.0	7.0	6.98	6.95	6.78	-
Fat (%)	3.91	3.92	3.90	3.91	6.37	-
Apparent viscosity (Pa.s) [@]	7.75 ^d	4.97 ^b	5.69 ^c	4.07 ^a	4.32 ^a	4.79 (0.29)
Hunter L* value	87.26	85.63	85.82	85.65	86.27	-
Hunter a* value	-1.16	-1.075	-0.91	0.96	-1.41	-
Hunter b* value	8.87	9.06	9.30	9.26	10.97	-

Means from duplicate experiments

NS—Non-significant; LSD—Least significant difference

Means with different superscripts in a row differ significantly ($P < 0.05$)

^a 15% TS milk (fat-SNF ratio, 0.50) added with fiber Blend-I or -II (5.5%) and 14% sugar; mixed-phase of *kheer* heated at 90 °C for 5 min

^b Presoaked rice cooked in boiling water containing 14% sugar for 15 min

[@] PC T-spindle of Heldal unit, 20 °C, at 10 rpm

leading to a better understanding and improvement of the process and the product. DFFK was made through the modified process of developing liquid/cream phase and particulate/rice phase separately, and subsequently blending the two. Further, by increasing the milk-solids-not-fat along with the proportion of DF blend to 16.5% TS, selecting lower heat treatment (90 °C/5 to 10 min) over intense heat treatment (121 °C/5 min) and conducting precooking of rice in sweetened water made DFFK fairly comparable to the traditional product in its sensory quality while definitely having a greater health potential with added DF and reduced-fat.

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