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Development of Iron and Calcium Enriched Nutraceutical Whey Based Porridge

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A B S T R A C T

The aim of this study was to develop a calcium and iron-rich whey-based porridge using finger millet and pearl millet flour at 10%, 20%, and 30% concentrations. Stevia partially substituted the sugar, with different sugar:stevia combinations at 8% level for the porridge. Organoleptic scores showed that porridge with 30% finger millet flour, 20% pearl millet flour, and a 25:75 sugar:stevia combination scored the highest. The developed porridge had a moisture content of 82.04% and total solid content of 17.96%, consisting of 1.3% fat, 1.85% protein, 4.6% lactose, 0.94% ash, and minerals such as 98mg/100g calcium and 1.44mg/100g iron. The porridge was packed in polyethylene terephthalate and refrigerated without affecting sensory attributes. Finger millet contributed to the porridge's high calcium content, while pearl millet contributed to the high iron content.

Introduction

Today's consumer is becoming aware of the concept for convenience and healthy foods. The demand for shelf stable and nutritious convenience foods has been increased due to improving economic status, life style logistics, urbanization and concern about health benefits. The modern trend for development of new food products aspires for complementary foods in order to fulfill the widening gap of food availability and nutritional security. Innovation in the production of value added dairy products offers a valuable growth opportunity for the food and beverage industries.

In India, wide ranges of traditional foods are consumed as breakfast. Porridge is a dish made of grains or legumes, milk or water, heated and stirred until thick and addition of salt or sugar typically eaten for breakfast. To attract consumers, traditional products must be reformulated to meet demands for fast preparation time, convenience and health significance. Acceptability and nutritional attributes are frequently enhanced by added ingredients and

sophisticated processing and packaging (Gandhi *et al.*, 2013). Development of products with the combination of dairy ingredients and cereals are being experimented in number of products.

Whey is a by-product obtained during coagulation of milk by using acid and/or rennet or physico-chemical process for the preparation of cheese, paneer, chhana, chakka and casein. Paneer whey contains sodium 350 mg/l, potassium 1300 mg/l, calcium 480 mg/l, magnesium 59 mg/l, chloride 1349 mg/l, citrate 6750 mg/l, zinc 280 µg/l, total protein 0.41 per cent, fat 0.01 per cent, lactose 4.5 per cent, total solids 5.8 per cent, pH 5.5 (Nupur and Gandhi, 2009). Many attempts have been made on utilization of whey in the formulation of various dairy products but, still there is lot of scope to explore the possibilities for its utilization in beverages particularly in health based energy drink production (Singh *et al.*, 2009).

Cereals are a major food source in arid and semi-arid parts of the world, and are good source of energy. They provide protein, fatty acids, minerals, vitamins, dietary fibre and polyphenols (Devi *et al.*, 2011). Finger millet also known as *ragi* in India, is one of the important cereals occupies highest area under cultivation among the small millets. It is rich in calcium (344 mg), dietary fibre (3.6 g), iron (3.9 mg) and protein (7.3 g). Moreover, it is also a rich source of thiamine, riboflavin, iron, methionine, isoleucine, leucine, phenylalanine and other essential amino acids. The abundance of these phytochemicals enhances the nutraceutical potential of finger millet, making it a powerhouse of health benefiting nutrients. (Chandra *et al.*, 2016). Traditionally ragi is processed either by malting or fermentation (Rao *et al.*, 2001). Malting of finger millet improves its digestibility, sensory and nutritional quality as well as pronounced effect in the lowering the anti-nutrients. Malting characteristics of finger millet are superior to other millets and ranks next to barley malt (Pawar *et al.*, 2007). The malted and fermented ragi flour are extensively used in preparation of weaning food, instant mixes and beverages. Kang *et al.*, (2008) reported that the fortification of finger millet in food not only improve the taste but is also helpful in controlling glucose level in diabetic patients very effectively.

Pearl millet (*Pennisetum glaucum* L. R.Br.) also known as bajra is an important coarse grain cereal crop and ranks fifth after rice, wheat, maize and sorghum. India is the largest producer of pearl millet both in terms of area (8.69 mha) and production (10.05mt) with an average productivity of 1156 kg/ha. Pearl millet has high nutritional value in terms of high levels of energy, dietary fibre and proteins with a balanced amino acid profile, many essential minerals, some vitamins and antioxidants. Pearl millet contains high amount of Iron (8mg/100g) and Zinc (3.1mg/100g), (NIN, 2003) which may help to increase the Hb levels. However the presence of several non-nutrients such as phytates and polyphenols may decrease the bioavailability of iron. Use of household processing technologies such as popping, germination, fermentation as described above may lead to reduction of these non-nutrients and further leads to increase in bioavailability of iron and zinc (Nambiar *et al.*, 2011). Millets are gluten-free, therefore an excellent option for people suffering from celiac diseases. It is also useful for people who are suffering from atherosclerosis and diabetic heart disease (Gelinas *et al.*, 2008).

Porridge can be used as good vehicle for supplementation of cereals and utilization of whey to improve nutritional composition and enhance health benefits. The present study involved in developing the whey based porridge incorporating finger millet and pearl millet flours in which sugar was partially substituted by natural sweetener stevia. It is heat-stable up to 200°C, acid-stable, and not fermentable (Kroyer, 2010), which make it suitable for use in different food products. Additionally, its organoleptic characteristics were found acceptable (Prakash *et al.*, 2008), which suggest that it could be used as a substitute for sucrose. Since the ingestion of sugar increases caloric intake and can lead to obesity, a risk factor for some chronic diseases, this

common sweetener has been restricted in the diet of diabetics.

Materials and Methods

Paneer whey was used from Students Experimental Dairy Plant (SEDP), Dairy Science College, Hebbal, Bangalore. Good quality cane sugar was procured from the local market in Bengaluru. The fresh ragi malt was prepared at laboratory of Dairy Science College, Bengaluru, in a clean and Hygienic condition as per Desai *et al.,* (2012) with slight modifications for the preparation of bioactive nutraceutical whey porridge. The fresh pearl millet malt was prepared at laboratory of Dairy Science College, Bengaluru, in a clean and hygienic condition as per Badau *et al.,* (2005) with slight modifications for the preparation of bioactive nutraceutical whey porridge. Stevia was used as a bio sweetener to replace sugar procured from the outlet of Stevia world in Bengaluru. Packaging material such as Polyethylene teraphthalate (PET) jars of standard size 100 ml were used for packaging of the whey porridge and dry blend of the ingredients required for preparation of whey porridge which was procured from Grace International, Valiv Vasai, Thane.

Preparation of control whey porridge

Control porridge was prepared by incorporation of finger millet flour at the rate of 20% and sugar at the rate of 8%.

Development of whey based porridge

Clear whey was obtained by the paneer prepared as per the procedure given by Arunkumar (2006), with slight modifications. Clarified whey was pasteurized at 90°C/ no hold and then cooled to 37°C. Combination of malted finger millet and pearl millet flours are added to the whey slowly at different levels i.e., 10%, 20% and 30% and stirred continuously in order to avoid lumps formation. Sugar replacement was tried with bio sweetener, Stevia with partial replacement of sugar at 50:50, 25:75 or 0:100. It was also tried by complete replacement of sugar at 2, 4 or 6 per cent of stevia and stirred continuously. Then the whole mixture was heated to 75°C for 5 min and cooled to room temperature. The final product was packed in Polyethylene teraphthalate (PET) jars and stored in refrigeration temperature.

Determination of compositional parameters

Standard procedure of ISI: SP 18 (Part XI) 1981 was adopted for carrying out chemical analysis such as fat, total solids, titratable acidity determination while pH was measured in digital pH meter at 25°C.

Sensory evaluation

Whey porridge samples were given to a panel of five judges for sensory evaluation. Each judge was supplied with standard score card of a total of 9 Point Hedonic Scale (Annexure-1) for colour and appearance, body and texture, flavor and overall acceptability. The scores given by panel of judges were then statistically analyzed. The samples were code numbered to avoid identification and bias.

Statistical analysis

The data was analyzed using R software {R Programme, R-Version 3.1.3(2015-3-09), Copyright © 2015} both one way and two way Completely Randomed Design (CRD) which is the most appropriate for the study.

Results and Discussion

Effect of different combinations of malted finger millet and pearl millet flour on sensory quality of whey porridge

Whey porridge was incorporated with malted finger millet and pearl millet flour at various combinations of 50:50, 60:40 and 70:30. Whey incorporated with 70:30 combination ratio of malted finger millet and pearl millet flour showed higher sensory scores with respect to colour and appearance, body and texture,

flavour and overall acceptability. It secured maximum overall acceptability scores of 8.16 out of 9.00 as against 8.33 for control sample. Other combinations like 50:50 and 60:40, the sensory scores were reduced and quality of product was unsatisfactory as shown by colour and appearance. Higher concentration of pearl millet flour had definite effect on body and texture and flavour. Hence 70:30 combinations were selected for further studies.

Effect of different levels of combination of malted finger millet and pear millet flour on the sensory quality of whey porridge

Combination of malted finger millet and pearl millet flour (70:30) was incorporated at 10, 20 and 30 per cent. Developed whey porridge with 20 per cent levels showed better sensory scores. It secured overall acceptability score of 8.26 as against 8.46 for control. Further increase in the levels of millet flour resulted in lower sensory scores with unacceptable body and texture and flavour.

Effect of different levels of sugar and stevia on sensory quality of finger millet and pearl millet flour incorporated whey porridge

Whey porridge was tried with three different combinations of sugar:stevia (50:50, 25:75 and 0:100). Sugar:stevia in the ratio of 25:75 showed better sensory quality with respect to colour and appearance, body and texture, flavour and overall acceptability compared to 50:50 and 0:100 combinations. It secured maximum overall acceptability scores of 8.31 out of 9.00 as against 8.46 for control sample. Hence sugar:stevia at the ratio of 25:75 is accepted in further studies.

Effect of different levels of stevia on sensory quality of whey porridge

Whey porridge was also tried with complete replacement of sugar with stevia at three different levels (2.0, 4.0 and 6.0 per cent) for preparation of whey porridge. Incorporation of 4.0 per cent stevia showed better sensory quality with respect to colour and appearance, body and texture, flavour and overall acceptability. It secured maximum overall acceptability scores of 8.4 out of 9.00 as against 2.0 (7.76) and 6.0 (7.6) per cent and 8.46 for control sample. Hence stevia at 4.0 per cent was selected for further trials, as complete replacement of sugar.

Chemical Composition of nutraceutical whey porridge

The chemical composition of control porridge and developed whey porridge is presented in Table 9. Porridge (control) had an average moisture content of 83.24, total solid content of 16.76 per cent which comprised of fat 0.3 per cent, protein 1.46 per cent, and ash 0.6 per cent and minerals like calcium content of 70 mg/100g and iron content of 1.2 mg/100g. Similarly the developed whey porridge had an average moisture content of 82.04, total solid content of 17.96 per cent which comprised of fat 1.3 per cent, protein 1.85 per cent, lactose content of 4.6 per cent and ash 0.94 per cent and minerals like calcium content of 98 mg/100g and iron content of 1.44 mg/100g. From the above results it is clear that there is significant increase in the components of fat, protein, calcium and iron in developed whey porridge, when compared with the control porridge. This could be due to the components present in finger millet and pearl millet flour which upon in combination resulted in the increased level of the total solids, fat, protein, calcium and iron.

Physical properties of nutraceutical whey porridge

The physical properties of control porridge and developed whey porridge studied in the present investigation have been presented in Table 7. The physical properties of porridge like pH, acidity and water activity were 5.60, 0.06 and 0.98, respectively. The developed whey porridge had an average pH of 4.9 which was lesser than the control porridge; the developed whey porridge sample had an average acidity of 0.23 per cent (lactic acid), which was more than the control porridge acidity.

Table.1 Effect of different combinations of malted finger millet and pearl millet flour on sensory quality of whey porridge

Levels of malted finger millet : pearl millet flour	Colour & Appearance	Body and Texture	Flavour	Overall acceptability
Control	8.16^{a}	7.93^{a}	8.26^{a}	8.33^{a}
50:50	7.6^{b}	7.4^{b}	7.53^{b}	7.73^{b}
60:40	7.9^{ab}	7.56^{bc}	7.66^{bc}	7.8^{bc}
70:30	8.26^{ac}	8.06^{ad}	8.0^{acd}	8.16^{acd}
CD(P≤0.05)	0.40	0.30	0.39	0.36

Note:
- Similar superscripts indicate non – significance at the corresponding critical difference
- Control – Standard porridge
- All values are average of three trials

Table.2 Effect of different levels of combination of malted finger millet and pearl millet flour on sensory quality of whey porridge

Levels of malted finger millet and pearl millet flour (%)	Colour & Appearance	Body & Texture	Flavour	Overall acceptability
Control	8.43^{a}	8.36^{a}	8.33^{a}	8.46^{a}
10	7.86^{b}	8.00^{b}	8.03^{b}	8.00^{b}
20	8.16^{c}	8.26^{ac}	8.26^{ac}	8.26^{c}
30	7.73^{bd}	7.6^{d}	7.86^{d}	7.8^{d}
CD(P≤0.05)	0.16	0.11	0.16	0.09

Note:
- Similar superscripts indicate non – significance at the corresponding critical difference
- Control – Standard porridge
- All values are average of three trials

Table.3 Effect of different combinations of sugar and stevia on sensory quality of finger millet and pearl millet flour incorporated whey porridge

Combinations of sugar : stevia	Colour & Appearance	Body and Texture	Flavour	Overall acceptability
Control	8.33^{a}	8.43^{a}	8.33^{a}	8.46^{a}
50:50	7.7^{b}	7.66^{b}	7.83^{b}	7.86^{b}
25:75	8.23^{ac}	8.16^{c}	8.16^{ac}	8.31^{c}
0:100	7.85^{bd}	7.55^{bd}	7.71^{bd}	7.83^{bd}
CD(P≤0.05)	0.19	0.25	0.18	0.11

Note:
- Similar superscripts indicate non – significance at the corresponding critical difference
- Control – Standard porridge
- All values are average of three trials

Table.4 Effect of different levels of stevia on sensory quality of whey porridge

Levels of stevia (%)	Colour & Appearance	Body and Texture	Flavour	Overall acceptability
Control	8.33^{a}	8.43^{a}	8.46^{a}	8.46^{a}
2	7.93^{b}	7.73^{b}	7.70^{b}	7.76^{b}
4	8.43^{ac}	8.36^{ac}	8.03^{ac}	8.40^{ac}
6	8.00^{bd}	7.73^{bd}	7.86^{bcd}	7.60^{bd}
CD(P≤0.05)	0.18	0.26	0.29	0.25

Note:
- Similar superscripts indicate non – significance at the corresponding critical difference
- Control – Standard porridge
- All values are average of three trials

Table.5 Chemical composition of bioactive nutraceutical whey porridge

Constituents (%)	Control porridge	Whey porridge	CD (P≤0.05)
	Mean		
Moisture	83.24^{a}	82.04^{b}	0.60
Total Solids	16.76^{a}	17.96^{b}	0.85
Fat	0.30^{a}	1.30^{b}	0.50
Protein	1.46^{a}	1.85^{b}	0.32
Lactose	-	4.6	-
Ash	0.60^{a}	0.94^{b}	0.28
Calcium (mg/100g)	70^{a}	98^{b}	1.50
Iron (mg/100g)	1.20^{a}	1.44^{a}	NS

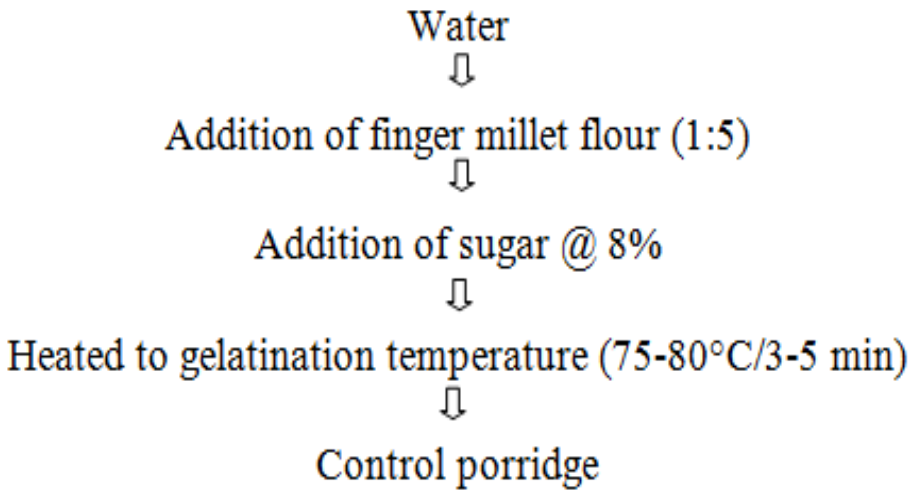
Note:
- Similar superscripts indicate non – significance at the corresponding critical difference
- Control – Standard porridge
- All values are average of three trials

Table.6 Physical properties of nutraceutical whey porridge

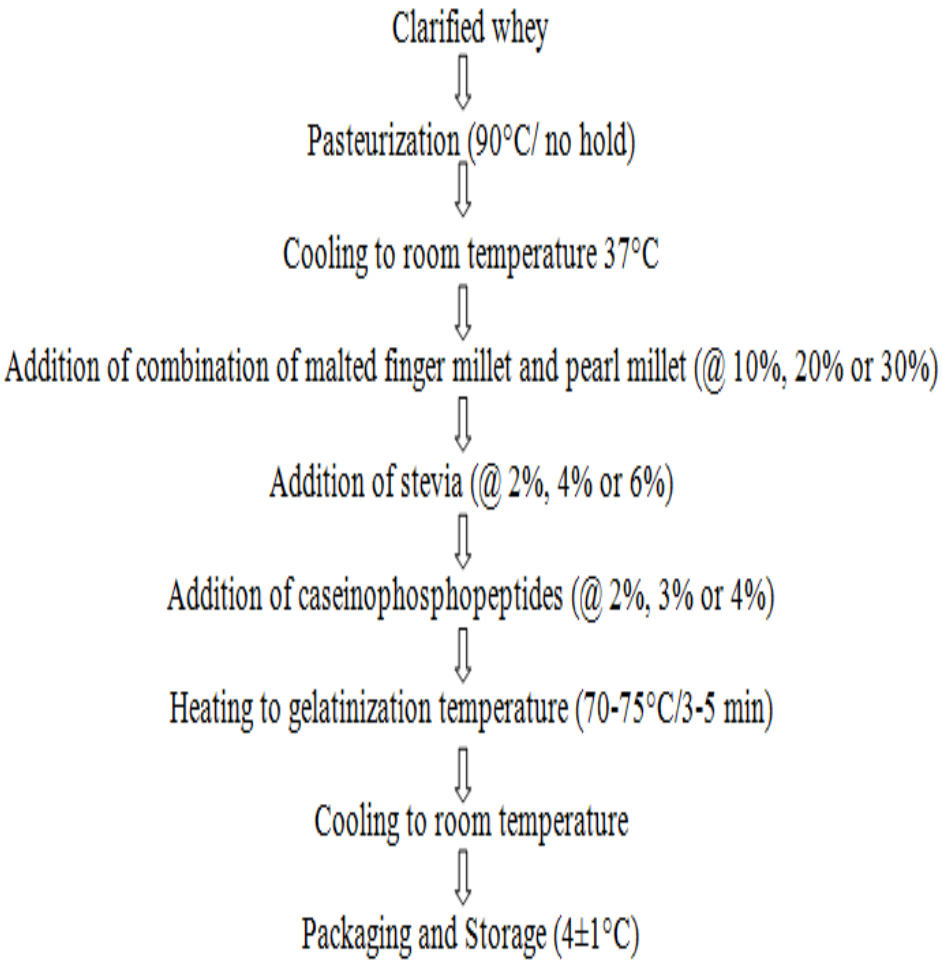
Constituents (%)	Control porridge	Whey porridge	CD (P≤0.05)
	Mean		
pH	5.60^{a}	4.90^{b}	0.60
Acidity (% Lactic acid)	0.06^{a}	0.23^{b}	0.13
Water activity (aw)	0.98^{a}	0.98^{a}	NS

Note:
- Similar superscripts indicate non – significance at the corresponding critical difference
- Control – Standard porridge
- All values are average of three trials

Flow chart.1 Flow chart for the preparation of control porridge



Flow chart.2 Flowchart for Preparation of nutraceutical whey porridge



The water activity of developed whey porridge was found to be 0.98. There was significant difference with respect to physical properties among control porridge and developed whey porridge. This could be due to pH and acidity variation in physical parameters. Higher acidity of developed whey porridge could be mainly due to whey which is taken as the base.

The developed whey based porridge contain 70:30 combination of finger millet and pearl millet with 20 per cent levels showed better sensory scores. Partial replacement of sugar with stevia in the ratio of 25:75 showed good organoleptic characters. Finally the developed product was found to be most acceptable and rich in calcium and iron contents. Processing millets like ragi (finger millet) and bajra (pearl millet) using traditional as well as contemporary methods for preparation of convenience products like porridges would certainly diversify their food uses. The synergy between whey and the combination of finger millet and pearl millet to develop porridge proved vital not only for taste and delight of eating but also for high nutritional quality and health benefits for children, diabetics and old age people

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