RESULTS

V. RESULTS

The study on the development of soy cheese spreads using both blend and slurry approaches was conducted in four successive stages. The first phase of the study was to standardise the raw materials used for the development of spreads. In the second phase, preliminary cheese spread making trials were conducted and several processing conditions were modified to develop satisfactory techniques. In the third phase, the processing conditions were optimised to obtain most acceptable cheese spread in terms of sensory parameters. Further, the spreads were characterised both chemically and microbiologically in terms of their behaviour during curing. In the final phase, the developed cheese spreads were subjected to shelf-life experiments under refrigerated conditions. Results of this study are presented in the following sections:

5.1 STANDARDIZATION OF RAW MATERIALS

The **Monnato** (yellow) variety (Glycine max.) of whole soybean was utilised for the extraction of milk and the preparation of slurry. The proximate composition of the soybean variety as analysed in the work along with data from literature is presented in Table 5.1.

Table 5.1 Proximate composition of Soybean

Composition (g)	Mean*	Range	Literature Source**
Moisture	7.32	7.31 - 7.34	-
Total solids	92.68	92.66 - 92.69	-
Protein	35.36	38.04 - 38.26	42.10 - 43.20
Carbohydrates	34.76	-	17.00 - 34.00
Lipid	17.10	18.43 - 18.46	18.00 - 20.00
Ash	5.46	5.86 - 5.90	4.60 - 5.50
Protein/Fat ratio - 2.07			2.11 - 2.39

* Mean of triplicates
** Katiyar (1988)
Gopalan et al.(1993)

The whole bean recorded 92.68 % total solids. The moisture level was well within the range of 10% (considered acceptable for dry storage). The protein content (38.15 g% on dry matter basis) was slightly lower than the reported value of Katiyar (1988), 42.1 g %, and Gopalan et al. (1993), 43.2 g %, where varieties were not specified. Similar trend was also observed in the fat content of the bean. The present study revealed 18.45 g% fat, while Katiyar (1988) and Gopalan et al. (1993) reported higher values viz. 20.0 and 19.5 g% respectively. On the other hand, the total ash content was found to be slightly higher (5.89 g%) than the reported value of Katiyar (1988), 5.5 g%, and Gopalan et al. (1993), 4.6 g%. The differences observed in the present study may be attributed to the varietal and agroclimatic variations which are known to influence the composition of the bean (Vaidehi *et al*., 1988).

5.1.1 Standardization of soy maska:

Soy maska, prepared by draining whey from soy curd, was used as the raw material for developing spread using the blend approach. For this purpose soy curd was set by lactic fermentation of soymilk. The yield of maska and its textural qualities are likely to be influenced by the composition of milk, and the resultant quality of curd. In order to standardise the maska preparation, it was therefore considered essential to standardise the conditions for the preparation of soymilk, setting of curd and drainage of whey. Results of these studies are presented below:

5.1.1.1 Effect of soybean/water ratio on the proximate composition of soymilk, soy maska, and soy by products such as residue and whey:

Soybean / water ratio has been considered to be an important determinant for the recovery of soy solids in soymilk (Vijayalakshmi and Vaidehi, 1982; Nasim *et al*., 1986). Hence, 100, 150 and 200 g bean/L of water was used to prepare soymilks for studying its effect on the proximate composition of the milks, resultant maskas, and the by products such as residues (okara), and whey. The results pertaining to this aspect are presented in this section.

As the Table 5.2 indicates, the increase in the level of soybean to water resulted in corresponding increase in soy total solids, proteins, fat, carbohydrates, and ash content in soymilk. A level of 100 g soybean/L water yielded soymilk with minimum per cent soy total solids, protein, fat, carbohydrates, and ash. The level of these components tended to rise along with the increase in bean concentration. For example, 5.4% total solids in 100 g soybean/L water rose to 8.7% in 200 g beans/L water. Similarly, the protein content was found to increase from 2.88 g to 4.91 g%, fat from 1.29 to 2.19%, and ash from 0.018 to 0.08% when the bean concentration was increased from 100 to 200 g. Nasim et al. (1986) have reported higher total solids (6%) and protein (3%) in soymilk prepared by grinding 100g soydal/L water than observed in the present study. The proximate analysis of residue indicated the same trend that was observed in soymilk with an exception to carbohydrates. The rest of the components were found to increase with an increase in soybean concentration/L water. Nasim et al. (1986) also made similar observations with different soy dal levels/L water.

A similar trend was also observed in the proximate composition of maskas prepared from the soy curds set from these milks. The maska prepared from 100 g bean/L water soymilk gave minimum total solids (17.7%). protein (10.7%), fat (5.2%), and ash (0.05%) compared to maskas prepared from soymilks by using 150 and 200 g bean/L water. Conversely, the yield of maskas was found to increase with an increase in bean level (216.4, 284.0,

Table 5.2 Proximate composition of soy milk, maska residue and whey

Soy Fractions	Proximate composition (%)					
	TS	Protein	Carbo - hydrates	Lipid	Ash	Yield (g/L)
			100 g bean/L water			
Bean	92.68	35.36	34.76	17.10	5.46	-
Soymilk	5.43	2.88	1.24	1.29	0.018	1000
Residue	18.57	3.40	10.79	1.98	2.4	190
Maska	17.79	10.72	1.80	5.22	0.05	216.43
Whey	1.58	0.54	0.70	0.18	0.05	762.73
			150 g bean /L water			
Bean	139.02	53.04	52.14	25.65	8.19	-
Soymilk	7.44	3.93	1.72	1.75	0.036	1000
Residue	19.04	5.30	8.44	2.60	2.7	254
Maska	17.93	10.84	1.78	5.23	0.08	284
Whey	1.71	0.61	0.72	0.29	0.06	639.40
			200 g bean/L water			
Bean	185.36	70.72	69.52	34.20	10492	-
Soymilk	8.74	4.91	1.56	2.19	0.08	1000
Residue	20.00	5.90	8.22	3.10	2.78	362
Maska	18.83	10.97	2.50	5.24	0.12	354.73
Whey	1.92	0.75	0.73	0.23	0.10	539.73

and 354.7 g /L soymilk for 100, 150, and 200 g beans respectively).

There was a clear trend of increased concentration of all the proximate components of whey with an increase in bean level/L water.

The data of proximate composition of soymilks, maskas, residues, and wheys were further analysed for partition during the process of making soymilks from beans, and maskas from soymilks. The data pertaining to this aspect are presented in Table 5.3. The total solids, and other proximate constituents that could not be accounted either in soy products like soymilks or maskas, or in by products such as residues and wheys were grouped under the loss in handlings.

As the level of bean in milk increased, the recovery of soy total solids, and other composition fractions exhibited a decrease during the extraction of milk from the bean, and further, during the prepartion of maskas from the curd. In case of ash, however, the recovery increased along with the increasing bean level in water.

As the Table 5.3 reveals, 100 g soybean/L water though yielded soymilk with minimum total solids and other proximate constituents, gave rise to the maximum extraction of total solids (58.6%), protein (81.4%), carbohydrates (35,7%) and lipid (75.4%). An increase in bean to water ratio from 100 to 200 g/L

Table 5.3 Per cent recovery of soy solids from bean to milk and milk to maska (on dry matter basis)

Soy fractions	Proximate composition (%)				
	TS	Protein	Carbo - hydrates	Lipid	Ash
			100 g bean/L water		
Soymilk	58.6	81.4	35.7	75.4	3.3
Residue	38.1	18.3	58.9	22.0	88.5
Handling loss (bean to milk)	3.3	0.3	5.4	2.6	13.2
Maska	33.7	64.3	5.6	66.1	1.5
Whey	10.5	11.4	7.7	8.0	1.7
Handling loss (milk to maska)	14.4	5.8	22.4	1.3	0.2
			150 g bean /L water		
Soymilk	53.5	74.1	33.0	68.2	4.4
Residue	34.8	25.4	41.1	25.7	83.8
Handling loss (bean to milk)	11.7	0.5	25.9	6.1	11.8
Maska	32.1	57.3	5.7	57.9	2.5
Whey	6.9	7.3	5.2	5.0	1.8
Handling loss (milk to maska)	14.5	9.5	22.1	5.3	0.1
			200 g bean/L water		
Soymilk	47.1	69.4	22.4	64.0	7.4
Residue	39.1	30.2	42.8	32.8	92.1
Handling loss (bean to milk)	13.8	0.4	34.8	3.2	0.5
Maska	32.5	56.6	7.2	54.4	4.2
Whey	5.0	5.9	3.2	3.6	3.1
Handling loss (milk to maska)	9.6	6.9	12.1	9.4	0.1

water resulted in decrease in the recovery of all the constituents, except the ash. Nasim et al. (1986) also indicated that increase in the level of soydal (100 to 170 g/L) to water, resulted in decrease in the recovery of soy solids and protein in soymilks. This fact may be evidenced in the present study by observing the recovery of different constituents in the soy residues. The per cent loss of protein, carbohydrates, lipids, and ash in residue was much higher in 200 and 150 bean/L water than the 100 g level indicating that the viscous suspension due to higher bean content in the slurry while preparing milk, might be causing difficulty in filtration, thus resulting in higher losses of solids and other constituents in the residues (Wang, 1967). Wang (1967) had reported that a level of 100 g soy bean/L water was optimum for the extraction of soy solids and protein. Nasim et al. (1986) confirmed this fact while preparing soymilks with different beans levels. The total solids of residue increased from 15.65 to 17.90% when soydal was increased from 100 to 170 g/L water.

In the present study, the extraction of milk was done by utilising 200 to 250 ml water in 2 to 3 lots. The viscous extract was made up to a liter by subsequent addition of the remaining water to the slurry. Hence, the extraction had occured with water much less than the total intended amount. However, at the commercial level, this situation is likely to be changed for better wherein, wet grinding can be followed by addition of total quantity of water and subsequent clarification and filtration under much lower viscosity conditions. Hence, the recovery of total solids may not be as critical as has been in manual, hot grinding extraction followed in this study at the laboratory level.

The per cent recovery of different proximate components in maska was in line with the recovery trend observed in soymilk with an exception of carbohydrates. The lowest bean level /L water (100 g) gave maximum recovery of total solids, protein, and lipids, and the rate of recovery of these components decreased with an increase in bean level. On the other hand, carbohydrates and ash recovery increased with increase in bean concentration. It was interesting to note that the per cent recovery of carbohydrates in maska was extremely small at all three levels of bean concentration (5.6, 5.7, and 7.2% for 100, 150, and 200 g bean/L respectively). The initial low carbohydrates present in soymilks (1.2, 1.7, and 1.6% in 100, 150,and 200 g bean/L water), as large amount of insoluble carbohydrates were found in residues, were utilised during fermentation by lactic organisms. The investigations of Mital <u>et al</u>. (1974) and Mital and Steinkraus (1975) have indicated that lacic acid bacteria possessing a-galactosidase can utilise galactose-oligosaccharides present in soymilk; but the extent is restricted due to the utilisation of sucrose which produces pH low enough to inhibit further utilisation of higher-saccharides.

However, in whey, overall loss of total solids and other fractions (except ash) were observed to be much less in 200 g bean level (which might be associated with firmer curd formed at higher solids levels). Improving recovery from bean to milk stage, might help in further improvement in the recovery of these components in maskas.

Hence, it was thought appropriate to further investigate the effect of solids level of soymilk on the curd forming properties. Adequate acidity development in curd/maska is critical in the development of desirable flavour in the cheese. As soybean is low in fermentable carbohydrates (Mital and Steinkraus, 1975), the effect of fortification of various fermentable sugars on the adequate acidity development in soymilk was also considered relavant at this point of the study. The results pertaining to these aspects are presented below:

5.1.1.2 Effect of solids level of soy milk on the acidity development:

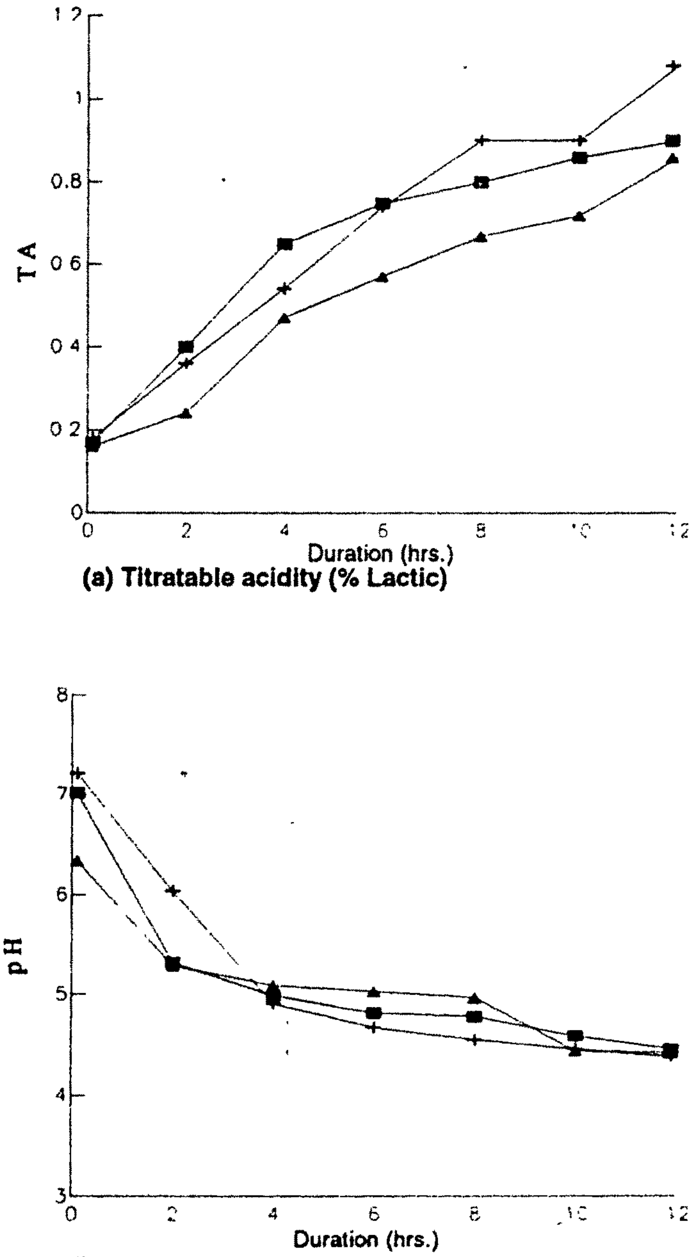
Desirable amounts of acid production is critical for the formation of curd and also in subsequent stages of maska and cheese making. However, acid production predominantly depends on the presence of sufficient amounts of carbohydrates in the medium that can be metabolised by the organisms. Since, mature soybeans contain largely oligosaccharides (Mital and Steinkraus, 1975), and polysaccharides (Pinthong et al.,1980; Kawamura, 1960; and Kawamura and Tada, 1967), soymilk, unlike cow's milk, contains only small quantities of simple sugars (Mital et al., 1977). Furthermore, pretreatments like soaking employed in soymilk preparation have been reported to substantially reduce the fermentable sugar content in the resulting milk (Hard, 1967). Hence, the soymilk prepared by three bean levels/L water were fortified with 1% lactose and 5% RSM, inoculated with 5% dairy culture, and was incubated at 30oC. Total acid development and pH were observed during the 12 hrs. incubation period. The trend of acid development and pH reduction is presented in Fig. 5.1 and the extent of changes in TA and pH is summarised in Table 5.4. The developed acidity was highest in soymilk prepared from 200 g/L, while lowest in 100 g bean/L soymilk (Fig.5.1a). However, there was a steady increase in the acidity development in all the three milks selected for the study. The milk with 5.4% TS attained the maximum acidity of 0.80 (% LA) in 12 hrs., while

Table 5.4 Effect of soymilk total solids level on the pH and TA during 12 hrs. incubation with lactic culture at 30oC.

TS levels of soymilks	Initial pH	Final pH	pH reduction	Initial TA	Final TA	TA reduction
5.4	6.34	4.42	1.92	0.16	0.86	0.66
7.4	7.02	4.45	2.57	0.17	0.90	0.73
8.7	7.21	4.38	2.83	0.18	1.08	0.90

the same level of acidity was developed in 10 and 8 hrs. in 7.4 (0.86% LA) and higher in 8.7% (0.9% LA) TS milk respectively.

As expected the trend of pH reduction was inversely related to the acid production and total solid levels of milk (Fig 5.1b).



(a) Titratable acidity (% Lactic)

(b) pH

Figure 5.1 Effect of bean / water ratio of soymilk on TA and pH

▲ 100 g/L ■ 150 g/L + 200 g/L

To understand the extent of acid development in soymilks of different solid levels, the difference between the initial and final acidity was calculated to represent the net developed acidity in the milks. The initial acidity was different in three soymilks selected for the experiment, and found to be directly proportional to the total solids levels.

The net developed acidity was higher in soymilk prepared by 200 g bean (0.9% LA) than 150 g (0.73% LA), and 100 g (0.60% LA). The higher acidity of higher solids level of milks may be somewhat related to the presence of higher concentration of inherent carbohydrates, eventhough the added carbohydrate content was constant in all the milks. The total reduction in pH was also observed to be the highest in the milks prepared by 200 g (2.83), followed by 150 g (2.57), and 100 g (1.92).

On the basis of above observations it is evident that **the milk with highest bean concentration (200 g/L) was able to develop maximum acidity during 12 hrs. of fermentation.**

5.1.1.3 Effect of fermentable sugars on the acidity development:

The addition of fermentable sugars to soymilk have been recommended (Yamamaka and Furukaw, 1970; Kothari, 1975; and Patel *et al.*, 1980) for adequate acid production. Therefore, the effect of fortification with sugars other than lactose, i.e., glucose, and sucrose in soymilk during curd formation was investigated. The culture used in the present study being dairy culture, are known to grow in milk media. Hence, the presence/absence of 5% RSM along with sugars was also considered appropriate to investigate. The results pertaining to this aspect of experiment are recorded in Table 5.5, and figures 5.2 - 5.3.

Table 5.5 Effect of fermentable sugars* and milk on the extent of TA and in pH in soymilk.**

TS level of milk (%)	Lactose	Lactose + milk	Glucose	Glucose + milk	Sucrose	Sucrose + milk	Milk
5.4							
pH	1.69	1.92	2.10	2.20	2.18	2.39	1.96
TA	0.60	0.66	0.51	0.61	0.49	0.57	0.47
7.4							
pH	2.57	2.74	2.62	2.85	2.61	2.67	2.40
TA	0.60	0.73	0.59	0.60	0.67	0.71	0.49
8.7							
pH	2.83	2.84	2.73	2.88	2.71	2.79	2.59
TA	0.88	0.90	0.64	0.82	0.71	0.79	0.55

Note: * - fortified at 1% level. ** - 5% RSM (10% TS).

The Table 5.5 reveals that the maximum acid production (fig. 5.2) was in 8.7% TS milk, followed by 7.4 and 5.4 % TS milks. When fortified with lactose plus milk, 8.7% TS milk showed maximum acid production (1.08% LA), and minimum, with milk alone (0.73% LA). The similar trend was observed also in 7.4% TS milk. On the other hand, 5.4% TS milk, while revealing the similar

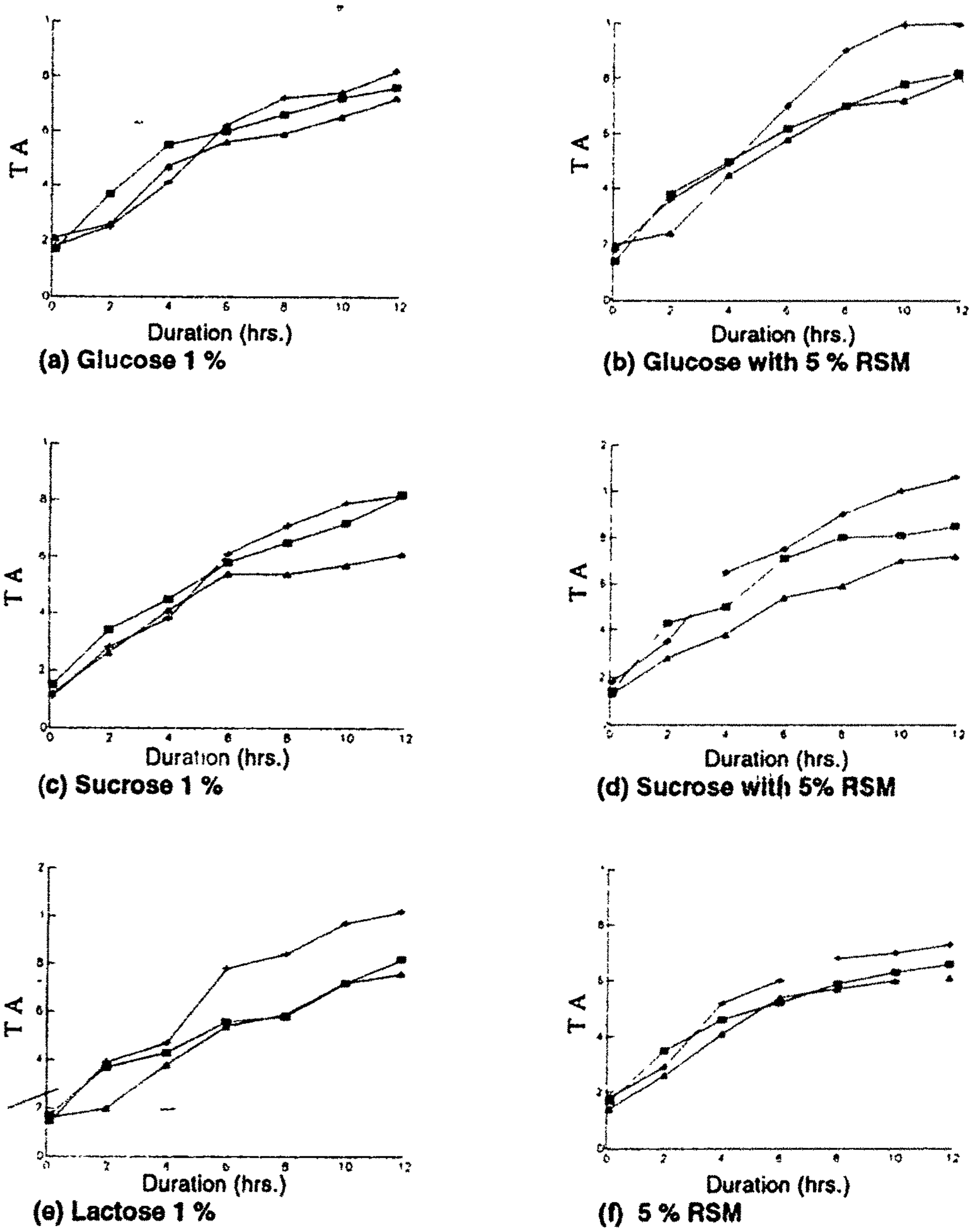


Figure 5.2 Effect of fermentable sugrs on TA development (% lactic) in soymilk with ▲ 5.4 % ■ 7.4 % + 8.7 % solid levels.

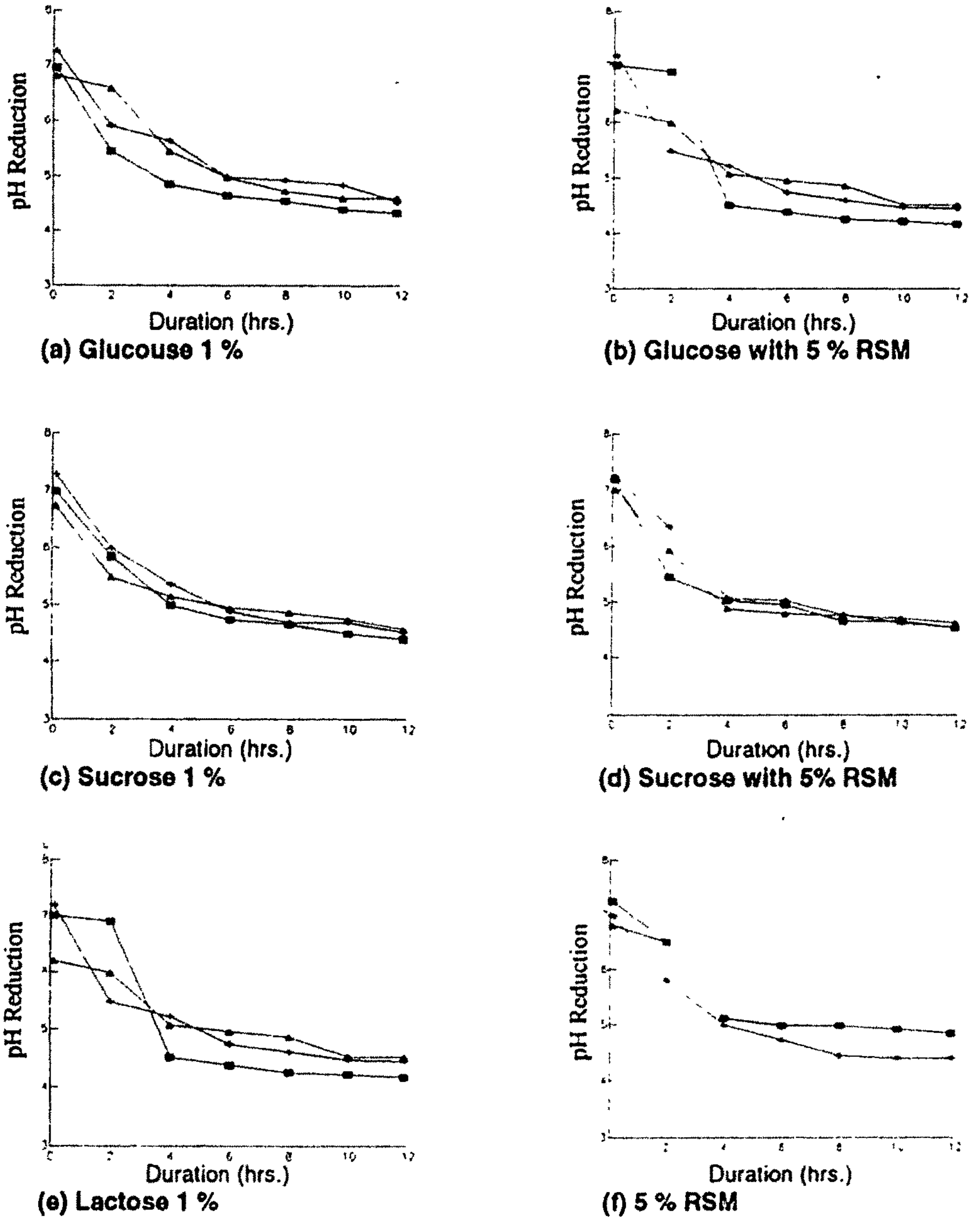


Figure 5.3 Effect of fermentable sugars on pH Reduction in soymilks with ▲ 5.4 % ■ 7.4 % + 8.7 % solid levels.

trend, also exhibited low acid production when fortified with sucrose. The net acid production (Table 5.5) was highest in highest TS concentration (8.7%) milk, when fortified with lactose plus milk, and lowest in 5.4% TS soymilk fortified with 5% RSM alone. Irrespective of type of sugars fortified, the higher solids level milk consistently showed higher acid production. Similar trend was also observed in pH reduction. The maximum pH reduction was observed in 200 g bean concentration (8.7% TS) milk irrespective of sugars fortified, indicating that pH reduction is positively related to TS level of milk (r = 0.98).

Lactose fortification (1%) with or without the addition of 5% RSM, was observed to substantially stimulate the acid product -ion over all the other sugars at all the solid levels of milk (0.66 to 0.90% LA, in 5.4, 7.4, and 8.7 % TS milk respectively). However, addition of lactose beyond 1% have shown to exhibit progressively less stimulatory effect (Hard, 1960, and Patel and Gupta, 1979). The better performance of lactose over sucrose (r = 0.88), and glucose (r = 0.84) may be related to the type of culture (dairy culture) used in our experiments. However, a few investigators have reported satisfactory performance of sucrose (Mital et al., 1974) and glucose (Kothari, 1968).

The trend of acid production and net amount of acid produced were better when milk were supplemented with 5% RSM (r = 0.89). The addition of milk have aided the acid production, mainly because of lactic culture used in the present study. However, the addition of 5% RSM alone resulted in low acidity production, perhaps due to lower availability of total fermentable sugar in the samples.

The trend of increased acid production was associated with a corresponding trend in the reduction of pH. The maximum pH reduction being observed in all the sugars, when supplemented with 5% RSM (fig. 5.3 f).

On the basis of the above experiments, it can be clearly stated that the acid production and lowering of pH is significantly related to solid levels of milk, highest being in 200 g bean/L water concentration. Among the sugars, lactose was able to produce maximum acid, while addition of 5% RSM was able to enhance acid production.

Based on the above observations, it was decided to add 1% lactose along with 5% RSM to soymilks at the time of curd setting and incubate for 12 hrs. at 30oC for adequate acid production.

5.1.1.4 Curd forming and syneresis properties of soymilks:

Obtaining a curd of appropriate firmness is essential to cheese making as this influences the loss of solids during subsequent treatments, and utlimately the quality of cheese itself. The quality of curd obtained depends on several factors particularly upon the inherent composition of milk in terms of protein (with reference to the calcium sensitive ones), fat, ionic environment, pH of the milk, heat treatments given to the milk, and rate of syneresis etc. (Eck, 1987).

The important variable being the total solids of the milk in the present study, wherein its influence on the acid production have been established previously, the effect of solids level of milk on the curd strength and syneresis was studied at this point. Samples of soymilk (50 g) fortified with 1% lactose, and 5% RSM was set with 5% dairy culture, and incubated for 12 hrs. at 30oC to determine the curd strength and syneresis as described in the method (4.1.2.3 and 4.1.2.4). The results pertaining to this aspect of the study are detailed in the Appendix 9.5.1-5.2 and summarised in Table 5.6.

Table 5.6 Effect of bean/water ratio of soymilk on the curd strength and syneresis.

Bean water ratio of soymilk	Total solids of soymilk (g)	Curd strength (g)	Quantity of whey expelled (12hrs.) (per 100 ml curd)
100 g /L water	3.5	67.6[a]	54.7[a]
150 g /L water	7.5	70.2[a]	50.0[a]
200 g /L water	8.5	81.4[b]	47.1[b]
F' value		36.64*	23.14*
SEm		6.45	1.9
C D		13.21	5.65

Note: Non-identical letters denote significant difference between two means at 5% level .
Figures in parentheses indicate range of scores.

The curd strength ranged from 67.6 to 81.4, and was (Table 5.6) found to be significantly related to total solids content of the soymilks. The soy curd prepared from 8.5% TS milk was significantly firmer (81.4 g) than the curd set with 5.5% TS milk (67.6 g). The curd firmness was found to be positively related to the protein and mineral content of the milks (Table 5.2). The higher the protein and mineral content in the milk, the higher were the firmness of the curd observed.

The data pertaining to the rate and amount of whey expulsion are detailed in Appendix 9.5.2 and graphically depicted in fig. 5.4.. It is apparent from the fig. 5.4 (a) that the rate of whey expulsion was highest during the first 30 min. in all the milk samples. There was subsequent levelling off during the next 2.5 hrs. In general, whey expulsion was found to be complete by three hrs. in all the milk samples tested. The rate of whey drainage was inversely proportional to the total solids levels of the milk, the rate being higher in lower solids levels. Draining was further continued for nine more hours, at the end of which (12 hrs.), the milks containing 5.5, 7.5, and 8.2% total solids were converted to soy maska of 17.8, 17.9, and 18.5% total solids respectively. Corresponding loss of whey was 54.7, 50, and 47.1 ml for 5.5, 7.5, and 8.2% total solids milks. When the total solids of the milk was related to the amount of whey drained, the milk which drained significantly less (47.1 ml), had highest (8.5%) total solids (Fig.5.4 b).

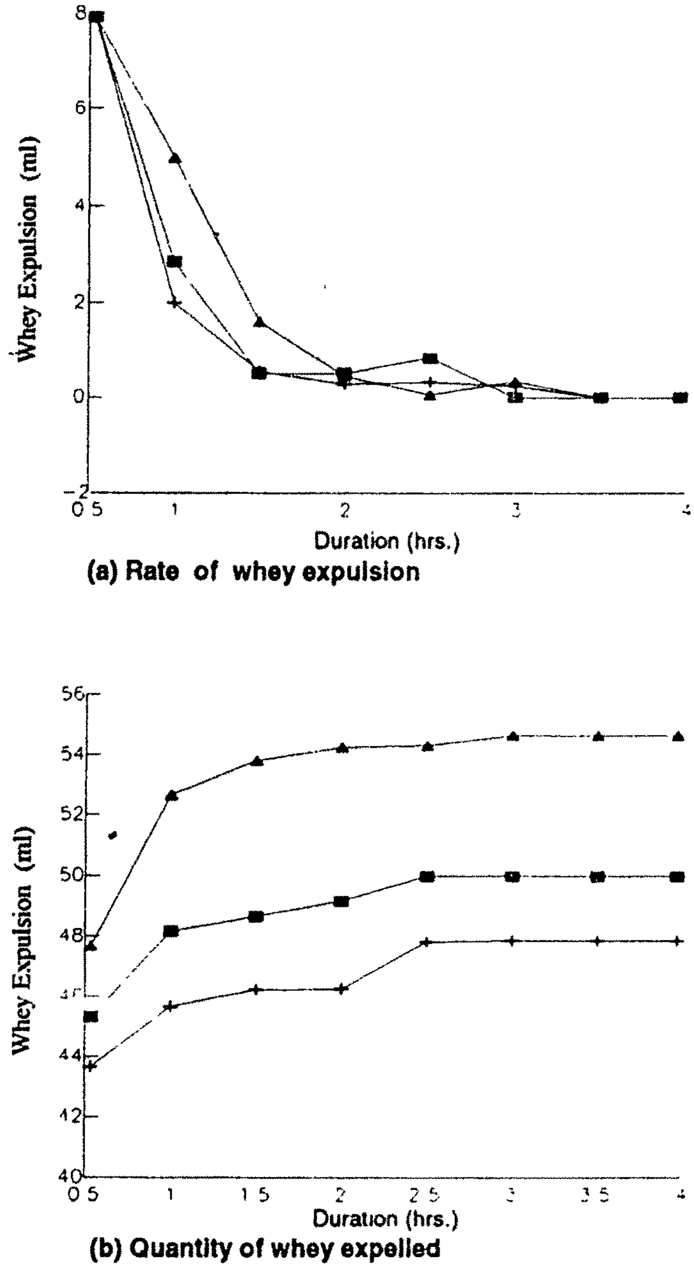


Figure 5.4 Effect of solid levels of soymilk on whey expulsion
▲ 5.5 % ■ 7.5 % + 8.2 %

The firmness of the curd and the amount of whey expelled depends on the moisture holding properties of the curd gel, which in turn are influenced by pH and acidity. It is apparent from the previous results that the pH and the titratable acidity are essentially related to the total solids level of the milk. The soy milks with different total solids level represented a moisture/total solids ratio of 17.1, 12,3 , and 10.7 repsectively for the samples containing 5.5, 7.5, and 8.2% total solids. However, at the end of 12 hrs. syneresis, the amount of moisture retained by the total solids component in the corresponding maska samples was within a very narrow range of 4.8, 4.6 and 4.4 respectively for milks with 5.5, 7.5, and 8.2%. Therefore, for the similar moisture holding capacity (i.e. moisture/total solids ratio of 4.8 - 4.4), the low total solids (5.5 and 7.5%) contain -ing milks had to expel relatively much more whey in comparison to milk samples with higher total solids (8.5%). Thus, the syneresis exhibited a reverse trend in relation to that noticed for curd firmness.

It is clear from the above observations of curd strength, and whey drainage that the milk prepared from high bean concentration (200 g/L) was able to form a firm curd. A satisfactory bean level/L water for extraction of soymilk for subsequent curd setting, and maska preparations required to be established on the basis of observations of acid development, curd strength, and yield of maska obtained from differnt solids level of soymilks. The milk extracted from 200 g bean/L water though gave lower recovery of total solids at bean to milk stage, its acidity development, curd forming properties, and yield of maska were in general higher than the lower bean concentrations. Hence, it was **considered appropriate to extract milk using 200 g bean/L water in subsequent experiments.**

5.2 INITIAL SOY CHEESE SPREADS MAKING TRIALS

After establishing the satisfactory bean/water ratio (200 g bean/L water) for maximum yield, and acidity development in maska, the basic ingredients viz., maska, and slurry were utilised for the development of cheese spreads. The development of soy spreads was followed using essentially two different approaches:

a) Blending with natural cheddar cheese, i.e. cheese dependent approach, and

b) Addition of milk solids and enzyme, i.e. cheese independent approach.

The basic experimental approach consisted of developing a satisfactory cheese spreads, based on organoleptic qualities in terms of flavour profile, body and texture,(B&T) spreadability, and over all acceptability, (OAA) as assessed by expert and trained panels. Depending on the sensory evaluation results, minor modifications in the preparatory steps were made to these initial trials.

In the cheese dependent approach, soymaska was blended with 40 parts of grated, natural cheddar cheese along with 1.8% sodium chloride, and incubated for 10-15 days at refrigerated temperature (8-10oC), with occasional agitation once in 2 to 3 days (Chakraborty, 1990). The practicability of blending cheese in a slurry base, along with papain and dairy culture, and daily agitation and incubated at low temperature (10oC) was also explored.

Mixing of milk solids in soy slurry (modified procedure of Singh and Mittal, 1984) for the development of soy spread formed the basis of cheese independent approach. This technique was also extended to soy maska, which was mixed with milk solids (30%), and enzyme (papain), and incubated for 8 days at 30oC with daily pH adjustment and agitation.

Based on the observations of several initial trials, the results pertaining to the development of acceptable soy cheese spreads are summarised in Table 5.7 - 5.8.

It is clear from the tables that slurry by both the approaches, viz. cheese dependent and cheese independent, were able to develop into acceptable cheese spreads with OAA scores ranging from 88 to 90 (moderately acceptable). However, none of the spreads were considered as highly acceptable (above 80 scores). Maska, when blended with 40 parts cheese and subjected to 10 to 15 days of curing at refrigerated temperature developed a milk cheese flavour scoring 90 for over all acceptablity. The flavour of fresh maska which was acidic and beany, gradually changed into mild cheesy acidic perception by 10-15 days. The

Table -5.7 Processing details of initial soy cheese spread making trials.

Raw materi-als	Milk* solids (%)	Cheese solids (%)	Curing period (days)	Curing temp. (oC)	Agitation	Adjusted pH to 5.3	Pasteuri-zation
Cheese dependent soy cheese spreads							
Maska	-	72.2	10-15	8-10	Occasional	Nil	65oC for 15 mts.
Slurry	-	23.5	8-10	8-10	Daily	Daily	72oC for 15 mts.
Cheese independent soy cheese spreads							
Maska	30	-	8	30 & 10	Daily	Daily	-
Slurry	30%	-	8	30	Daily	Daily	72oC for 15 mts.

Note: supplied as a mixture of 70% cream (60% fat) and 30% SMP.

Table 5.8 Sensory evaluation of initial soy cheese spreads.

Types of cheeses	Sensory scores				Criticisms
	Flavour (40)	B&T (30)	spreadability (30)	OAA (100)	
Cheese blended in soymaska	36.3	28.7	28.9	90.0	Mild cheesy slight grainy texture
Cheese blended in soy slurry	34.4	25.0	30.0	88.4	Mild, slight grainy
Milk solids in soy maskas	-	-	-	-	Off-flavour, grainy texture
Milk solids in soy slurries	38.0	25.0	27.5	90.0	Mild, slight bitter taste

alcoholic and yeasty and moldy flavour disappeared eventually after pasteurization. The final product was devoid of beany flavour, and there was no manifestation of any kind of lingering afertaste and bitterness.

However, maska did not respond well to cheese independent approach. Besides, developing an off flavour, the body and texture of the spread was found to be inferior (lumpy), owing to the further whey separation during curing period at room temperature (30oC). On the other hand, maska failed to develop any change in flavour with milk solids at refrigerated temperature (10oC). The addition of calcium chloride (380 ppm), and low methoxy pectin (100 ppm) did not improve the grainy texture that were observed in the spreads after pasteurization. Hence, the cheese independent approach for maska was discontinued at this stage.

The cheese spreads in these initial trials, were somewhat mild in flavour, and lacked smooth texture/and meltdown qualities considered desirable for spreads on hot toast. Besides, it was also considered necessary to explore the scope of reducing the milk solids/cheese solids in soy spreads and to investigate the possibilities for the application of several flavour additives. In addition to above, the effect of altering the processing conditions in cheese making techniques in enhancing the sensory attributes required to be studied. Keeping the above points in mind, subsequent experiments were undertaken to explore the possiblities of further improving the sensory qualities of soy cheese spreads.

5.2.1 Effect of different cheese solids and milk solids levels in soy spreads on sensory scores:

In the preliminary soy cheese spread making trials, acceptable cheese spreads were made by using cheese solids as much as 72.2% of total solids in maska-based cheese blend, as 23.5% of total solids in slurry-based cheese blend, and 30% of total solids as milk solids mixed in slurry. The effect of further reducing the level of cheese solids and milk solids on sensory qualities of the spreads were studied. The results pertaining to these experiments are summarised in this section, as under:

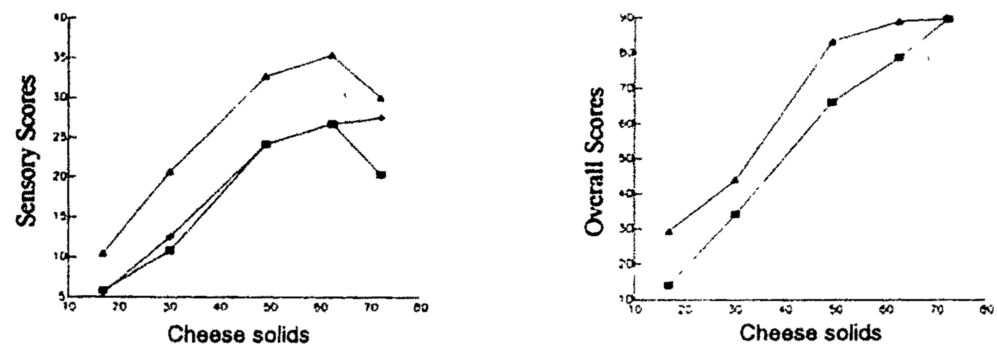
- Cheese blended maska based spreads
- Cheese blended slurry based spreads
- Milk solids blended slurry based spreads.

5.2.1.1. Cheese blended maska based spreads:

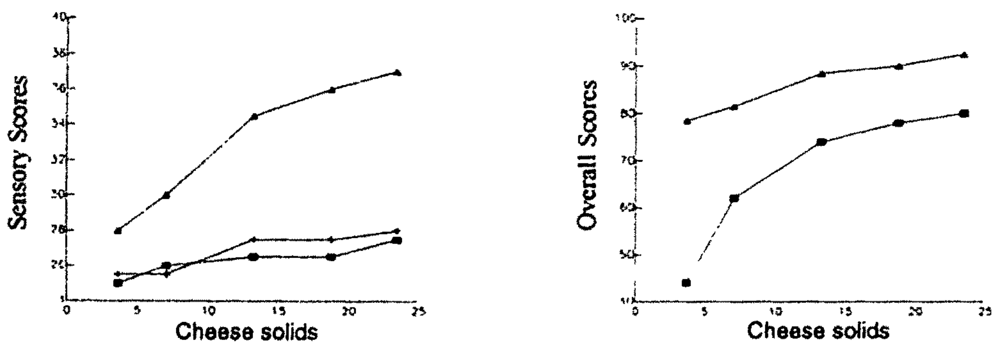
The compositional differences with respect to cheese and soy solids, fat, and proteins are detailed in Appendix 9.5.3. The cheese solids varied from 72.2 to 17.0% of total solids in the blend, while, cheese fat and cheese protein content varied from 12.0 to 1.5, and 11.2 to 1.4 g respectively in different blend samples. The results of the sensory evaluation of cheese blended in maska spreads as assessed by trained panel of judges are detailed in Appendix 9.5.4, and presented graphically in fig.5.5 (I and III).

The flavour scores of various spreads ranged from 38.0 to 18.5. Though the spread having 72.2% cheese solids scored highest in flavour, there was no significant differences in flavour scores between the spreads of 72.2% to 49.3% cheese solids. All these spreads were considered pleasant, cheesey, and were acceptable by the panel of judges (fig. I a). In general, the flavour scores increased with increasing in cheese solids levels in the blend, and were found to be significantly proportional to cheese solids (r = 0.92), and cheese fat and cheese protein (r = 0.92), contents in the spreads, indicating their contribution in the favourable flavour development (Appendix -9.5.3 b).

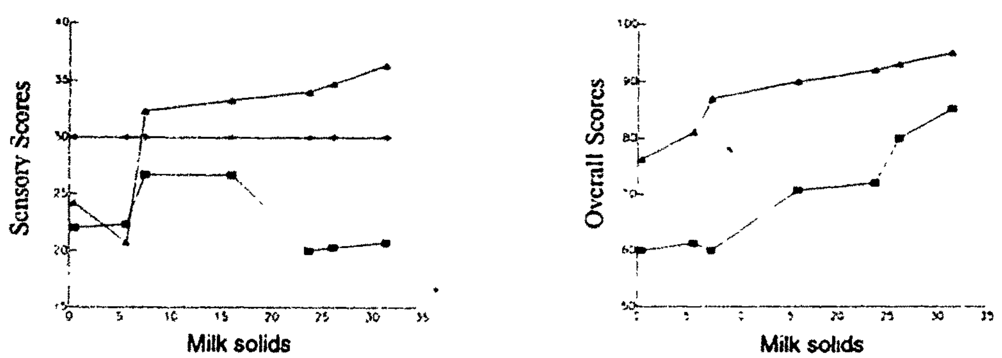
Similar trends were also noticeable with respect to B&T, and spreadability attributes. Cheese spreads prepared from higher cheese solids percentage (72.2% to 49.3%) had spreadable qualities. However. cheese spread from 72.2% cheese solids was alone smooth, while others were rated grainy in B&T. Soy spreads prepared from 30.2%, and 17.0% cheese solids blends revealed significantly poor textural quality, being coarse, lumpy, and unspreadable. B&T, and spreadability scores were found to be directly related to cheese fat (r = 0.93, and 0.91 respectively for B&T, and spreadability), and cheese protein (r = 0.93 and 0.91 for B&T, and spreadability) of the spreads.



I - Cheese solids blended maska



II - Cheese solids blended slurry



III - Milk solids blended slurry

Figure 5.5 Effect of cheese solid / milk solid levels on sensory scores

▲ Flavour
■ Body and Texture
+ Spreadability

▲ Total Scores
■ Overall acceptability

The OAA scores of soy maska based cheese spreads having various levels of cheese solids ranged from 90 to 14.0. The highest score was received by the spread having maximum (72.2%) cheese solids. There was a direct relationship between the OAA scores and the amount of cheese blended in the spreads (r = 0.97). The contribution of cheese fat (r = 0.97), and cheese protein (r = 0.98) in OAA of the spread was also well realised (fig.5.5, I b). The total scores of sensory attributes (sum of flavour, B&T, and spreadability scores) were found to be positively and significantly correlated (r = 0.99) to OAA scores, indicating that the panels have considered the individual sensory parameters while evaluating the OAA of the cheese samples.

Based on the sensory quality evaluation scores, it is evident that a minimum level of 49.3% cheese solids seems to be essential for the development of a desirable mild cheesy flavour, and spreadable quality in soy cheese samples. Hence, **49.3% cheese solids level was selected to blend in a maska base** in subsequent experiments wherein attempts were made to enchance the intensity of flavour and improve the B&T of the spreads by altering the processing conditions.

5.2.1.2 Cheese blended in slurry based spreads:

The compositional differences of cheese blended in slurry samples in terms of cheese and soy solids, cheese and soy fat, cheese and soy fat and, proteins are detailed in Appendix-9.5.5(a). The cheese solids varied from 23.5 to 3.7% as total solids of the blends, and soy solids ranged from 96.3 to 76.5% of total solids. The cheese fat and cheese proteins ranged from 12 to 1.5 g and 11.2 to 1.4 g respectively in the blends. The results pertaining to the organoleptic qualities of spreads is presented in Appendix 9.5.6, and graphically represented in fig. 5.5 (II a,b).

The flavour scores for the spreads ranged from 37.0 to 28.0, higher scores being associated with higher cheese solids levels in the spread (23.5%). The flavour scores were found to decrease with decrease in cheese solids in the spreads. The spreads having cheese solids less than 7% were found to be significantly lower in flavour scores over other blends. The cheese solids level less than 10% in the spreads was criticised being bitter in taste, and also associated with mild to moderate uncharacteristic flavour. As the level of cheese solids rose above 13.3%, the flavour of the spreads were commented to be pleasant, clean, and mild cheesy. The flavour was found to be significantly related to cheese solids (r = 0.9), cheese fat (r = 0.87), and cheese protein (r = 0.88) content of the spreads.

The B&T of the slurry spreads was considered to be pasty by the panel. The low cheese solids level spreads (less than 10%) exhibited slight coarse texture. However, none of the spreads differed with each other statistically with respect to B&T (fig. IIa). All the samples were rated as spreadable to the satisfaction of the judges. The B&T scores were apparaently found to be significantly related to cheese fat (r = 0.93), cheese solids (r = 0.92), and cheese protein (r = 0.92) content of the spreads.

The total scores of the spreads ranged from 92.5 to 78.5, the higher scores being received by higher cheese solids containing spreads. Total scores obtained for different cheese solids level spreads were consistent with OAA scores (r = 0.96).

The trend of OAA were also found to be similar to flavour scores. The OAA scores ranged from 80.0 to 44.0, the scores descending with decrease in cheese solids levels in the blend. The spreads having 23.4 to 13.3% cheese solids scored significantly higher than 3.7% cheese solids spreads (fig. 5.5 IIb). However, no statistical differences were noticed between 7.1 and 3.7% cheese solids level spreads. Soy cheese spreads having cheese solids above 7.1% were within the acceptable range of scores (60 and above slightly liked category). The OAA scores of spreads were significantly related to cheese solids (r = 0.87), cheese fat (r = 0.73), and cheese protein (r = 0.89) content of the spreads.

It is apparent from the sensory scores that a minimum of 13.3% of cheese solids (of total solids) is required for the development of mild cheese flavour, and satisfactory B&T in soy slurry based spreads. Hence, 13.3% cheese solids in the slurry based spreads were selected for subsequent experiments.

5.2.1.3 Milk solids blended in slurry cheese spreads:

The differential composition of milk solids blended in slurry based spreads are detailed in Appendix- 9.5.7(a). Milk solids (% of TS) ranged from 10.74 to 1.44, and soy solids (% of TS) from 68.4 to 98.6. The milk fat and milk protein ranged from 7.1 to 0.77, and protein ranged from 2.88 to 0.2 respectively. Similarly, soy fat and protein ranged from 4.62 to 6.8, and 14.4 to 21.2 respectively in various blends.

The results of sensory evaluation of slurry blended with different levels of milk solids are presented in Appendix -9.5.8, and summarised graphically in fig. 5.5 (III a,b). The flavour scores ranged from 36.3 (mild cheesy flavour) to 24.3 (mild off-flavour, bitter taste), only spreads containing less than 5% milk solids were rated below 30 for flavour scores. Flavour scores of spreads containing 31.5% to 23,7% milk solids were significantly higher than the lower milk solids containing spreads (fig. 5.5 IIIa). However, 16.1% and 7.5% milk solids containing spreads also gave mild cheese flavour which were acceptable to the panel of judges. The flavour scores obtained for the spreads were found to be positively and significantly related to milk solids percentage (r = 0.95), milk fat (r = 0.97), and milk protein (r = 0.92) content of the spreads, indicating the desirable role of milk solids components towards flavour development in soybased cheese spreads.

The above trend was also seen in B&T characteristics of the spreads. The B&T scores ranged from 22.0 to 28.7 (fig. 5.5 III b). The quality of B&T decreased with decreasing in the milk solids percentage in the spreads. The spreads were considered coarser at lower milk solids percentage levels. In general, B&T of all the spreads were considered pasty by panel of judges. Irrespective of the B&T scores, all the spreads were considered spreadable (30 scores) by the panel.

The total scores ranged from 95.0 to 76.3 among the spreads, the scores were found to decrease with decreasing milk solids level in the samples (fig. 5.5 III b).

The OAA scores of the spreads ranged from 85.0 to 60.0, however, all the slurry spreads were rated in the acceptable' range (60-80 scores) except for the 0.2% milk solids containing samples which had a score range of 40-60. The highest OAA scores were received by maximum milk solids containing slurry (31.5%). The OAA scores decreased with decreasing in milk solids level in the samples (fig.III b) The spreads containing 5.7 and 0.2% milk solids were significantly lower in OAA scores (61.3, and 60.0 respectively), compared to 31.5% and 26.2% milk solids containing samples (85.3 and 80.0 scores respectively). However, no significant differences were observed in OAA scores between 31.5 and 7.5% milk solids containing spreads. The computed correlation co-efficient values revealed that OAA scores were positively and significantly related to milk solids ($r = 0.80$), milk fat (r = 0.83), and protein (r = 0.97) content of the spreads.

When the total scores of sensory parameters were correlated with OAA scores, a statistically significant (r = 0.92) relationship was evident to indicate that panels were consistent in considering individual sensory parameters while evaluating OAA of the samples.

It is apparent from the above experiment that a minimum of 7.5% milk solids is absolutely necessary for acceptable flavour development in the soy slurry-based cheese spreads. The spread containing 7.5% milk solids was equally acceptable in OAA and, B&T characteristics, as higher milk solids percentage spreads. The spread was devoid of any beany, unpleasant flavour which was detected in 5.7%, and 0.2% milk solids containing soy slurry spreads. Hence, it was decided to continue subsequent experiments with 7.5% milk solids in the slurry-based samples.

From the above experiment, it is apparent that the minimum requirements of cheese solids/milk solids in the soy slurry spreads (14.8% and 7.5% cheese solids) seems to be comparatively less than the soy maska-based spreads (49.3%) to develop into an acceptable flavour, and B&T. The total solids of the raw materials (34.0% in slurry as against 18.0% in soy maska) seems to be critical in the requirement of cheese/milk solids addition for acceptable spread making. In general, the developed spreads were mild in flavour, lacking in smooth B&T, and melt-down properties, the qualities desirable in a spread. Hence, the subsequent experiments were planned to improve these qualities by altering the processing conditions.

5.2.2 Effect of agitation and pH adjustment on the sensory qualities of soy cheese spreads:

As a means of controlling the redox, and enzyme activities daily agitation, and pH adjustment has been recommended as an essential step for slurry cheese making (Kristoffersen et al., 1967; Singh and Mittal, 1984). The first part of the experiment was to assess the effect of agitation alone on the sensory qualities of the spreads. One lot of the sample from each group of cheeses, viz., maska and slurry based samples, were daily agitated for 8-10 days without adjusting the pH to 5.3, while another lot was kept undistrubed during entire curing session. The results pertaining to agitation experiments are discussed in below.

5.2.2.1 Effect of agitation :

Tha maska based cheese blend (49.3% cheese solids) after 10 days of ~~curing revealed, a mildly~~ cheesy, and alcoholic flavour in agitated samples. The undisturbed samples showed a strong, alcoholic, yeasty, and moldy flavour, which disappeared during heat processing. The cloudy appearence was distinctly apparent on the surface of the undisturbed samples (Table 5.9). The slurry based cheese blend (13.3% cheese solids) kept undisturbed for 8 days developed a strong ammonia type putrid flavour. There was a

Table 5.9 Effect of agitation on sensory characteristics of soy cheese spreads.

Treatments	Sensory characteristics
A. Maska-based cheese spreads: (49.3%CS)	
Agitated daily	Mildly cheesy flavour, surface smooth and clean.
Undisturbed	Strong alcoholic, yeasty and moldy flavour. Surface cloudy, grainy texture.
B. Slurry-based spreads:	
1. Slurry with 13.3% CS:	
Agitated daily	Strong objectionable flavour, surface smooth and clean, smooth texture.
Undisturbed	Musty flavour, unclean and uncharacteristic off flavour, surface cloudy, grainy texture.
2. Slurry with 7.5% MS:	
Agitated daily	Strong objectionable flavour, smooth and clean surface, pasty texture.
Undisturbed	Strong putrid unclean flavour, orangish-yellow, violet spots visible on the surface, and grainy texture.

visible pale-orangish growth on the surface. The agitated samples also developed a strong objectionable putrid flavour at the end of 8 days. The putrid flavour persisted even after heat processing in both the samples. The texture of undisturbed samples were criticised as grainy, while agitated samples were considered smooth. The undisturbed samples of milk based (7.5% milk solids) slurry developed strong ammonia type, putrid and unclean flavour which persisted in the same intensity even after heat treatment. A visible orangish-yellow growth was apparent in the non-agitated slurry samples. In addition to this, the texture of 8 day old non-agitated samples were criticised as coarse, and grainy, while agitated samples were smooth in texture. The agitated samples also developed a strong putrid flavour which was highly objectionable to the panel of judges. Due to the strong objectionable flavour, the slurry based soy cheese spreads were not subjected to the sensory evaluation. The results pertaining to organoleptic quality of maska based cheese spreads are tabulated in Table 5.10.

Table 5.10 Effect of agitation on the sensory scores of maska based spreads.

	Sensory scores				
Variables	**Flavour (40)**	**B & T (30)**	**Spreadability (30)**	**Total score (100)**	**OAA (100)**
Agitated daily	33.6 (30-35)	25.0 (25)	25.0 (25)	83.6	82.9 (60-100)
Undistrubed	30.7 (25-30)	24.0 (20-25)	25.0 (25)	79.7	62.9 (60-80)
t' value	2.17*	-	-	-	1.92*

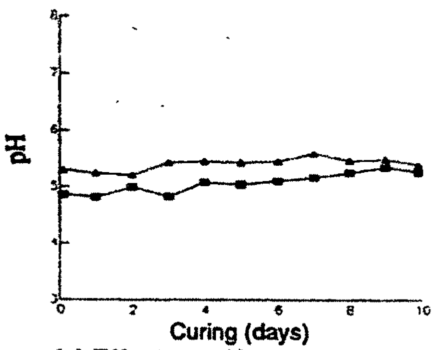
Note: Figures in parentheses indicate range of scores.
* - Significant at 5% level

The daily agitated samples scored significantly higher in flavour and over all acceptability over non-agitated samples. The undisturbed cheese samples were criticised for having an acid-alcoholic flavour perception, while, agitated samples for having mild cheesy flavour. The body and texture of both the spreads were rated as coarse and grainy and, with slight resistance to spreadability.

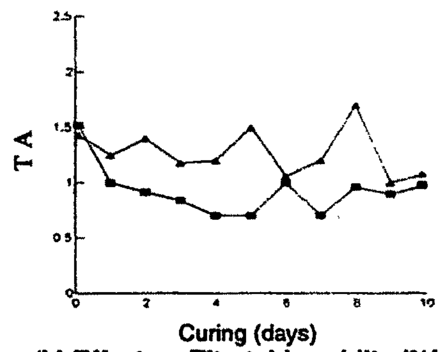
It is clear from the above observations that agitation alone seems to be inadequate in the development of desirable flavour in slurry based cheese spreads. Kristoffersen et al. (1967), Singh and Mittal (1984), and Kumari and Singh (1985) have stressed the role of pH adjustment to 5.3 in slurry based cheese spreads during storage period for full development of flavour. The results of the study on pH adjustment to 5.3 initially and maintaining the same pH throughout the curing session on the sensory qualities of soy based cheese samples are presented in this section. The data pertaining to these results are presented in this section.

5.2.2.2. Effect of pH adjustment on pH and TA during curing.

The fig.5.6 depicts the variation in pH and TA during ripening of soy cheese samples. As evident from the fig. 5.6(I,a) that the pH of fresh sample maska based cheese blend was around 4.8 in pH not adjusted lot. Initial pH being 5.3 in the samples where pH was adjusted, decreased during first 24 hrs., and thereby there was a steady increase in pH upto 7 days followed by

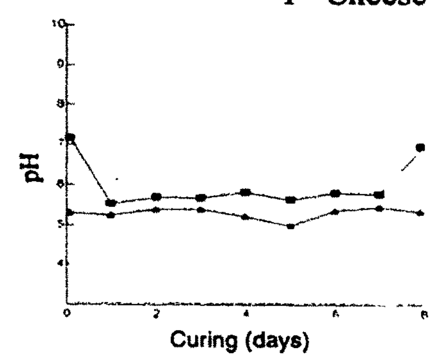


(a) Effect on pH

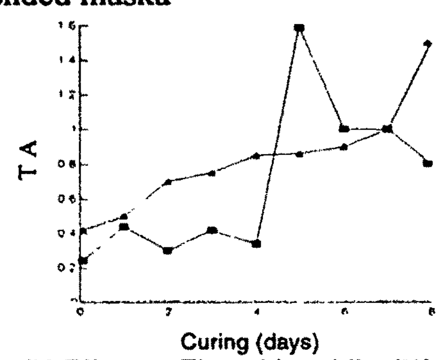


(b) Effect on Titratable acidity (%lactic)

I - Cheese solids blended maska

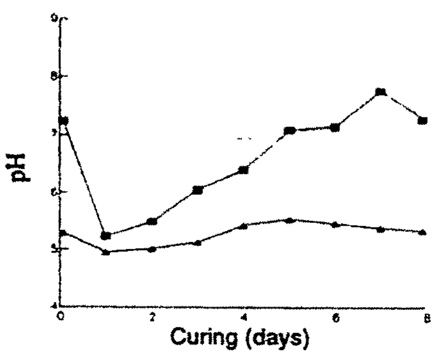


(a) Effect on pH

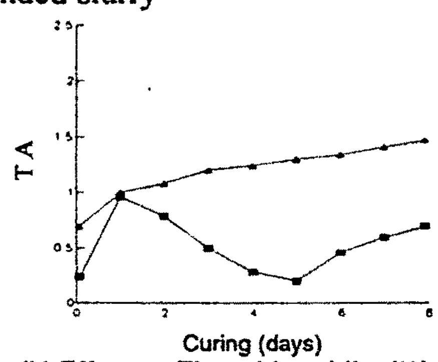


(b) Effect on Titratable acidity (%lactic)

II - Cheese solids blended slurry



(a) Effect on pH



(b) Effect on Titratable acidity (%lactic)

III - Milk solids blended slurry

Figure 5.6 Effect of pH adjustment on pH & TA during curing

▲ pH adjusted ■ pH not-adjusted

a drop, reaching approximately to 5.48 by 10 days of curing. The trend was similar but at a lower pace in pH not adjusted samples.

A rise and fall in acid production was noticeable during the curing period in cheese blended maska samples (fig.5.6, I b). The acid production in daily pH adjusted samples were higher than the pH not adjusted samples throughout the curing period. However, the final acid production in both the samples was found to be more or less same (1.08 and 0.98 respectively) for pH adjusted and not adjusted samples.

The data pertaining to the pH and TA variations during curing of cheese blended slurry are presented in fig. 5.6(II). It is apparent from the fig.5.6 (b) that the initial pH of the cheese blended slurry was high (7.16) in pH not adjusted samples. A steep reduction in pH to 5.6 was observed within 24 hrs. of curing. The level of pH below 5.6 was well maintained for about 7 days, followed by sudden increase in pH above 6.0, which was well correlated with the development of strong putrid flavour in the slurries which persisted even after pasteurization. The pH maintained near 5.2 to 5.38 for 5 days in pH adjusted slurry samples. Though a sudden reduction in pH to 4.97 was observed on the 6th day, the pH tended to balance around 5.3 by 8 to 10 days. The flavour of the pH controlled slurries were clean and mild cheesy.

A steady increase in acid production was observed in pH controlled slurry samples, while, the rise and fall in TA pattern was obvious in the samples where pH was not adjusted to 5.3(IIb).

The fig. 5.6 (III a) presents the pH variations during the curing of milk solids blended slurries. The decrease in pH was maximum during the first 24 hrs., particularly for those samples without initial pH adjustments. Thereafter, the pH tended to be more or less stabilise upto 5 days in pH adjusted samples, followed by slight rise and stabilise around 5.3 at the end of 8 days curing period. On the other hand, there was a sharp increase in pH after third days, in the samples where pH was not adjusted to 5.3 initially and tended to increase above 7.0. The flavour of the pH adjusted soy cheese sample was pleasent, clean and mild cheesy during curing session. An intense putrid flavour developed in the slurries in which pH was not adjusted. The slurries developing the unpleasent strong ammonia based flavour coincided with maximum pH gain in the slurries (pH above 6).

A steady increase in TA production was observed which reached 1.4% at the end of 8 days curing in pH adjusted slurries (fig.IIIb). Though, there was an initial rise in TA to 1.0% in pH not adjusted samples, during first 2 days, the TA tended to decrease by 5 days, followed by a steady increase at a lower pace reaching the final TA of 0.78% at the end of 8 days.

5.2.2.3 Sensory characteristics of soy cheese spreads:

The table 5.11 presents the effect of pH adjustment to 5.3 on the sensory characteristics of soy cheese spreads.

Table 5.11 Effect of pH adjustment during curing on the sensory characteristics of soy cheese spreads.

Treatments	Sensory characteristics
A. Maska-based cheese spreads: (49.3%)	
pH adjusted to 5.3 daily	Mild cheesy, clean surface, no off flavour
pH not adjusted	Mild cheesy, clean surface, no off flavour
B. Slurry-based cheese spreads:	
1. Slurry with Cheese solids (13.3%)	
pH adjusted to 5.3 daily	Mild cheesy, clean surface, no off flavour
pH not adjusted	Strong putrid flavour
2. Slurry with milk solids (7.5%)	
pH adjusted to 5.3 daily	Mild cheesy, clean surface, no off flavour
pH not adjusted	Intense putrid flavour

The daily pH adjustments did not bring any beneficial change in cheese blended maska spreads. Both the samples (pH adjusted and not adjusted) were rated as mild cheesy with absence of any off flavour. The slurry based spreads (both cheese and milk solids blended) were able to develop into a mild cheesy flavour during 8 days of curing with pH adjustment and daily agitation.

The flavour of pH not adjusted samples were highly putrid. Due to objectionable flavour, the slurry based spreads were not subjected to sensory evaluation. The results of sensory evaluation pertaining to cheese blended maska based spreads are presented in table 5.12.

Table 5.12 Effect of pH adjustment during curing on sensory scores of maska-based cheese spreads

Variations	Sensory scores				
	Flavour (40)	B & T (30)	Spreadability (30)	Total (100)	OAA (100)
pH adjusted to 5.3 daily	33.9 (30-40)	24.0 (20-25)	25.0 (25)	82.9 -	81.7 (60-80)
No pH adjustment	32.4 (30-40)	24.0 (20-25)	25.0 (25)	81.4 -	77.8 (60-80)
t' value	0.47^{NS}	-	-	-	1.03^{NS}
Table t' value at 5%	2.04				

Note: NS - not signigicant at 5% level
Figures in parentheses indicate range of scores.

As evident from the table, no statistically significant differences were observed in any sensory parameters evaluated between the samples, indicating that pH adjustment is not very critical for desirable flavour development. Both the samples (pH adjusted and not adjusted) were rated in the range of slightly to moderately liked (77.8 to 81.7 scores) from the point of OAA. Though, the flavour developed was mildly cheesy, body and texture, and spreadability characteristics were criticised for being grainy and slight resistance to spreading in both the samples.

From these two experiments, (agitation, and pH adjustment), it is very obvious that agitation along with pH adjustment is essential for development of desirable flavour particularly in soy slurry based samples. The beneficial effect of agitation on sensory characteristics (with specific reference to flavour) may be related in part to the incorporation of air (oxygen).

From the pH adjustment studies, it can be inferred that pH adjustment to 5.3 initially, and to maintain the level throughout the curing period coupled with agitation was more crucial to slurry based cheese spreads for desirable flavour development. The pH values greater than 5 (5.2 to 5.3) are known to be compatible with the useful chemical an enzymatic reactions (Eck, 1987) which regulates the desirable flavour development in cheese. However, the cheese blended with maska spreads were found to be not much dependent on pH (around 5.3) for favourable flavour development during curing. The physical and chemical compositional differences between maska and slurry might be the reason for obvious results. The maska which is prepared from aqueous extract of soybean, essentially contains the water soluble components, while the slurry prepared from dehusked soybean may also contain several insoluble constitutents. On the other hand, TS levels also varied between the two, the slurry having more TS (33.3% TS) than maska (18%). These differences perhaps may be the reason that daily agitation and pH adjustment to 5.3 was critical for desired flavour development in slurry than maska system.

Realising the beneficial role of agitation, and pH adjustment on full flavour development of cheese spreads, it was **decided to daily agitate and adjust pH initially to 5.3 and maintain the same level thoughout the curing period in slurry based samples. While daily agitation alone was considered adequate in maska based samples in subsequent experiments.**

5.2.3 Effect of adding papain and reduced gluthathione (GSH) during curing on the sensory qualities of soy cheese spreads:

Addition of proteolytic enzyme and GSH are recommended for full flavour development in slurry based cheeses (Kristoffersen et al., 1967). To compare the effect of addition of papain and GSH, the samples were divided into 4 lots. Papain in the concentration of 0.01% TS was incorporated in one lot, GSH (100 ppm) in the second, and combination of papain (0.01% TS) and GSH (100 ppm) in the third lot. The fourth lot, without these additives served as control. All the samples were agitated daily, and the pH of the slurry-based samples were alone adjusted to 5.3 initially and maintained the pH level throughout the curing session. The results pertaining to these experiments are presented in this section.

5.2.3.1 Maska based cheese blend:

The table 5.13 presents the results of organoleptic evaluation of cheese blended in maska-based spreads (49.3% CS). The flavour and OAA scores of the spreads ranged from 31.0 to

Table 5.13 Effect of adding papain and GSH on sensory scores of maska-based cheese spreads

Treatments	Sensory scores				
	Flavour (40)	B & T (30)	Spreadability (30)	Total (100)	OAA (100)
No addition (Control)	34.0 (30-40)	24.0 (20-25)	25.0 (25)	83.0 -	84.0 (60-100)
Addition of papain(0.01%)	31.0 (25-35)	24.0 (20-25)	25.0 (25)	80.0 -	82.9 (60-100)
Addition of GSH(100 ppm)	31.0 (30-35)	24.0 (20-25)	25.0 (25)	80.0 -	82.0 (60-100)
Additon of GSH & papain	33.0 (30-40)	24.0 (20-25)	25.0 (25)	80.0 -	81.3 (60-100)
Calucated F'	3.0^{NS}	-	-	-	2.17^{NS}

Note: NS - not significant at 5% level. Figures in parentheses indicate range of scores

Table 5.14 Effect of adding papain and GSH on sensory scores of cheese blended slurry spreads.

Treatments	Sensory scores				
	Flavour (40)	B & T (30)	Spreadability (30)	Total (100)	OAA (100)
No addition (control)	32.5^{b} (30-40)	25.0 (25)	30.0 (30)	87.5 -	72.0^{d} (60-100)
Addition of papain (0.01%)	34.0^{a} (30-40)	25.0 (25)	30.0 (30)	89.0 -	82.0^{c} (80-100)
Addition of GSH (100 ppm)	36.5^{a} (35-40)	25.0 (25)	30.0 (30)	91.5 -	84.0^{b} (80-100)
Additon of GSH & papain	37.0^{a} (35-40)	25.0 (20-25)	30.0 (25)	92.0 -	88.0^{a} (80-100)
Calucated F'	4.4	-	-	-	4.5
SEm	1.42	-	-	-	4.5
CD	4.0				12.8

Note: Non-identical letters denote significance difference between two means at 5% level. Figures in parentheses indicate range of scores.

34.0, and 81.0 and 84.0 respectively between the different samples. Though the control spread scored high in flavour, and OAA, the difference between the treatments were not statistically significant, indicating that adding papain or GSH either alone or in combination could not improve the sensory scores. Similarly, the addition did not exert any influence on B&T, and spreadability characteristics, criticisms being grainy and slight resistance to spreadability in all the samples.

5.2.3.2 Slurry based cheese blend:

The effect of adding papain and GSH on the sensory scores of slurry spread (13.3% CS) are presented in Table 5.14. The flavour scores for different treated and control spreads ranged from 32 to 37. The flavour scores of control (no addition) was significantly lower than the others. It was evident that there was no significant difference when papain or GSH were added either alone or in combination in the spreads with respect to flavour scores. When GSH and papain added either singly, or in combination in the slurries, the flavour during the first two days was similar to that of untreated samples. However, after four days of storage, a definite trend in the development of well balanced cheese flavour was apparent in all the samples except control. The control samples developed mild cheesy flavour only after six days of storage. The additives did not seem to influence the B&T, and spreadability qualities of the spreads (25.0 and 30.0 for B&T, and spreadability respectively for all the treatments). The OAA scores of slurry spreads ranged from

72.0 to 88.0, lowest being scored by control and highest by the sample which had both papain and GSH in combination. A statistically significant difference was observed between all the treatments in OAA scores. The spread which had both papain and GSH in combination was rated as highest (88.0), followed by GSH (84.0) alone, papain alone (82.0), and least by control (72.0). However, all the samples were rated in the range of slightly to moderately liked' from the point of OAA as assessed by the panel of judges.

5.2.3.3 Slurry based milk solids blend:

The effect of addition of papain and GSH on the organoleptic qualities of slurry spread are shown in Table 5.15. The flavour scores ranged from 25.0 - 39.0 between the treatments, the highest score being received by the slurry which was treated by both papain and GSH. The control spread scored significantly low in flavour. When 0.01% papain, and 100 ppm GSH alone, or in combination were added to the slurries, the flavour during first two days of curing was similar to that of control. However, after three days of storage, the trend of fermented and later, mild cheesy, well balanced flavour was apparent. The flavour increased in intensity with prolonged storage and reached desirable intensity by 8 days.

The incorporation of papain and GSH did not exert any influence on the B&T, and spreadability characteristics (25.0 and 30.0 scores respectively for B & T, and spreadability in all the

Table 5.15 Effect of adding papain and GSH on sensory scores of milk solids blended in slurry spreads

Treatments	Sensory scores				
	Flavour (40)	B & T (30)	Spreadability (30)	Total (100)	OAA (100)
No addition (control)	25.0[a] (20-30)	25.0 (25)	30.0 (30)	80.0 -	42.0[a] (20-60)
Addition of papain(0.01%)	32.0[b] (20-40)	25.0 (25)	30.0 (30)	87.0 -	64.0[b] (40-80)
Addition of GSH (100 ppm)	34.0[b] (30-35)	25.0 (25)	30.0 (30)	89.0 -	74.0[b] (40-100)
Addition of GSH & papain	39.0[b] (30-40)	25.0 (25)	30.0 (30)	94.0 -	82.0[b] (60-100)
Calucated F'	7.82	-	-	-	11.59
SEm	1.77	-	-	-	7.29
CD	5.73				20.85
Table 'F' (5% level)	2.86				

Note: Non-identical letters denote significance between the means at 5% level. Figures in parentheses indicate range of scores.

treatments) of spreads. The OAA scores of spreads followed the set pattern of flavour, where control scored (42.0) significantly less than the others (64.0, 74.0, and 82.0 for addition of papain, GSH, an papain and GSH combinations respectively).

It is apparent from the above observations that the incorporation of papain or GSH either alone or in combinations improved the flavour quality. However, the combinations of papain and GSH proved to be the best for full development of flavour in slurry-based cheese spreads.

The beneficial effect of papain in soy system have been indicated by Obara (1968), Emmons et al., (1970), and Green (1972). However, the flavour quality in soy slurries were found to be decreased by increasing the papain concentration beyond 0.01% (Kumari and Singh, 1985).

GSH is known to increase the rate of proteolysis (Kristoffersen, et al., 1967). Harper et al. (1971) explained the proteolytic behaviour of GSH through degradation of proteins. According to them, the first effect of GSH appears to be the disaggregation of protein-bound peptides, while the second role appears to be associated with rapid increase in the rate of degradation after four days of ripening. The GSH-released peptides appear to stimulate the production of proteases which selectively degrade the peptides and soluble protein components. Kumari and Singh (1990) have further demonstrated that incorporation of papain and GSH had a stimulatory effect on the concentration of free amino groups, formation of active -SH groups, and solublinization of protein during stroage in soy slurry system.

Based on the beneficial role of above additives, it was decided to add papain 0.01% and GSH 100 ppm, in combinations in slurry based soy cheeses in subsequent experiments.

5.2.4 Effect of temperature and Extent of curing on the curing behaviour and sensory qualities of soy cheese spreads:

Curing of cheese involves a number of physico-chemical and biochemical changes initiated by enzymes, starter organisms, and native microflora of food system. The nature, rate and extent of curing process are known to be affected by temperature and duration of curing (Eck, 1987).

5.2.4.1 Effect of temperature:

During preliminary trials, the cheese dependent spreads, viz., maska and slurry based were cured at refrigerated temperature (8 to 10oC) for 8 to 10 days, while milk based slurry was cured at room temperature (24 to 30oC) for 8 days. The present experiment was undertaken to study the effect of temperature and extent of curing on the behaviour, and sensory qualities of cheese. An attempt was also made in the present study to investigate the effect of altering these curing temperature on curing behaviour of the samples. The results pertaining to this aspect are presented below.

In contrast to the low temperature (LT) curing, the maska based cheese sample developed an unacceptable cooked' or sulphydryl' (-SH) flavour within two days of curing at room temperature (RT), followed by whey separation. As the spread was unfit for evaluation from the point of sensory qualities, the experiments on curing maska based samples at RT was discontinued.

The milk solids based slurry when cured at refrigerated temperature (LT) did not bring any appreciable change in flavour even after 16 days of curing. On the other hand, the desired mild cheesy flavour was apparent in the samples when cured at RT within 8 days. On the basis of these observations, it was considered appropriate to cure milk based samples only at RT in subsequent trials. The results pertaining to the organoleptic qualities of slurry based cheese blend spreads cured at LT and RT as presented in table 5.16, indicate that although the flavour and OAA scores of LT cured samples were higher than RT cured samples, the differences between the two were not statistically significant.

Table 5.16 Effect of curing cheese blended slurry sample at LT and RT on the sensory scores.

Curing temperature	Senosry scores					Criticism
	Flavour (40)	B&T (30)	Spreadability (30)	Total (100)	OAA (100)	
LT (8 to 10oC)	28.5 (25-30)	25.0 (25)	30.0 (30)	83.5 -	54.0 (20-80)	very mild flavour
RT (24 to 30oC)	26.0 (20-30)	25.0 (25)	30.0 (30)	81.0 -	38.0 (20-60)	hint of off-flavour
t' value	1.90NS	-	-	-	1.99NS	

Note: NS-not significant at 5% level.
Figures in parentheses indicate range of scores.

The spread cured at LT were commented as having very mild cheese flavour. On the other hand, the cheese cured at RT showed a hint of off-flavour and with bitter taste.

As none of these two curing temperatures gave acceptable results, (ie., OAA not more than 60), alternating the LT and RT curing was investigted in the next stage. Accordingly, the slurry was subjected to the following four combinations of alternating LT and RT during curing, vi., (a) 5 days LT and 3 days RT,(b) 3 days LT and 5 days RT,(c) 2 days LT and 6 days RT,(d) and, 3 days RT, 3 days LT, and 2 days RT. The results pertaining to this aspect of experiments are presented in Table 5.17.

Table 5.17 Effect of curing cheese blended slurry sample at alternating temperatures on the sensory scores.

Curing temperature	Senosry scores				
	Flavour (40)	B&T (30)	Spreadability (30)	Total (100)	OAA (100)
RLT LT RT#					
5 + 3	26.0^{b}	25.0	30.0	81.0	66.0^{b}
	(25-30)	(25)	(30)	-	(20-80)
2 + 6	25.5^{b}	25.0	30.0	80.5	58.0^{a}
	(20-30)	(25)	(30)	-	(40-80)
3 + 5	28.5^{b}	25.0	30.0	83.5	62.0^{ab}
	(25-30)	(25)	(30)	-	(40-80)
3 + 3 + 2	37.0^{a}	25.0	30.0	92.0	84.0^{c}
	(30-40)	(25)	(30)	-	(40-80)
F'value	24.07	-	-	-	3.57
S Em	1.54				1.91
CD	4.39				5.46

Note: Non-identical letters denote significant difference between means at 5% level. Figures in parenthese indicate range of scores
 # LT - curing temperature between 8 to 10oC and RT at between 24 to 30oC.

The flavour scores of spreads ranged between 25.5 to 37.0. The spread cured at 3 days LT, 3 days RT, 2 days LT scored significantly higher (37.0) than the other samples by having desired, pleasent and mild cheesy flavour. A slight bitter taste and uncharacteristic flavour was detected in the samples cured at other alternative temperatures. However, the B & T, and spreadability were found to be not influenced by any altered curing temperatures. All the samples were considered pasty, and were rated as spreadable.

The OAA scores of different samples ranged from 58 to 84. The cheese cured at 3 days LT, 3 days RT, 2 days LT scored significantly high (84) over other spreads. It was interesting to note that cheese which were cured for longer period at RT (2 days LT, 6 days RT, and 3 days LT, 5 days RT) scored low in OAA (58 and 62 respectively).

Curing at refrigerated temperature have been shown to slow down the biochemical reactions which in turn slow down the curing process (Eck, 1987). Thus is is apparent that curing only at low temperature (8 to 10oC) for 8 days rendered the slurry spread with very low cheesy flavour.

On the contrary, continous exposure to higher temperature (24 to 30oC) might have accelerated several important biochemical reactions at different phases,rendering the product off-flavoured and bitter which were not acceptable.

The alternative curing temperature adopted in several combinations in slurry based cheese, which gave acceptable results might be due to the regulation of several enzymatic reaction in phase manner. For example, initially lactic fermentation, followed by proteolysis, and lipolysis.

On the basis of above results, it was decided to cure cheese blended maska based spread samples at refrigerated temperature (8 to 10oC), milk blended slurry based spread at room temperature (24 to 30oC), and cheese blended slurry based spread samples at alternating curing temperature schedule of 3 days at LT, RT, and 2 days of LT in subsequent experiments.

5.2.4.2 Effect of extent of curing:

The flavour of cheese blend in maska which was distinctly acidic on the 0 day of storage, changed gradually into mild cheesy and alcoholic perception by the end of 8 to 10 days. The intensity of flavour did not vary much even after prolonged curing for 24 hrs.

The table 5.18 presents the effect of duration of curing on the sensory qualities of cheese blended in maska based samples.

Table 5.18 Effect of extent of curing on sensory scores of cheese blended maska based spreads.

Duration of curing (days)	Sensory scores				
	Flavour (40)	B & T (30)	Spreadability (30)	Total scores (100)	OAA (100)
8	36.0 (30-40)	24.0 (20-25)	25.0 (25)	85.0 -	74.0 (60-80)
16	36.0 (30-40)	24.0 (20-25)	25.0 (25)	85.0 -	74.0 (60-80)
24	34.5 (30-40)	24.0 (20-25)	25.0 (25)	83.5 -	72.0 (60-80)
F'value	0.40^{NS}	-	-	-	0.17^{NS}
SEm	1.93	-	-	-	0.94

Note: NS - Not significant at 5% level
Figures in parentheses indicate range of scores

It is evident from the table that none of the sensory parameters viz., flavour, B&T, spreadability, and OAA were found to be affected by prolonged storage in the spreads. However, the spreads which were cured for 24 days revealed alcoholic sour taste. Though no statistical differences were apparent between the samples, a trend of decreasing in sensory scores (flavour and OAA) during prolonged curing was noticed.

The freshly prepared cheese blended in slurry base was essentially bland, with slight suggestion of acid, due to addition of culture. After three days of storage, the flavour was distinctly fermented. This flavour was slowly replaced by mild cheese flavour by 8 days of storage. However, with further ripening upto 16 days, resulted in a distinct decrease in flavour quality due to the development of a definite unclean, putrid flavour. The development of putrid flavour might have been resulted from the formation of excess sulfide compounds. Onset of increased pH beyond six (Appendix -5.9), and the formation of characteristic putrid flavour in the slurries was well coincided.

The results of organoleptic evaluation of cheese and milk blended slurry cheese spreads are presented in Table 5.19, and 5.20.

It is clear from the table that flavour and OAA scores decreased with prolonged storage. However, there was no statistical significant differences between the samples cured for different periods with respect to flavour and OAA. The cheese spreads cured for 8 days were commented as pleasent, mild cheesy, while cheese cured for 12 days were considered having developed uncharacteristic flavour. On the other hand, a slight putrid flavour was perceived in the samples cured for 16 days. Prolonged storage was not found to influence the B & T, and spreadability attributes.

The flavour of milk solids blended in slurries were essentially cooked beany with a slight suggestion of acid due to addition of culture on the 0 day of curing with respect to flavour. After 3 to 4 days of storage, the flavour was distinctly fermentative. This flavour disappeared after 6 days and a desirable, mild, cheesy flavour appeared by 8 to 10 days. When the storage of slurries was prolonged over 10 days, the

Table 5.19 Effect of extent of curing on sensory scores of cheese blended slurry based spreads.

Duration of curing (days)	Sensory scores				
	Flavour (40)	B & T (30)	Spreadability (30)	Total scores (100)	OAA (100)
8	31.6 (25-40)	25.0 (25)	25.0 (25)	81.6 -	82.0 (60-80)
12	29.7 (15-35)	25.0 (25)	25.0 (25)	79.7 -	82.0 (60-80)
16	28.4 (15-35)	25.0 (25)	25.0 (25)	78.4 -	79.1 (40-80)
F' value					
SEm	2.07	-	-	-	7.44

Note: NS - not significant at 5% level
Figures in parentheses indicate range of scores

Table 5.20 Effect of extent of curing on sensory scores of milk solids blended slurry based spreads.

Duration of curing (days)	Sensory scores				
	Flavour (40)	B&T (30)	Spreadability (30)	Total scores (100)	OAA (100)
8	39.0[a] (35-40)	25.0 (25)	30.0 (30)	94.0 -	72.0[a] (60-80)
12	29.0[b] (25-35)	24.0 (20-25)	30.0 (30)	83.0 -	64.0[a] (40-80)
16	19.0[c] (15-25)	24.0 (20-25)	30.0 (30)	73.0 -	24.0[b] (10-40)
F' value	37.51*	-	-	-	20.67*
SEm	2.31	-	-	-	8.0
CD	8.5				29.44

Note: * - significant at 5% level
Figures in parentheses indicate range of scores

When the storage of slurries was prolonged over 10 days, the flavour was typical of that sharp ammonia type with distinct putrid perception. The intensity of this trend increased with increase in duration of storage.

It is clear from the table 5.20, that flavour and OAA scores decreased with prolonged storage period. The maximum scores for flavour and OAA was obtained by the spreads which were cured for 8 days. These spreads were rated as mild cheesy and pleasent and between moderately to most liked category from the point of OAA. The spreads cured for 16 days were found significantly interior with respect to flavour and OAA attributes over other samples, being criticised as putrid and bitter. A slight bitterness was also detected in the spread which was cured for 12 days. However, prolonged storage did not influence the B&T spreadability characteristics.

Based on the above results, it was decided **to cure all the soy based cheese spreads for the period of 8 days as further curing did not bring any improvement in the sensory characteristics in any samples.**

5.3 PROCESSED CHEESE SPREAD MAKING TRIALS

The cured cheese is heat processed as a means of improving the sensory parameters like B&T, flavour, and keeping quality. The effective heat treatment given during processing results in attainment of physcio-chemical, and bacteriologically stable product (Meyer, 1979). During processing of spread several additives are usually added such as emulsifying salts, stabilisers, and other food (non-cheese materials like butter, ghee, spices ,etc.), and non-food (vitamins, colours etc.) materials, to improve the appearance, consistency, B&T, and flavour, and partly to enrich the nutritional substances.

The cured samples viz. cheese blended maska, and slurry, and milk solids blended slurry which were selected based on the optimization experiments were heat processed . The maska samples were heat processed for 15 mts. at 65°C, and slurry based samples were processed at 72°C for 15 mts. Series of experiments were conducted at this point with addition of :

- Emulsifying salts
- Stabilizers
- Spices
- Fat

The results pertaining to the effect of above additives on modification of textural, and flavour qualities of soy cheese spreads are presented in this section:

5.3.1 Effect of adding emulsifying salts:

The task of emulsifying salts is to destabilise the cheese sol. Citrates, and phosphates are known to be used in practice as common emulsifiers in processed cheese spread making. Citrates are very soluble having fairly good protein dissolving powers, while phosphates has a strong buffering action (Meyer, 1973).

The results of the preliminary trials of heat processing of spreads with (1-3%), and without the addition of emulsifying salts indicated that the addition of 2% emulsifying salts was absolutely essential during spread making for satisfactory B&T. The spreads without emulsifying salts in all samples were criticised to be coarse, granular,and mild to moderately resistant to spreading. The B&T were also found to be weak. Hence, after establishing the essentiality of emulsifying salts, subsequent trials were conducted to select the most appropriate salt combination at 2% level to impart desirable textural characterisitcs to the spreads. The results with respect to these trials are presented in table 5.21.

5.3.1.1. Cheese blended soy maska spreads:

The initial processed spread making trials with emulsifying salts using 49.3% cheese solids blended in soy maska samples failed to impart a satisfactory textural qualities. The spreads were found to be coarse, and grainy, with moderate resitance to spreadability. The lower cheese solids level (49.3%) was though able to develop an acceptable flavour profile, satisfactory B&T was possible only when cheese solids level was raised to 72% in the samples. The previous optimization experiments (effect of agitation, pH adjustment, addition of papain and GSH, time and temperature of curing) repeated with 72% cheese solids blended in

Table 5.21 Effect of adding emulsifying salts on the textural characteristics of soy cheese spreads.

Salts	Sensory scores			
	Body & Texture (30)	Spreadability (30)	Total scores (100)	OAA (100)
Cheese blended Maska				
Tri Sodium PO4	26.5[b] (20-30)	28.5 (25-30)	55.0	70.0 (60-80)
Tri Sodium Citrate	21.5[a] (20-25)	28.0 (25-30)	49.5	66.0 (40-80)
50% Tri Sodium PO4 and Citrate	21.5[a] (20-25)	27.0 (25-30)	48.5	62.0 (40-60)
F' Value	11.06*	0.71 NS		0.75 NS
SEm	1.228	1.283		0.62
CD	4.11	-		-
r' (TSS x OAA) = 0.62				
Cheese blended slurry				
Tri Sodium PO4	27.0 (25-30)	27.0 (25-30)	54.0	74.0 (40-100)
Tri Sodium Citrate	27.5 (20-25)	27.5 (25-30)	55.0	80.0 (40-100)
50% Tri Sodium PO4 and Citrate	261.0 (20-25)	26.5 (25-30)	52.5	74.0 (40-100)
F' Value	0.97 NS	0.39 NS		0.76 NS
SEm	1.1	1.14		0.468
r' (TSS x OAA) =	0.80			
Milk solids blended Slurry				
Tri Sodium PO4	25.0 (25-30)	28.3 (25-30)	55.3	76.7 (40-100)
Tri Sodium Citrate	26.7 (25-30)	29.2 (25-30)	55.9	80.0 (40-100)
50% Tri Sodium PO4 and Citrate	25.8 (25-30)	28.3 (25-30)	54.0	76.7 (40-100)
F' Value	0.09 NS	0.24 NS		0.05 NS
SEm	2.24	1.39		11.80
r' (TSS x OAA) =	0.72			

Note: Non - identical letters denote signficant difference between two means at 5% level. NS - Non significant at 5% level. Figures in parentheses indicate range of scores.

maska based samples revealed similar results as 49.3% cheese solids blended in maska samples. Therefore, it was decided to make maska based spreads with 72% cheese solids in subsequent experiments. The table 5.21 indicates the results of adding different types of emulsifying salts (2%) on the textural characteristics of 72% cheese solids blended maska spreads.

The B&T scores of spreads with various emulsifying salts ranged from 21.5 to 26.5, highest being scored by the spreads which had tri-sodium-phosphate. It is evident from the table that the addition of tri-sodium phosphate at the rate of 2% was also able to impart significantly better B&T to the spread compared to citrate alone and its combination with phosphate. Similar trend was noticeable with respect to spreadability, and OAA scores of the spreads. Though, the spread containing phosphate were rated highest in the above parameters, the differences between the salts were not significant statistically. All the spreads were commented to be slightly grainy in texture. However, the addition of phosphate imparted slightly smooth texture to the spread. The correlation co-efficient (r) between total solids and OAA revealed a significant relationship (r = 0.93), indicating that the panels were consistant in considering individual textural components while evaluating the OAA parameters.

5.3.1.2. Slurry based cheese spreads:

On the other hand, the addition of tri-sodium-citrate was able to score better in slurry based samples for B&T, spreadability, and OAA. All the samples, irrespective of the type of emulsifying salts added were considered smooth, but pasty with satisfactory spreadable qualities. Though a slight differences in scores between the spreads treated by different emulsifying salts was apparent, it was not significant statistically. However, the total scores correlated (0.6 and 0.7 respectively for milk solids and cheese blended slurries) significantly with OAA scores in both the slurry samples.

This experiment was further extended to study the effect of stabilizers along with the emulsifying salts on the textural qualities of soy cheese spreads.

5.3.2. Effect of adding stabilizers:

Stabilizers such as low methoxy pectin (LMP), and agar agar (China grass) with a high water holding capacity are known to contribute significantly towards the improving of the textural characteristics of the spreads (Meyer, 1973).

The stabilizers were used at the level of 0.1% in the spreads at the time of heat processing along with the emulsifying salts. The results pertaining to this experiment are presented below:

5.3.2.1. <u>Cheese solids blended in maskas:</u>

It is evident from the table 5.22 that when pectin or agar agar (0.1%) were added along with citrate and phosphate, there was an improvment in the B&T quality of the spreads. The addition of pectin with tri-sodium phosphate or citrate imparted (29 scores) cohesive and silky body to the spread compared to agar agar (28.5 scores), which gave a moist, and weak body structure.

The similar trend was also apparent in the spreadability characteristics of the spreads. The spreads containing the pectin and agar agar combination with 50% citrate and phosphate, scored significantly lower than the phosphate and citrate with pectin. In general, agar agar combination with any salt proved to impart a weak body texture to the maska based spreads compared to pectins.

The total scores ranged from 51.5 to 58.5, the higher scores being associated with phosphate and citrate with pectin combinations. The OAA scores ranged from 62 to 88 for the various spreads. The spreads with pectin and phosphate (88) or citrate (80) scored significantly higher over other stabilizer combinations. The spreads with phosphate and pectin was considered having silky, cohesive body, while the same salts with agar agar (68 and 70 for phosphates and citrates respectively) were being criticised for having weak body. The spreads with 50% citrate and phosphate either with pectin or agar agar failed to

Table 5.22 Effect of adding stabilisers (0.1%) along with emulsifiers (2%) on the textural qualities of maska based cheese spreads

Additives	Sensory scores			
	B&T (30)	Spread-ability(30)	Total score(60)	OAA (100)
Tri sodium PO + pectin	9.0[b] (25-30)	29.5[b] (25-30)	58.5	88.0[c] (80-100)
Tri sodium citrate + pectin	29.0[b] (25-30)	29.5[b] (25-30)	58.5	80.0[cd] (60-100)
PO4 + Agar Agar	28.5[ab] (25-30)	28.0[ab] (25-30)	56.5	68.0[a] (60-80)
Citrate + Agar Agar	28.5[ab] (25-30)	27.5[ab] (25-30)	56.0	70.0[ac] (60-80)
50% Citrate +PO4 + Agar Agar	26.0[a] (25-30)	25.5[a] (25-30)	51.5	62.0[a] (40-80)
50% Citrate + PO4 + pectin	26.5[a] (25-30)	25.0[a] (25-30)	51.5	68.0[ab] (60-80)
F' value	2.44*	9.25*		296.9*
SEm	1.01	1.41		7.25
CD	2.4	3.34		12.44
r' (TS x OAA) =	0.78			

Note: Non identical letters denote signficant differences between two means at 5% level. Figures in parenthes indicate range of scores.

impart desirable B&T to the maska based spreads, lacking in stable and cohesive body structure.

The total scores were found to be positively, and significantly correlated (r = 0.6) with OAA indicating the consistency in considering individual items while judging the OAA parameters.

5.3.2.2. <u>Cheese blended slurry spreads:</u>

The table 5.23 present the results of adding stabilisers on the slurry based soy cheese spreads. The B&T scores ranged from 26 to 28.5 between the treatments. The addition of agar agar along with citrate though gave better B&T (28.5) to the spread, the difference between the treatments were not significant statistically. No apparent differences were observed when citrates were replaced by phosphates when pectin was added. However, the spreads processed by using 50% citrates and phosphates either with pectin or agar agar revealed an undesirable weak body in the spreads.

The addition of stabilisers in any combinations with emulsifying salts were found not to influence the spreadability characteritstics of the spreads. All the spreads were considered spreadable, but lacking in melt-down quality when tested on the hot toast.

The total scores ranged from 50 to 55.5, the highest being associated with agar agar combination with citrates.

Table 5.23 Effect of adding stabilisers (0.1%) along with emulsifiers (2%) on the textural qualities of cheese blended slurry spreads

Additives	**Sensory scores**			
	B&T (30)	**Spread-ability(30)**	**Total score(60)**	**OAA (100)**
Tri sodium PO4 + pectin	**26.5** (25-30)	**26.0** (25-30)	52.5	**70.0** (40-100)
Tri sodium citrate + pectin	**26.5** (25-30)	**26.0** (25-30)	52.5	**80.0** (60-100)
PO4 + Agar Agar	26.5 (25-30)	26.5 (25-30)	53.0	74.0 (40-100)
Citrate + Agar Agar	28.5 (25-30)	27.0 (25-30)	55.5	80.0 (60-100)
50% Citrate +PO4 + Agar Agar	26.5 (25-30)	21.0 (25-30)	53.0	74.0a (40-100)
50% Citrate + PO4 + pectin	26.0 (25-30)	26.0 (25-30)	52.0	70.0 (40-100)
F' value	1.02^{NS}	0.35^{NS}		0.74^{NS}
SEm	1.23	1.00		7.42
r = (TS x OAA)	0.6			

Note: NS - Not signficant at 5% level.

Table 5.24 Effect of adding stabilisers (0.1%) along with emulsifiers (2%) on the textural qualities of milk solids blended slurry spreads

Additives	Sensory scores			
	B&T (30)	Spread-ability(30)	Total score(60)	OAA (100)
Tri sodium PO4 + pectin	25.0 (20-30)	27.5 (20-30)	52.5	80.0 (40-100)
Tri sodium citrate + pectin	25.0 (20-30)	28.3 (25-30)	55.3	73.3 (40-100)
PO4 + Agar Agar	25.0 (20-30)	27.5 (20-30)	52.5	76.7 (60-80)
Citrate + Agar Agar	28.3 (25-30)	29.2 (25-30)	56.6	86.7 (60-80)
50% Citrate +PO4 + Agar Agar	26.7 (20-30)	27.5 (20-30)	55.9	76.7 (40-80)
50% Citrate + PO4 + pectin	25.8 (20-30)	25.0 (20-30)	50.8	66.7 (40-80)
F' value	0.88 NS	1.19 NS		
SEm	2.08	1.86		
r = (TS x OAA)	0.8			

Note: NS - Not significant at 5% level.

The OAA scores ranged from 70 to 80 between the samples. The agar agar combination with citrates (80) were found to impart shiny appearance to the spreads, the quality which was not apparent in other treatments. The phosphate combination with pectin or agar agar and phosphate citrate combination (50%) in either stabiliser combination in general, were found to score low in OAA lacking in cohesive, and shiny appearance. However, the differences between the treatments were not significant statistically. All the samples were lacking in melt down quality which is desirable in a cheese spread.

The total score was found to be significantly correlated (r = 0.6) with OAA scores, indicating the consistency in scoring pattern of panels.

5.3.2.3. Milk solids blended slurry spreads:

It is evident from the table 5.24 that agar agar along with citrate was able to impart better B&T (28.3), spreadability (28.3), and OAA (86.7) over other combinations to the spreads. However, the differences between the different salts were found statistically not significant. All the spreads were considered smooth, but pasty, lacking in melt-down property, but easily spreadable on the toast. The combination of citrate with agar agar was commented to have better textural characteristics in a spread over others, being cohesive, and firm. The phosphate combinations either with agar agar or pectin were criticised for imparting weak body to the spreads.

It is obvious from the above experiments that combinations of emulsifying salts and stabilisers are essential to impart desirable B&T qualities to the soy based cheese spreads. Emulsifers are multi-functional and play an important role in formulations of the spreads. The stabilisers are binding agents, help in improving the consistency and stability of the spreads by forming heavy glutinous masses by the absorption of water. The stabilisers also appear to act as protective colloids (Meyer, 1973).

Based on the results of the above experiments, it was decided to **add the tri-sodium-phosphate (2%) combination with LMP (0.1%) in maska based samples, and tri-sodium citrate (2%)** combination **with agar agar (0.1%) for slurry based samples** in subsequent experiments.

5.3.3 Effect of adding spices on the sensory qualities of the soy based cheese spreads:

To produce new combinations, and variations in the flavour profile in the soy cheese spreads, one can think of adding different spices at the time of heat processing.

During the initial trials, aromatic, spicy, and ingredients wither singly, or in combinations were incorporated in the soy cheese samples at the time of heat processing, and subjected to sensory evaluation after a day of storage in refrigeration (for opitmum absorption of the flavour). The spices were added at the begining of the heat processing in order to obtain uniform distribution of flavour throughout the cheese mass, and also to effect a certain amount of pasteurization.

The OAA of cheese spreads with spices as judged by the panels are detailed in table 5.25. As evident from the table, only pepper was considered acceptable among the dry spices used. It is also apparent that none of the traditional masala powders widely used in various preparations were accepted in cheese spreads. Among the fresh additives, onion, garlic, ginger, and green chillies, were rated as acceptable. Mint was not considered satisfactory as flavouring agent in cheese spreads. On the other hand, combination of fresh spices like garlic with green chillies, ginger with onion, green chillies with onion were considered acceptable.

Spices which were usually used at a level of 1% had practically no effect on the texture of the spread. However, colour was found to be affected by addition of mint, and masala powders which was not accepted by the judges.

The acceptable spices either alone or in combinations were incorporated in several concentrations (0.5 to 5%) to determine the optimum concentration that is desirable (based on the sensory scores) in cheese spreads. The comparative sensory scores of spreads in most acceptable spice concentration are presented in Table 5.26.

Table 5.25 Effect of adding selected spices on the acceptability of added spices (1%) in soy cheese spreads.

Acceptable	Not acceptable
Dry spices:	
Pepper	Coriander seeds
	Cumin seeds
	Cinnamon
	Cloves
	Asafetida
	Onion seeds
Masala powder:	
	Sambar powder
	Rasam powder
	Chat masala
	Garam masala
	Gujarati masala
Fresh spices:	
Onion	Mint
Garlic	
Ginger	
Green chillies	
Combination of spices:	
Garlic and green chillies	Ginger and green chillies
Ginger and onion	
Onion aand green chillies	
Ginger and cumin seeds	

Table 5.26 Effect of incorporating spices in soy cheese spreads on the sensory scores.

Spice combination	concent-ration(%)	Sensory Scores				
		Flavour (40)	B&T (30)	Spreadability (30)	Total Scores (100)	OAA (100)
Pepper	1	39.0[c] (35-40)	28.3 (25-30)	30.0	97.3	94.0[c] (80-100)
Onion	3	30.5[f] (35-40)	28.3 (25-30)	30.0	88.8	66.0[ab] (40-80)
Garlic	1	32.0[e] (35-40)	28.3 (25-30)	30.0	90.3	78.0[b] (60-80)
Ginger	1	26.0[d] (20-30)	28.3 (25-30)	30.0	84.3	68.0[ab] (60-80)
Green chillies	1	29.0[d] (25-30)	29.2 (25-30)	30.0	88.2	60.0[a] (40-80)
Garlic + green chillies	1	39.0[c] (35-40)	29.2 (25-30)	30.0	98.2	94.0[c] (80-100)
Ginger+onion	1+3	25.0[b] (20-30)	29.2 (25-30)	30.0	84.2	70.0[ab] (40-60)
Onion + green chillies	3+1	22.5[a] (20-30)	29.2 (25-30)	30.0	81.7	66.0[ab] (60-80)
F' value		34.63	0.37NS			10.19
SEm		11.63	1.37			5.81
CD		3.29				11.74

Note: Non identical letters denote significant difference between two means at 5% level.
Figures in parentheses indicate range of scores.

The flavour scores of various spreads ranged from 22.5 to 39.0. The spreads having pepper ((39.0), and garlic and green chillies (39.0) as spice were found to score significantly higher than the others. Onion with green chillies (22.5), and ginger (25.0) scored significantly lower than others, followed by ginger, and green chillies combinations. Onion, and garlic additions in spreads scored significantly higher than combinations of ginger. The panels detected a slight uncharacteristic and/or off flavour in the soy cheese spreads, which had spice combinations like onion with green chillies, ginger, ginger combination with green chillies, and green chillies alone. In general, the flavour of pepper, and garlic in combination with green chillies were found to be most acceptable spice in soy cheese spreads.

5.3.4 Effect of adding hydrogenated fat on the textural characteristics of soy cheese spreads:

To improve the melt down quality and textural quality characteristics, one can use several fat sources such as clarified butter, butter, and hydrogenated fat. The addition of fat also helps in increasing the calorific value of the processed spreads. The fat can be incorporated either at the time of curing or at the time of pasteurization. Initially, 10% of hydrogenated fat and butter was added on the 0 day of curing in the three samples viz., two cheese dependent and one cheese independent samples. The cheese after 8 days of curing developed a flavour which was not acceptable to the judge's palate. However, it was noticed that due to the addition of fat, viscosity of the blend was considerably decreased, and the consistency of the spread became softer. The samples were criticised for having a sort of rancid flavour and bitter taste.

In the second phase of this experiment, 5% and 10% of hydrogenated fat was added at the time of pasteurization. The results pertaining to this aspect of the experiment are presented in table 5.27.

It is evident from the table that addition of 5 to 10% fat significantly improved the B&T (29.5 to 30.0 scores respectively), and spreadability (30.0 scores) of the cheese blended in maska based spreads. The control spread which was devoid of any added fat was considered slightly grainy (26.5), lacking in melt down quality , however, rated as spreadable (27.5) by the panel of judges.

Though the control sample spreads scored low (88.0) as against 5% fat added (94.0), and 10% fat added (98.0) spreads in OAA parameters, the ANOVA did not reveal any significant differences between the treatments. The control and the sample which contained 5% added fat were considered very low in desirable melt down properties when spread on the hot toast. The sample which had 10% fat added at the time of processing showed satisfactory meltdown quality on the hot toast.

Table 5.27 Effect of adding hydrogenated fat on the texture of soy cheese spreads.

Treatments	Sensory scores			Criticisms
	B&T	Spreadability	OAA	
Cheese blended Maska				
Control (no addition)	26.5[a] (25-30)	27.5[a] (25-30)	88.0 (80-100)	Slighlty grainy, no melt dow quality, spreadable.
5% addition	29.5[b] (25-30)	30.0[b] (25-30)	94.0 (80-100)	Smooth, & silky body, slight melt down quality.
10% addition	30.0[b] (30)	30.0[b] (30)	98.0 (80-100)	Smooth & silky body, better melt down quality than above.
Cal. F'value	12.9*	6.01*	3.2NS	
SEm	0.75	0.67	4.0	
CD	2.5	2.24	-	
Cheese blended slurry				
Control (no addition)	28.5 (25-30)	27.0 (25-30)	79.0[a] (60-100)	Smooth cohesive, very low melt down quality.
5% addition	29.5 (25-30)	27.5 (25-30)	88.0[b] (80-100)	Smooth, & silky body, slight melt down quality.
10% addition	29.5 (25-30)	29.0 (25-30)	94.0[b] (80-100)	Smooth & silky body, better melt down quality than above.
Cal. F'value	0.59[NS]	1.8[NS]	5.12*	
SEm	0.925	1.098	4.39	
CD	-	-	14.7	
Milk solids blended slurry				
Control (no addition)	26.0[a] (25-30)	25.5[a] (25-30)	86.0 (80-100)	Smooth and cohesive body No melt down quality.
5% addition	29.0[b] (25-30)	30.0[b] (30)	88.0 (80-100)	Smooth, & slight silky body, no melt down quality.
10% addition	30.0[b] (30)	30.0[b] (30)	92.0 (80-100)	Smooth & silky body, better melt down quality than above.
Cal. F'value	14.6*	81.33*	0.91[NS]	
SEm	0.77	0.41	4.52	
CD	2.58	1.86	-	

Note: Non-identical letters denote significant at 5% level
NS - Not significant at 5% level.

The addition of fat either at 5% or 10% failed to reveal any significant differences with regard to B&T, and spreadability characteristics in cheese blended in slurry based spreads. Both the control, and 5% fat added spreads were considered smooth, but low in melt down quality. However, the sample which contained additional 10% fat were rated as having better melting quality than the other two, besides having silky, smooth, and cohesive body.

The addition of 5 to 10% fat however, significantly improved the OAA scores of the cheese blended in slurry spreads (88 to 94 OAA scores respectively for 5 to 10% fat additions). The control spread scored 79 for OAA. All the samples were rated between moderately' to most-liked' category.

The control milk solids blended in slurry spread scored significantly lower for B&T, and spreadability qualities than the spreads which were fortified with 5 to 10% hydrogenated fat. The control sample was criticised for not having melt down quality, and being pasty in texture. Both the samples with added fat revealed a smooth, cohesive and silky body. The spread with 10% fat had better melt down quality on hot toast which was lacking in the spread which contained 5% fat. Inspite of these differences, no statistical differences were apparent betwen the samples.

The OAA scores ranged between 86 to 92, rated as moderately' to most liked' category. Though the spread with 10% added fat scored highest (92), the difference between the control, and fat fortified samples were not significant statistically.

The addition of fat besides helping in increasing the calorie density of the spreads, have improved considerably the textural qualities such as smooth and shiny body, and in particular the melt down quality of the soy cheese spreads. Hence, it **was decided to add 10% hydrogenated fat at the time of processing in all the samples.**

5.4 SCHEDULE ESTABLISHED FOR THE PREPARATION OF SOY BASED CHEESE SPREADS:

On the basis of initial soy cheese spread making trials, and subsequent process modifications, three soy based cheese spreads, two slurry based, and one maska based were developed. The manufacturing technique of these soy cheese spreads are outlined in Figs. 5.7 - 5.9.

Although the slurry approach with milk solids were initially based on the method developed by Singh and Mittal (1984) using 36% milk solids, the established slurry spreads in the present study differed from the previous method in the following manner:

- Initial slurry making technique using wet-grinding approach with whole beans, rather colloidal mill grinding of dal.
- Reduction of milk solids level from 36% to 7.5%.
- The replacement of milk solids by 13.5% cheese solids:

Soybean (200 g)

+ 0.04 % Sodium Bicarbonate

← Soak and wet grind

→ Residue (352 g)

↓

Soymilk (1 L)

+ 5% RSM
+ 1% Lactose
+ 5% Lactic Culture

↓

Curd (1 L)

Drain → Whey (540 ml)

↓

Soy Maska (355 g)

+ 237 g Cheddar cheese(6 mts)
+ 6.4 g NaCl

↓

Blend
(598 g)
Incubate for 8-10 days at 8-10oC
with daily agitation

+ 10% Fat
+ 2% Trisodium Phosphate
+ 0.1% Low methoxy pectin

↓

Heat (15 mts. at 65oC)

+ 1% Coarse ground pepper or 1% garlic - green chilli paste (after 10 mts. heating)

↓

Package

Cool for 1 h.

↓

Store at Refrigerated temperature

Fig 7: Manufacturing schedule for Soy Maska based cheese spreads.

Soybean (200 g)

Grinding
- Soak in 0.04% Na_2CO_3
- Boil for 60 mts with 1% sodium bicarbonate
- Dehusk

↓

Slurry (600 g)
- + NaCl

↓

Adjust pH to 5.3

↓

Pasteurize
(72oC for 30 mts)

↓

Cool to 30oC
- + 20 g Natural Cheese
- + 4 g NaCl
- + 0.01% Papain
- + 100 ppm GSH

↓

Mix and Store

Daily agitation
pH adjustment to 5.3
- 3 days refrigerated temp
- 3 days room temp
- 2 days refrigerated temp

- + 10% fat
- + 2% Trisodium Citrate
- + 0.1% Agar Agar

↓

Heat
(72oC for 15 mts)
- (after 10 mts. heating)
- + 1% Pepper or Garlic with green chilli (coarsely ground)

↓

Package & Storing at Refrigerated temperature

Fig 8 : Manufacturing schedule of cheese blended slurry spreads

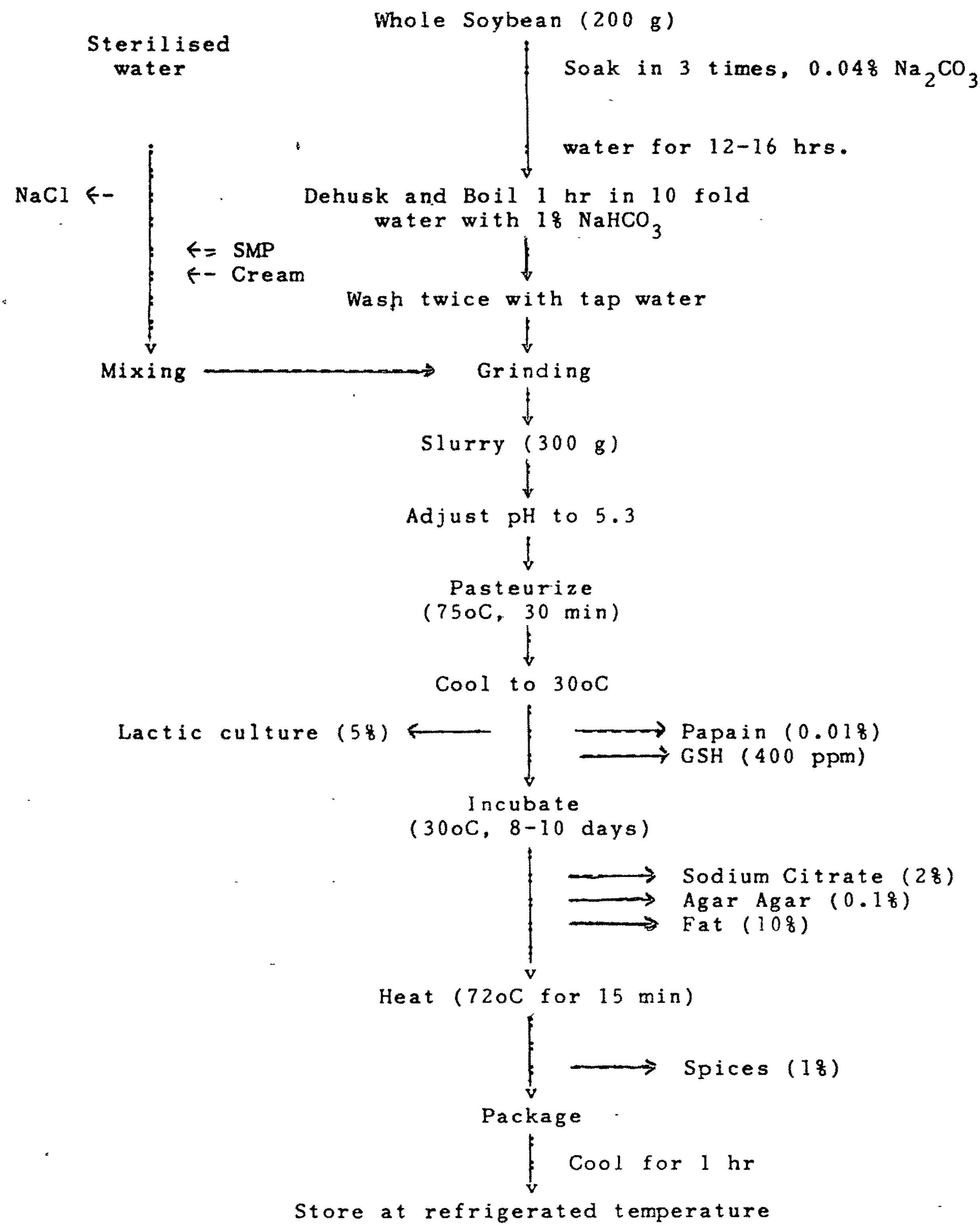


Fig 9 : Manufacturing schedule for developing milk solids blended slurry spreads.

Though blending of natural cheese to accelerate the ripening has been suggested earlier, no studies are reported to suggest using this approach in case of soy slurry based spreads.

- Though some of the commercially available cheese spreads in India are prepared by blending milk based maska with cheddar cheese, no published informations are available on the blending of soy maska with natural cheese.

In general, all the spreads developed in the present study were characterised by mild flavour, none of them suggested the beany flavour that has been criticised with the utilization of soybean. All the spreads were having acceptable B&T and spreadability.

5.5 CHARACTERISATION OF SOY CHEESE SPREADS

The soy cheese spreads, the preparations of which were finalised in the previous section were characterised in terms of physico-chemical, and microbiolgical parameters during curing, after heat processing, and subsequent storage.

5.5.1 Changes during curing:

The curing of cheese spread represents complex biochemical changes influenced by factors such as pH, TA, and temperature. These factors affect the biochemistry of cheese ripening by influencing directly, or indirectly the microbial ecology responsible for curing them. The results pertaining to the changes in micro flora, pH, and TA are presented graphically in this section:

5.5.1.1 Changes in pH and TA:

The pH and TA recorded during the curing of soy cheese spreads are depicted in Figs. 5.10. As evident from the figures, the initial pH of the maska based blends being 4.86, increased steadily during the ripening period attaining a pH of 5.34 by 8 days of curing. There was a concomitant decrease in TA from 1.42, (at 0 day) to 1.0 on the 8 day of storage.

The pH changes in slurry based cheese solids blend revealed a sharp initial reduction (from 5.3 to 5.11) within 48 hrs of curing, followed by increase, reaching a pH of 5.32 by 8 days of curing period. The corresponding TA revealed a steady rise up to 5 days attaining 1.3% LA by the end of storage period.

The pH of the soy slurries with milk solids, decreased at a relatively faster rate during the first 24 hrs, followed by slow increase upto 3 days, reaching a pH of 5.5. After a temperorary fluctuation in pH between 5.5 to 5.3, the pH of the slurries tended to stabilise around 5.3 by 6 to 8 days. There was a steady increase in TA throughout the curing period, reaching 1.3 by 8 days of storage.

It was interesting to note that the pH progressed towards 5.1 by 3 to 4 days of curing in all the samples, upwards trend in maska based samples, due to initial lower pH (4.86), and lower trend in slurry based samples due to initial pH adjustment to 5.3. The pH shift observed may be due to the release of basic amino acid.

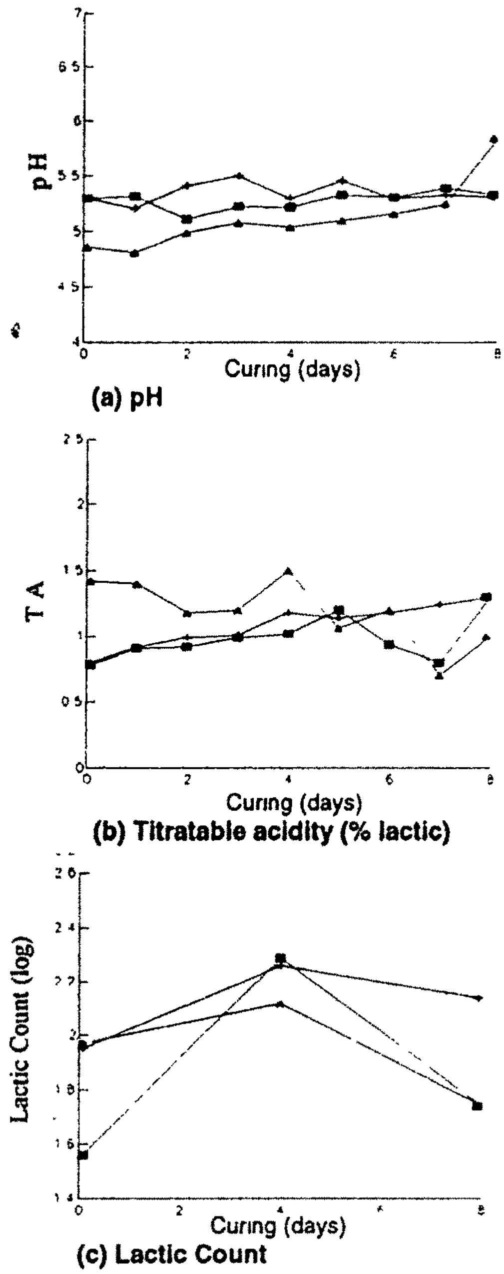


Figure 5.10 Changes in pH, Titratable acidity and Lactic count during curing

▲ Cheese solids blended maska ■ Cheese solids blended slurry
+ Milk solids blended slurry

The trend of change in pH during storage showed that it decreased during the early part of the curing due to the formation of lactic acid. The lactic counts depicted in fig. 5.10 (c) reveals that there was an initial sharp increase in counts in the cheese blended samples between 0 to 4 days relatively rapid in cheese blended slurry samples, followed by an equally sharp decline in the counts by 4 to 8 days of curing. On the other hand, a steady but relatively slower increase in lactic counts was apparent through out the curing period in milk solids based slurry samples. The initial decrease in pH within 4 days of curing was well coincided with an increase in lactic count in all the samples studied.

It is pertinent to notice that changes in TA and pH revealed certain relationship with the activities of lactic acid bacteria. The fermentable carbohydrate content of milk solids based slurries being much more than that in the cheese solids based samples, milk solids containing samples exhibited a steady increase in TA along with an increased lactic counts. Whereas, soy maska, and soy slurries in cheese blended samples being very low in fermentable carbohydrates, downward trend in lactic counts were revealed during later period of curing. Similar utilization of fermentable sugars such as lactose has also been reported in cheddar cheese (Eck, 1987).

5.5.1.2. Proteolytic changes:

Soy based cheese spreads was measured for proteolytic changes in terms of TN, NPN, SN, and AN, and also by proteolytic counts. The detailed data on these chemical parameters are presented in Appendix - 9.5.15 -9.5.17, and summarised in fig.- 5.11. The results of SN, SPN, an AN are expressed as % of TN. As the fig. 5.11 indicate TPN (estimated as TN - NPN) registered a slight decrease during curing in all the samples. Protein breakdown in cheese was associated with an increase in the values of SN, NPN, and AN. In general, proteolysis was faster in slurry based samples than that of maska based ones.

Three ripening indices as suggested by Wolfschoom (1983) were derived from the nitrogen fractions analysed. They were (1) Actual ripening extension index, represented by the ratio of SN to TN, (2) Ripening depth index, i.e. the ratio of NPN/TN, which accounts for the amino peptidase activity of starter bacteria in the cheeses, and (3) the ratio of AN to TN. The data pertaining to these indices are detailed in Appendix - 9.5.18 to 9.5.20, and represented graphically in fig. 5.12. The results clearly indicated a rise in values of actual ripening index (SN/TN) over the 8 days of storage in all the samples, higher being noticed in slurry based samples. The similar trend was also observed in the values of AN/TN in all the three samples.

The ripening depth index (NPN/TN) has been introduced to evaluate the action of lactic acid bacteria in the formation of

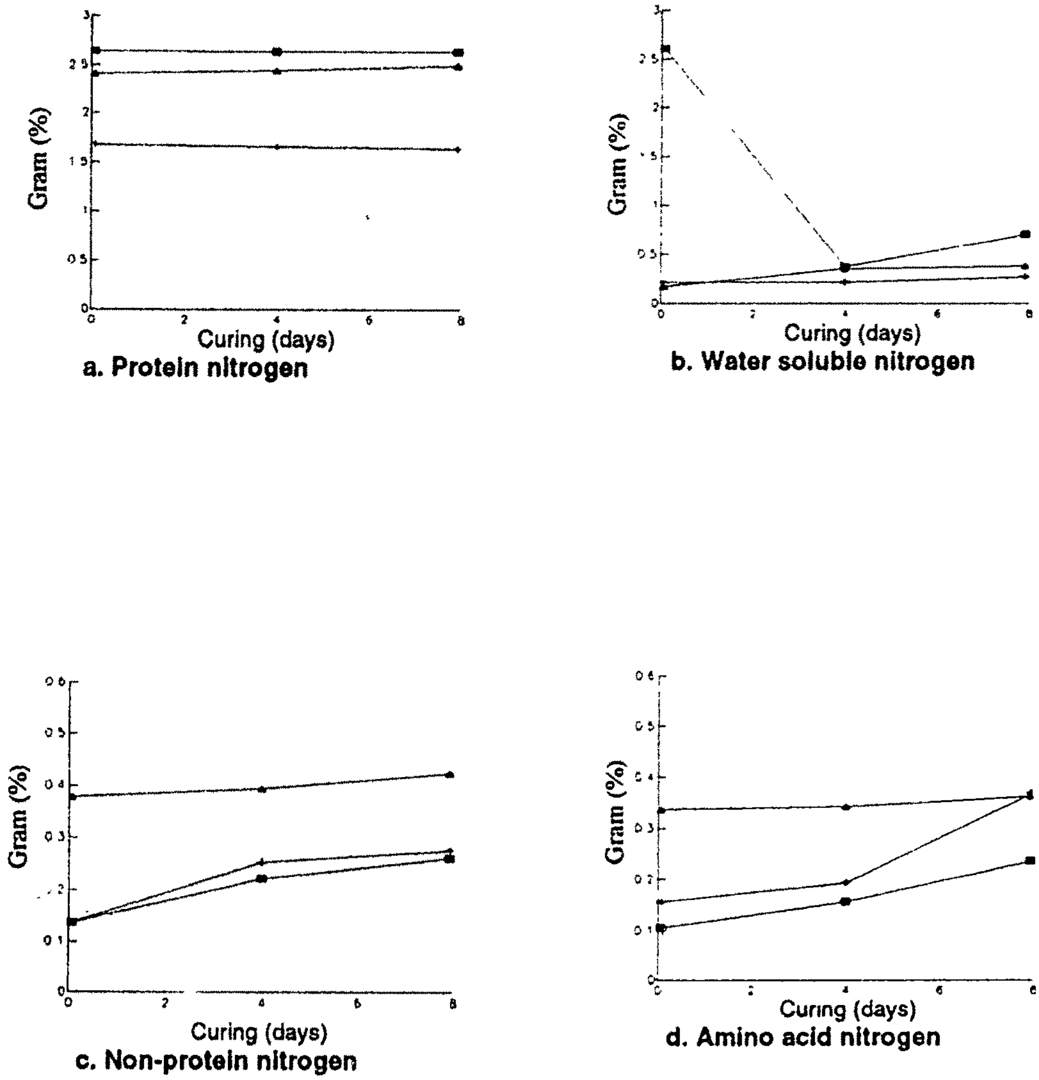


Figure 5.11 Changes in nitrogeneous fractions (%) during curing

▲ Cheese solids blended maska ■ Cheese solids blended slurry
+ Milk solids blended slurry

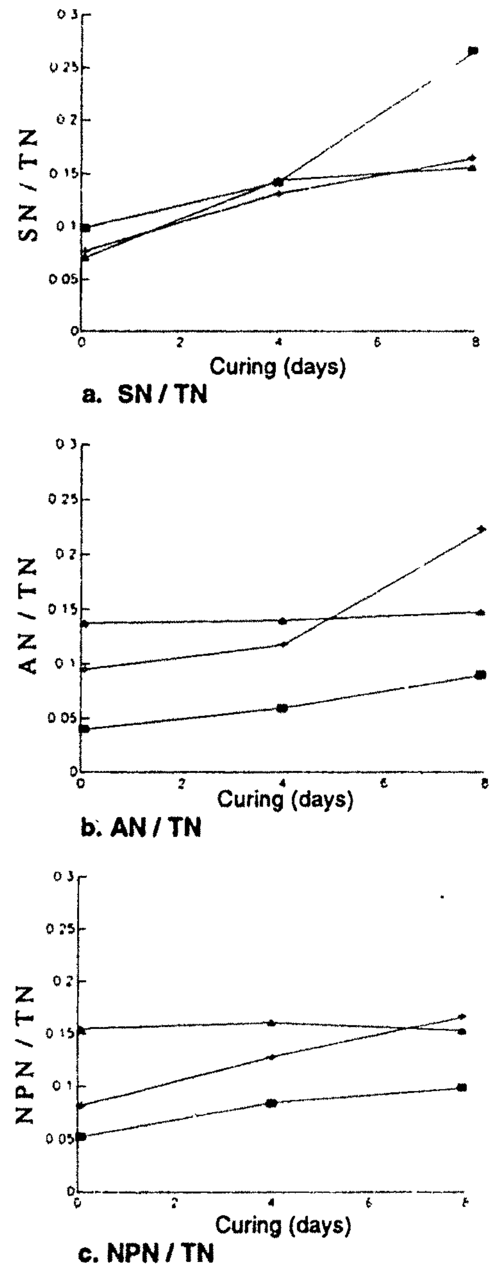


Figure 5.12 Changes in curing indices during curing

▲ SN / TN ■ AN / TN + NPN / TN

dissolved nitrogen compounds in cheese samples (Wolfschoom, 1983). An increase in the values of NPN/TN was apparent in the slurry based samples during the 8 days of curing, while, a decrease in NPN/TN value was observed between 4 to 8 days of curing in maska based samples.

The proteolytic counts were estimated by the protein sources viz. skim milk and soymilk. The counts obtained by these media are detailed in Appendix -9.5.21(a) to 9.5.23(b), and summarised in fig.- 5.13. As evident from the figures, the proteolytic behaviour of the cheese dependent soy spread samples i.e. both maska, and slurry based revealed essentially a similar pattern. The counts of soymilk based media were though initially low, by the end of 8 days, the counts were at par with those in the skim milk media, which had registered initial higher activity. On the other hand, the differences between the two media counts were reversed in the milk solids based slurry samples. However, these differences were not statistically significant in all the three studied samples.

The proteolytic counts of the soy cheese spreads were essentially similar to the trend observed in the chemical analysis (nitrogen fractions). At the end of 8 days ripening period, the proteolytic counts of maska based cheese blends decreased, while a steady increase was apparent in slurry based samples. The proteolytic counts exhibited a positive, and significant correlation with SN/TN, NPN/TN, and AN/TN in slurry

Figure 5.13 Changes in proteolytic counts during curing

▲ Soy milk ■ Skim milk

based samples. The higher proteolytic counts at fourth, and eight days of ripening in slurries indicate higher proteolytic activites. In comparison, the proteolytic counts in soy maska based blends exhibited a negative but significant correlation with respect to SN/TN, and NPN/TN, while insignificant negative correlation with AN/TN. In general, the curing behaviour of maska based blends indicated a slower rate.

As the milk based culture (dairy culture) was used in soy cheese spread making, it was thought relavent to investigate the effectiveness of these cultures in soy system. Hence, while plating for estimating the proteolytic counts, the effectiveness of both soymilk, and skim milk media were explored. The data revealed that the soy based media intially resisted the growth of lactic cultures, which was evident by low proteolytic counts. However, this resistance was eventually over come by proliferating satisfactorily by the end of curing (8 days). This may have two implications. Lactic strains might have over come the initial resistance to grow in larger numbers in soy system, at a later stage, different strains of micro organisms prefers to grow on soy system eventually over comes the growth of other lactics strains. However, this aspect needs to be established.

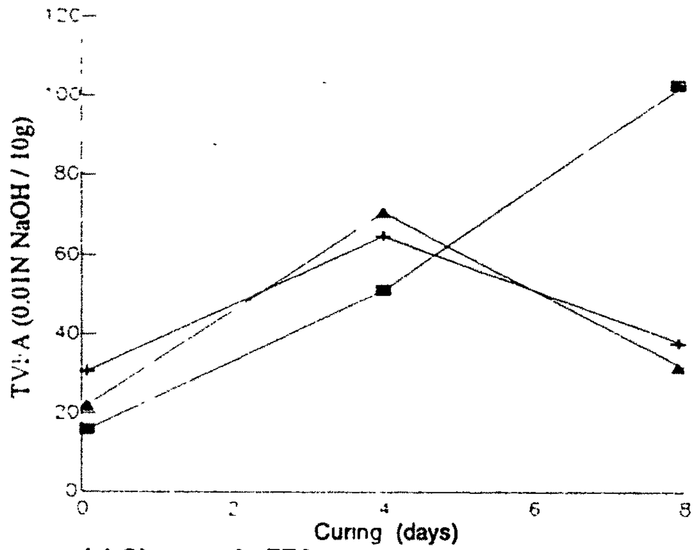
5.5.2.2 Lipolytic changes:

The lipolytic behaviour of soy cheese spread samples during curing was studied in terms of the concentration of free fatty acids (FFA), and total volatile fatty acids (TVFA), and also by lipolytic counts. Data pertaining to these values are presented in Appendix - 9.5.24 to 9.5.25. The average values are plotted in fig.- 5.14.

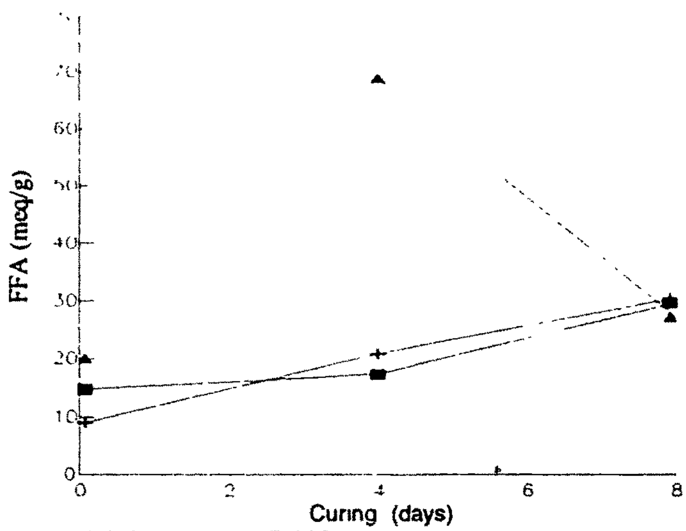
There was a steady increase in the levels of FFA, and TVFA up to 4 days of curing in maska based cheese blend samples, following a sharp decline by 8 days. Though a similar trend was noticed in milk solid based slurry samples, the change was very slight. The lipolytic organisms was found to grow more effectively in butter media than soy oil, in general, during initial days of curing (Fig.5.15). However, by 8 days of curing, effective utilization of soy fat by the lipolytic organisms was apparent. The trend of growth of lipolytic organisms on soy system was essentially similar to butter system, and the differences between the two media was not statistically significant. The lipolytic counts exhibited a positive, and significant correlation with FFA, and TVFA content in all the soy based cheese samples.

5.5.2 Characaterization of processed soy based cheese spreads:

The heat application during processing at 65 to 72oC for 15 mts. at the end of curing period (65oC for maska based and 72oC for slurry based spreads) was primarily aimed at arresting the microbial growth and to check the biochemical reactions, in order to stabilise the sensory qualities of soy based cheese spreads, and to prolong the shelf-life under refrigerated storage. The effect of such process on chemical composition, physico-chemical,



(a) Changes in FFA



(b) Changes in TVFA

Figure 5.14 Changes in fat fractions during curing

▲ Cheese solids blended maska
■ Cheese solids blended slurry
+ Milk solids blended slurry

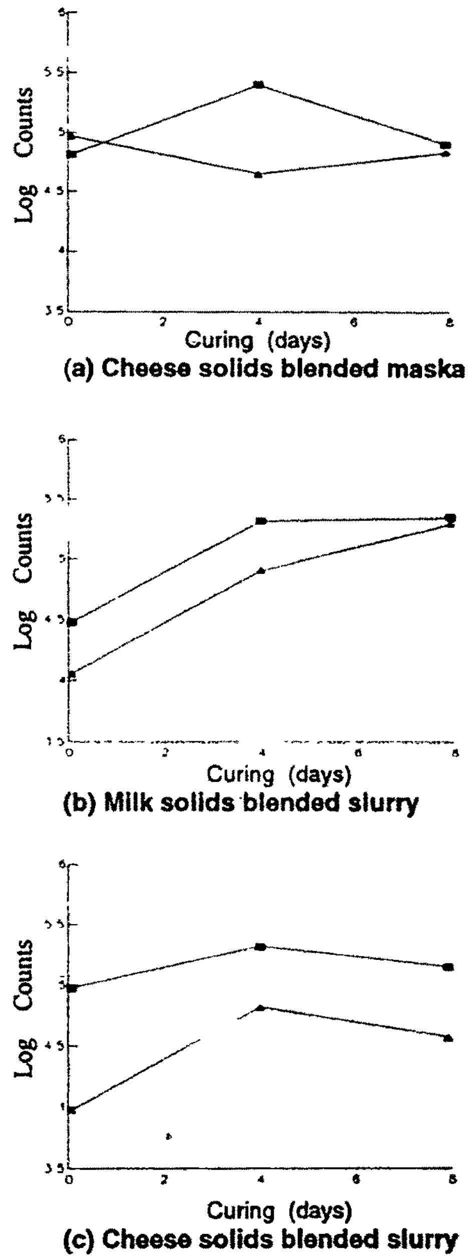


Figure 5.15 Changes in lipolytic counts during curing

▲ Soy Oil ■ Butter

sensory, and microbial quality parameters were investigated and presented in this section.

5.5.2.1 Gross chemical composition:

The soy cheese spreads were analysed as per the methods detailed in chapter VI, for moisture, protein, fat, ash content, and salt content. The results of the chemical analysis are presented in the table - 5.28.

Table 5.28 Chemical composition of soy cheese spreads

Composition (%)	Cheese blended		Milk solids
	Maska	Slurry	Slurry
Moisture	63.0	65.0	64.1
Total solids	37.0	35.0	35.9
Protein	23.9	31.6	35.1
Fat	41.0	37.9	34.1
Ash	8.0	4.1	9.9
Salt on moisture	1.8	2.0	1.9

The moisture content ranged from 63 to 65%, the fat, 40 to 41%, protein, 23.9 to 33%, and ash, 8 to 10%. The salt content of the spreads ranged from 1.9 to 2% on the moisture basis. The protein content of maska based spread was lower (23.9%) than the cheese and milk solids based slurry samples (31.6 and 35.1%

respectively). In absence of available standards for soy cheese spreads, the gross composition of the products was compared with the PFA and BIS standards available for milk based cheese spreads. The soy cheese spreads were meeting the legal requirement of 40% fat. Though the salt content was with in the maximum level specified (not more than 3%), the moisture content of the soy spreads were slightly high which could be reduced during heat processing.

5.5.2.2 <u>Sensory, physico-chemical and microbial quality of soy cheese spreads:</u>

The soy cheese spreads which were stored under refrigeration temperature as per specifications mentioned in the Method chapter VI, in a polystyrene cups tightly packed with aluminium foil were evaluated for moisture, pH, TA, sensory attributes, and microbial quality on the 0 day. The cheese samples were subsequently drawn after one month initially, and at 15 days interval from the refrigerator for sensory evaluation. The results pertaining to these aspects of the study are presented under following subheadings:

- Sensory evaluation
- Physico-chemical and microbiological quality.

5.5.2.2.1 <u>Sensory evaluation:</u>

The soycheese spreads which were stored after heat processing as per the specifications mentioned in the Chapter IV, in a polystyerene cups, tightly packed in alcohol flamed aluminium foil, under refrigeration were evaluated for sensory attributes on the 0 day, subsequently after one month of storage, and at 15 days interval until the product was unfit for consumption from the point of sensory qualities. The sensory evaluation scores of 0 day soy cheese spreads are presented in table 5.29.

Table 5.29 Sensory evaluation of soy cheese spreads

Soy cheese spreads	Sensory scores				
	Flavour (40)	B&T (30)	Spreadability (30)	Total scores (100)	OAA (100)
Cheese blended maska	38.0 (35-40)	30.0	30.0	98.0	90.0 (80-100)
Cheese blended slurry	38.0 (35-40)	30.0	30.0	90.0	92.0 (80-100)
Milk solids blended slurry	36.5 (35-40)	30.0	30.0	96.5	86 (80-100)
F' value	1.77 NS				0.57 NS
SEm	1.11				

Note: NS - Not significant at 5% level
Figures in parentheses indicate range of scores.

It is apparent from the table that the cheese blended slurry spread registered highest score for flavour, and OAA, followed by maska based cheese blend sample (38 to 38.5 for flavours, and 92 to 90 for OAA respectively). The slurry based milk solids blend which has lowest milk solids (7.5%) received lowest score for flavour (36.5), and OAA (86.0) attributes. However, the statistical test revealed an insignificant differences between the scores of sensory attributes between the samples. The B&T of all the samples were rated as smooth, and spreadable with satisfactory melt-down qualities. Both the cheese blended soy spreads were in the range of highly acceptable category, while milk solids based spreads ranged between moderately to highly acceptable category from the point of OAA.

The sensory quality scores of spreads during storage are presented graphically in fig. 5.16. It is evident from the figure that all the spreads were able to store satisfactorily up to 3 months, though there was a slight decline in sensory scores after 2 to 2.5 months. The deterioration in sensory quality in terms of development of strong aromatic flavour and bitter taste was extremely rapid during the end of the storage period. The textural quality of the samples were not affected during the 3 months of storage. The shelf-life study was terminated after 3.5 months of storage in slurry based smaples on the development of objectionable sensory qualities in the spreads.

5.5.2.2.2 Physico-chemical and microbiological quality:

The assessment of physico-chemical and microbiological quality involved estimating the TA, pH, and counts of total plate, yeast and molds, coliforms, and aerobic sporeformers. These served as an indicator of surviving microflora after heat

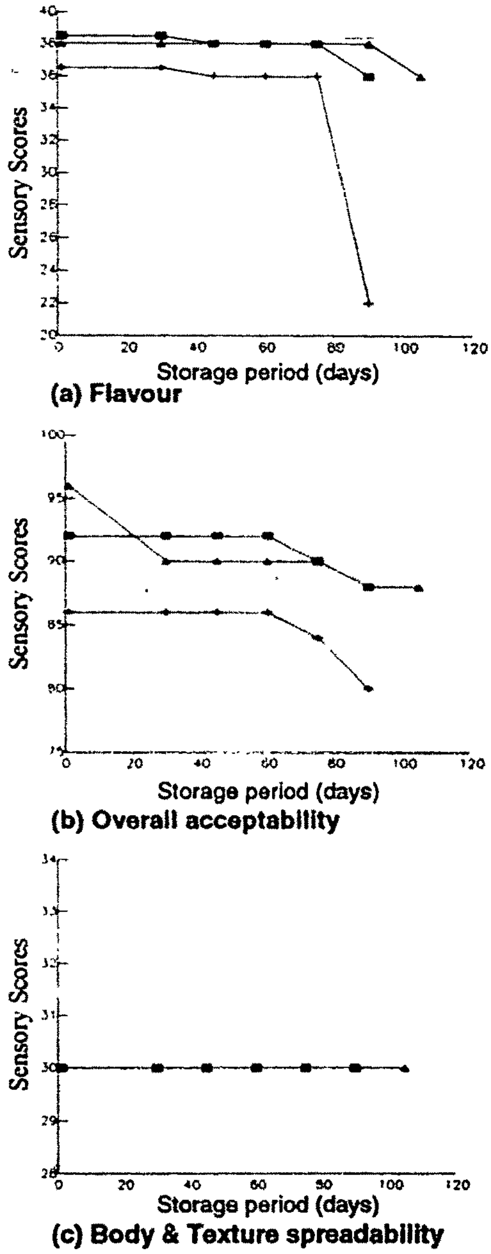


Figure 5.16 Sensory scores during storage

▲ Cheese solids blended maska
■ Cheese solids blended slurry
+ Milk solids blended slurry

processing and post processing contamination. The results pertaining to this aspect are presented in Table 5.30.

Table 5.30 Physico-chemical and Microbiological quality of cheese spreads during storage.

Storage period	Moisture (%)	pH	TA (%LA)	Microbial log counts/g TPC	Y&M	Coliforms	Sporeformers	Sensory quality
				Maska based cheese blend				
0 day	64.1	6.13	2.35	2.8	3.2	nil	2.0	mild cheesy
3 months storage	63.7	6.76	2.31	4.3	4.0	nil	2.8	bitter
				Slurry based cheese blend				
0 day	65.0	5.47	3.1	2.8	3.6	nil	2.1	mild cheesy
3 months storage	63.1	5.78	2.0	4.1	3.8	nil	2.4	strong putrid flavour,bitter
				Slurry based milk solids blend				
0 day	64.7	5.94	1.5	3.0	nil	nil	1.9	mild cheesy
3 months storage	62.1	6.23	1.2	3.3	nil	nil	2.0	moderately aromatic flavor bitter

The log total counts (TPC) of the samples ranged between 2.8 to 3.0/g of sample initially, and 3.3 to 4.3 /g after 3 months of storage under refrigerated conditions. None of the samples was found to be having coliforms counts during storage period. No visible colonies of any kind was apparent on the surface of the products, though no special treatments, either in the form of preservatives or commercial packaging system were used. The yeast and mold counts had a special significance in the present study as products were wrapped in alcohol flammed aluminium foils, and not hermitically sealed which may permit the entry of air. The yeast and mold log counts which were estimated by using patato dextose agar registered about 3.2 to 4.0, 3.6 to 3.8 in maska and slurry based cheese blends during 3 months storage. The aerobic sporeformers increased from 1.9 to 2.8 during 3 months of refrigerated storaged in soy cheese spreads. On the other hand, milk solids based slurry blend was found to be free from yeast and mold contamination. Irrespective of increase in the microbial counts, all the samples were well within the standards suggested by Ramaswamy and Reddy (1990) for processed cheeses (milk based) under Indian conditions even after 3 months of storage. The shelf life study was terminated at the point when the samples were unfit for consumption from the point of sensory qualities by developing strong objectionable proteolytic flavour, or bitter taste, which once again coincided with the increase in pH, decrease in TA, consistent with the earlier observation. A reduction in the moisture content observed in all the samples during storage may due to the evaporation.

On the basis of above experiments it is apparent that satisfactory in terms of sensory, and microbiological, soy cheese spreads can be made utilising soybean as a main ingredient, using both maska and slurry approaches. The soy based cheese spreads are rich in protein and fat, and can be stored satisfactorily for 3 months under the refriegrated temperature of 8 to 10oC.