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Whey Protein Concentrate qs A Substitute to Skim Milk Powder in Soy Yoghurt

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Abstract

Background: Soymilk contains very low amount of sugars essential to prepare fermented foods. Therefore, milk-soymilk blends were fortified with 1 to 3% skim milk powder (SMP) and whey protein concentrates (WPC 35 and 60) and evaluated for the quality attributes of resultant yoghurt.

Materials and methods: The milk-soymilk blends were homogenized, pasteurized, inoculated with Lactobacillus delbruekii subsp. bulgaricus and Streptococcus thermophillus (1:1), fermented at 41 °C and assessed at regular intervals for titratable acidity, viscosity, syneresis and sensory scores.

Results and Discussion: The effect of all three ingredients was found to be significant on titratable acidity, viscosity, syneresis and sensory scores. The rate of acid development increased with augmented inclusion being highest in SMP, followed by WPC35 and WPC60. The viscosity (cP) of yoghurt increased and syneresis declined significantly in all the samples. The sensory scores for appearance, body and texture, flavor and overall acceptability were affected appreciably. The incorporation of WPCs improved smoothness of product but concentrations higher than 1% imparted an unbecoming flavor. However, the overall acceptability of WPC containing yoghurt samples was comparable to that of SMP.

Conclusion: Good quality yoghurt could be prepared by blending soymilk up to 50 % level in milk. Whey protein concentrate (WPC) could successfully replace SMP to supplement total solids and fermentable sugars in soymilk for yoghurt manufacture.

Keywords: Dairy ingredients; Soymilk; Yoghurt; Whey protein concentrate; Skim milk powder; Fermentation.

Introduction

Soybean is rated high among vegetable foods because it serves an excellent source of vegetable protein especially in the diet of vegetarians. It also contains appreciable quantity of oil that is rich in polyunsaturated fatty acids. Moreover, it supplies fairly good amount of vitamins and minerals such as calcium, phosphorous and iron. It can yield 6-8 L of soymilk per Kg, therefore soymilk is less costlier than milk. Furthermore, soymilk is low in fat content, and is rich in linolenic acid and lecithin. It is free of lactose therefore, considered suitable for lactose intolerance people [1]. Soymilk is used in the preparation of tofu, however, it can be converted into a variety of hot and cold beverages, fruit shakes, yoghurt, ice cream or used directly for cooking [2].

Yoghurt is a cultured dairy product produced by fermenting milk with Lactobacillus delbruckii subsp. bulgaricus and Streptococcus thermophilus bacteria. It usually contain 12-14% total milk solids and has a soft friable custard like consistency and a clean, distinct acid flavour [3]. It is popular for its nutritional value and is believed to be effective both in prevention and treatment of various illnesses in man e.g: gastro intestinal disorder, heart disease, tumour development etc. [4]. Soy based foods including yoghurt and other food products offer considerable appeal for a growing segment of consumers with special dietary and health requirements. Soymilk lacks in fermentable sugars and certain salts to feed and develop the bacteria for the preparation of fermented products. It requires additional carbohydrates to promote fermentation. Hence, soy yoghurt is less acidic than regular. The acid development and sensory properties of soy yoghurt may be improved by fortifying soymilk with milk solids such as milk powders, whey based powders or milk retentate powders [5].

Whey protein concentrates represent a protein source with considerable potential for blending with a variety of food products because of their excellent technological functionality and high nutritional value. Moreover, these contain appreciable quantities of lactose which may serve as source of fermentable sugars for use by lactic acid bacteria. Skim milk powder (SMP) is generally incorporated to improve the acid development and sensory attributes of yoghurt. The systematic work on yoghurt production from soymilk with the incorporation of whey protein concentrates (WPCs) as a source of fermentable carbohydrate to replace SMP is scanty, therefore, the present investigation was proposed with the objective to compare the performance of SMP and whey protein concentrates in soymilk w.r.t physico-chemical and sensory characteristics of yoghurt made thereof.

Materials and Methods

The milk was procured from the dairy processing plant of the Department of Food Science and Technology, and soybean (variety SL-525) from the Department of Plant Breading Genetics and Biotechnology Punjab Agricultural University, Ludhiana. Skim milk powder (SMP) was purchased from the local market (Verka). Whey protein concentrates (35 and 60) were supplied by Cepham Milk Specialities Ltd. (Dera Bassi, Punjab). Yoghurt culture containing Lactobacillus delbruckii subsp. bulgaricus and Streptococcus thermophilus (1:1), was procured from NDRI, Karnal.

Starter culture propagation

The lyophilized mixed yoghurt starter was activated by inoculating 10ml sterile skim milk with loopful of culture and incubated at 37 °C till the formation of a firm curd. The activated cells were cultured on tomato juice agar slant. These slants were stored in refrigerator till further use. For the preparation of mother culture, a loop ful of inoculum from tomato juice agar slants was transferred in 10ml sterile skim milk and incubated at 37 °C till firm curd was formed. The process was repeated 4-5 times. The inoculum @2% from mother culture tubes was transferred to desired amount of sterilized milk in a flask and incubated at 37 °C for 5h to be used as a bulk culture.

Soymilk and blends

Soymilk was prepared by soaking soybeans overnight, dehulling, grinding with hot water (soybean: water: 1:7w/v) in a blender and filtering through muslin cloth. The total solids of soymilk were adjusted to 6+0.1%. Blends of soymilk (TS 6% and fat 2%) and milk (fat 2%) were prepared with 5% sugars, and 1 to 3% skim milk powder/whey protein concentrate. Each blend was pasteurized at 85 °C for 5min, cooled to 45 °C, inoculated with 2% starter culture, filled in plastic cups and incubated at 41 °C till a firm curd was obtained. Packaging and storage.

Physico-chemical analyses

Milk, soymilk, whey, SMP, WPC and yoghurt were analyzed using AOAC [6] procedures. Total nitrogen in the sample was determined by micro-Kjeldhal method and a conversion factor of 6.38 and 6.25 was used for calculating crude protein content of milk and soymilk, respectively. The fat content in milk and soymilk was estimated using Gerber's method of BIS 1981 and for soybean, SMP and WPC soxhlet extraction was used. The titratable acidity was determined by titrating 10ml of sample against standard alkali and the results expressed as % lactic acid. The viscosity was measured with Brookfield viscometer (Model LVT) at 20 °C using spindle no. 4. For syneresis estimation, 20g sample was taken in a dry tube and centrifuged at 20 °C. The whey was drained and its weight recorded [7].

Sensory evaluation

The yoghurt samples were evaluated for appearance, body, texture and flavour by a semi-trained panel of judges on 9 point hedonic scale and assigned scores from liked extremely (9) to disliked extremely (1) [8]. The overall acceptability was estimated by taking mean of all the three attributes.

Statistical analysis

The data collected from studies were subjected to analysis of variance [9].

Results and Discussion

Proximate composition

The proximate composition of soybean, soymilk, milk, whey, skim milk powder, WPC 35 and WPC 60 is presented in Table 1. Soymilk and milk contained 6.00+0.1 % and 10.65+0.2 % total solids and 3.54 and 3.88% protein and 0.20 and 0.74% ash, respectively. Skim milk powder contained 96.85 % total solids, 34.03% protein and 0.57% fat, 7.82% ash and 54.43% carbohydrates. The values for total solids in WPC 35 and WPC 60 were 94.25 and 93.62%, respectively. The protein content and fat contents of WPC 60 was appreciably higher than WPC 35.

Table 1: Proximate composition of Soymilk, Milk, Skim milk powder, WPC 35 and WPC60.

Constituents	Soymilk	Milk	SMP	WPC35	WPC 60
Moisture (%)	94	89.35	3.15	5.75	6.38
Total Solids (%)	6	10.65	96.85	94.25	93.62
Protein (%)	3.54	3.88	34.03	33.8	59
Fat (%)	2	2.1	0.57	1.93	4
Ash (%)	0.2	0.74	7.82	6.83	4.88
Carbohydrate (%)	0.26	3.93	54.43	51.69	25.74

SMP: Skim Milk Powder; WPC: Whey Protein Concentrate.

Effect of fortification of dry ingredients on lactic acid development

There was a increase in rate of acid development in all the samples including control and milk-soymilk blends with the addition of SMP and WPC (Figure 1-5) due to increase in fermentable carbohydrate i.e. lactose. The control (milk) yoghurt

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without additional dairy ingredient attained 0.75 % acidity in about 6 h of incubation. However, supplemented samples attained much higher acidity in this period. The samples containing 25% soymilk reached this level of acidity in 6 to 7h with 1% SMP, whereas samples with higher SMP attained this acidity within 5 h. However, with the incorporation of WPCs desirable acidity was achieved within 6 to 7h. The samples having 50 % soymilk developed the desirable acidity in 8h of incubation and those with 75% soymilk within 8 to 10h and soymilk (100%) without any dairy supplement does not develop much acidity even after 12h of incubation. However, on supplementation, the period of desired acid development was reduced to 7 to 8h with SMP and 10 to 12h for WPCs. Kothari [10] reported that acid production from soymilk was insufficient for manufacture of fermented products even with lactose enrichment. Rajasekaran & Rajor [11] observed that decrease of soy solids and addition of skim milk (50:50) produced desirable yoghurt-like product.

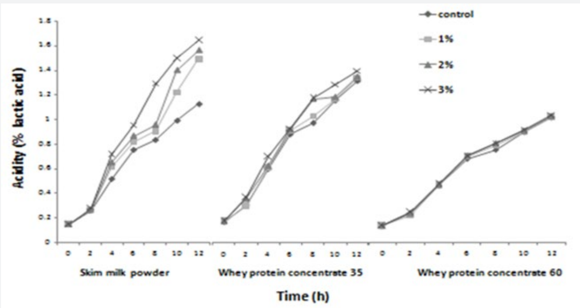

Figure 1: Effect of SMP and WPC on acid development in milk (control).

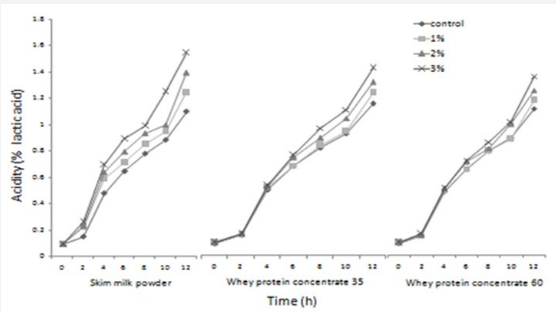

Figure 2: Effect of SMP and WPC on acid development in blends containing 25% soymilk.

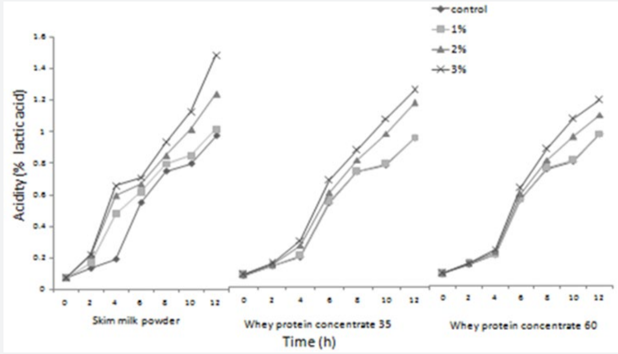

Figure 3: Effect of SMP and WPC on acid development in blends containing 50% soymilk.

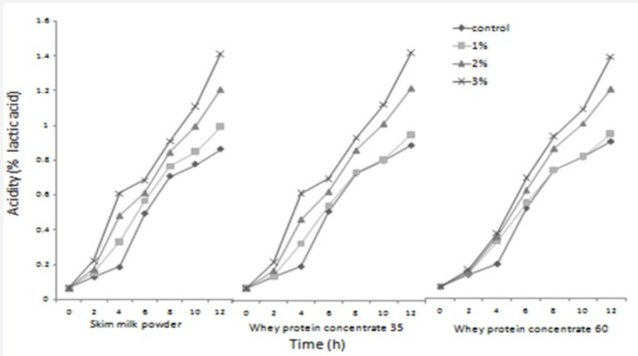

Figure 4: Effect of SMP and WPC on acid development in blends containing 75% soymilk.

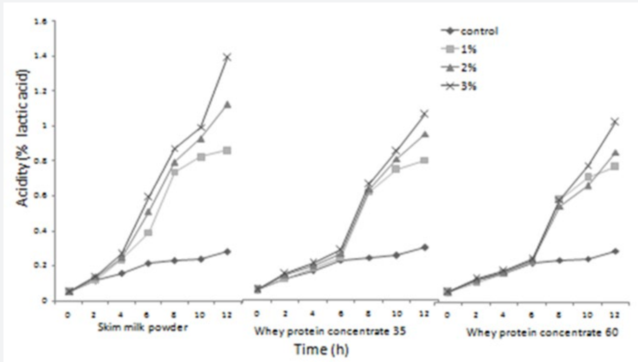

Figure 5: Effect of SMP and WPC on acid development in soymilk (100%).

Effect of level of soymilk and dairy ingredients on viscosity (cP) and syneresis of yoghurt

Table 2: Effect of SMP and WPC on the viscosity and syneresis of soymilk yoghurt.

Soymilk	Concentration (%)							
	Viscosity (cP)				Syneresis (%)			
%	0	1	2	3	0	1	2	3
SMP								
0	2100	2950	4400	5650	74.28	71	68.9	66.79
25	2150	3900	4650	5300	71.26	69.02	65.9	62.78
50	2900	4250	4800	5400	69.78	65.98	62.29	60.9
75	3100	4400	4950	5650	66.15	63.26	60.7	57.68

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100	1600	3300	4350	5000	76	74.1	72	68.2
WPC 35								
0	2100	2800	4150	5400	74.28	59.26	57.2	54.94
25	2150	3300	4400	4700	71.26	57.56	54.17	51.11
50	2900	3600	4550	4800	69.78	52.4	49.62	46.9
75	3100	3700	4600	4950	66.15	49.82	46.85	44.02
100	1600	2600	3250	4300	76	62	60.43	56.4
WPC 60								
0	2100	2600	3900	5200	74.28	48.91	46.66	43
25	2150	3100	4200	4550	71.26	45.62	43.23	40.61
50	2900	3350	4350	4600	69.78	42.09	40.42	37.13
75	3100	3600	3450	4750	66.15	39.62	36.98	34.25
100	1600	1800	2850	3250	76	56.42	54.73	51.69
ANOVA								
Source	**d.f**	**MSS**						
		Viscosity	**Synersis**					
Concentration	3	18109040.0**	1152.5860**					
DI	2	2266535.0**	1354.3080**					
Soymilk	4	2282869.0**	296.92060**					
DI x Soymilk	8	115828	5.12486					
Error	42	157432	22.636					

The viscosity of yoghurt increased significantly ($p<0.01$) with the addition of soymilk up to 75% and decreased in 100% soymilk (Table 2) due to the fact that at high level of soymilk proteins are unable to coagulate properly with less acid development [12]. The viscosity increased with increased inclusion of dry ingredients. The viscosity was lowest in 100% soymilk and the highest in 3% SMP in control (100% milk). Similar trend was earlier observed by Bozanic [13]. Sokalinska [14] also reported that viscosity of yoghurt increased with the addition of WPC.

The syneresis reduced significantly ($P<0.01$) with increased soymilk level up to 75% due to the reason that soy protein gels have excellent water binding capacity [15,16]. The reduction in syneresis was also observed with 1 to 3% incorporation of dry ingredients. The samples containing WPC had low syneresis value as compared to SMP. The findings are in concordance with Guzman [17] who observed that yoghurt's supplemented with WPCs had less syneresis than SMP because of WPCs enhanced water binding capacity in the yoghurt coagulum. Modler & Kalab [18] using electron microscopy studies, showed that yoghurts prepared with casein, SMP and MPC (Milk protein concentrates) exhibited a high degree of fusioned micelles compared to yoghurt stabilized with WPCs. Additionally, yoghurts prepared with WPCs were generally softer and suffered less syneresis than other yoghurts.

Effect of level of soymilk and dried ingredients on sensory attributes of yoghurt

The appearance scores declined with increase in amount of soymilk due to creamish/yellowish tinge imparted by soymilk, however, the scores improved with the incorporation of dry ingredients. Earlier, Cheng [19] reported that yoghurt like product made from soymilk was less white than that of milk. The body and texture scores were lowered with the increase in soymilk in yoghurt due to its lower total solids than milk resulting in a weaker body. The inclusion of dry ingredients noticeably improved body and texture scores because of raised solid content leading to firm bodied product. A desired content of acid (about 0.9%) is a requisite for characteristic flavor of yoghurt. The flavor scores decreased with the increased level of soymilk in yoghurt due to less acid development. Moreover, augmented soymilk imparted a beany flavor. The scores for the attribute of flavor were acceptable with the addition up to 1% dry ingredients. Thereafter, scores decreased due to the reason that these additions imparted their typical flavor. The overall acceptability scores decreased with increase in soymilk level and it were lowest in pure (100%) soymilk. However, scores improved with the supplementation of SMP and WPC. The overall acceptability scores were found to be highest at 1% addition of dry ingredients (Figure 6). However, the scores were comparable at 2% and lower at 3%.

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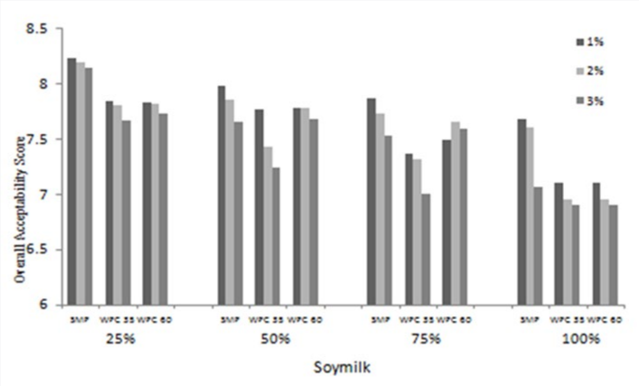

Figure 6: Effect of SMP and WPC on the overall acceptability scores of soy yoghurt.

Conclusion

Soymilk extracted from soybean contains oligosacchrides such as raffinose and stachyose that are not readily utilized by lactic acid bacteria for the production of lactic acid. Therefore, the acid development is extremely slow in soymilk. Henceforth, it needs to be supplemented with fermentable carbohydrates to manufacture cultured foods. Skim milk powder (SMP) is generally incorporated to improve the acid development and sensory attributes of yoghurt. The yoghurt samples containing 25 and 50% soymilk, 5% sugar and 1% SMP/WPC 35/WPC 60 were found highly acceptable. Good quality yoghurt could be prepared by blending soymilk up to 50% level in milk. Whey protein concentrate (WPC) could successfully replace SMP to supplement total solids and fermentable sugars in soymilk for yoghurt manufacture. However, supplementation at higher level imparts characteristic whey flavor.

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