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WHEY PROTEINS AS A FAT REPLACER IN THE MANUFACTURE OF LOW FAT SOFT CHEESE

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ABSTRACT: A trail has been carried out to produce low fat soft cheese of acceptable quality using whey proteins as a fat replacer. A preliminary study was made to determine the limits of replacing the reduced fat in low fat milk with whey proteins. Results showed that replacing more than 50% of the reduced fat with whey proteins prolonged the clotting time and decreased curd syneresis. In the light of the foregoing mentioned evidence, cheese milk was standardized to contain 1.8 or 0.9% fat, then 50% of the reduced fat in both cases was replaced with whey proteins and converted into low fat soft cheese. Also cheese was made from milk containing 3.6% fat as a control. Resultant cheese was pickled in fresh or in old brine of good quality. Replacing 50% of the reduced fat with whey proteins enabled to improve cheese yield and obtaining acceptable quality product when cheese was made from milk containing either 1.8 or 0.9% fat. Pickling the low fat cheese in good quality old brine enhanced both flavour and texture of the resultant low fat cheese. Meanwhile this treatment accelerated the formation of soluble nitrogenous compounds and the accumulation of volatile fatty acids, so that the level of these compounds in low fat cheese pickled in old brine tended to approach their corresponding levels in control cheese made from whole fat milk.

Key words: Soft cheese, low fat, fat replacer, whey protein.

INTRODUCTION

Recent years have seen a considerable interest on the influence of level and type of dietary fat on human health. Dietary fat has been shown to be linked with increased risk of obesity, atherosclerosis, cardiovascular disease hypertension, gall stones and tissue injury disease associated with lipid oxidation (Fenelon and Guinee 2000). This apparent connection between dietary fat and health has increased the awareness for healthier food and has created an increased consumer demand for low or reduced fat foods including cheeses, (Dexheimer, 1992). The consumption of low/reduced fat cheeses is still complicated with poor consumer preference based on the inadequate flavour and texture qualities. Therefore research efforts have focused on the development of a consumer acceptable low fat cheese that is similar in flavour and texture to their full fat counterparts. Meanwhile the costs of production were taken into account (Wilkinson, *et al.*, 2001).

Low reduced fat cheeses can be made by replacing fat with ingredients that bind water. Several fat replacers have been developed and used in dairy industry with a range of success. However these ingredients increased the production costs (Lo and Bastian, 1998).

Whey proteins are well known for their high nutritional value and excellent functional properties in food products (De Wit 1997). There has been a growing interest in increasing the level of whey proteins in cheese. The motivations for this trend have included increased cheese yield and replacement of milk fat in low or reduced fat cheese (Pundidadas, *et al.*, 1999). Whey proteins could be incorporated into cheese in their denatured form by two methods. The first is to give milk a sufficiently high heat treatment to cause denaturation of whey proteins and form a complex with the casein micelles (Banks, *et al.*, 1987). This has an adverse effect on coagulation so steps have to be taken to improve the gel forming properties of milk (Pundidadas, *et al.*, 1999). The second approach is to add denatured or thermally modified whey proteins to cheese milk (Walker 1970; Banks and Muir 1985 and Guinee 2002). The influence of whey proteins on the yield and properties of various cheese types has received some attention by several investigators. They showed variable effects on both yield and quality of the resultant cheeses (Brown and Ernstrom 1982; Banks, *et al.*, 1985 and Ibrahim, *et al.*, 2001). This could be attributed to the use of various whey proteins concentrates which differ in their source, protein compositions and added amounts.

There is little recent information concerning the effect of pickling media on the quality and ripening of pickled cheese particularly low fat one. Magakian (1982), showed that old brine of good quality had favourable effects on the ripening and flavour development of pickled cheese.

The present study was undertaken to evaluate the effect of replacing milk fat with whey proteins on the yield and quality of low fat soft cheese (Domiati type). The effect of pickling media on the quality and ripening of low fat soft cheese was also taken into consideration.

MATERIALS AND METHODS

Materials

Fresh cow's milk was obtained from the Laboratory of Dairying, Agricultural Researches Center, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. A standard calf rennet was obtained from Hansen's Laboratories, Copenhagen Denmark.

Commercial fine grade salt was obtained from the local market. A whey protein powder (74% proteins) produced by Corporate Circle, Golden Co USA was used.

Preparation of Denatured Whey Protein Dispersions

Whey proteins powder (74% protein) was reconstituted in warm water (40 °C) at a ratio of 1: 5. The pH of the protein solution was adjusted to 4.6 and heated at 95 °C for 5 minutes then it was vigorously stirred (Pundidadas, *et al.*, 2000).

The total protein content of the protein solution was determined (Ling, 1963).

Evaluation of Milk Clotting time and Curd Syneresis as Affected by Replacing Reduced Fat with Whey Proteins

A preliminary trial was carried out to assess information on the extent of replacing the reduced fat in low fat milk with whey proteins. Cow's milk (3.6% fat) was standardized to 1.8 and 0.9% fat i.e. half and quarter the original fat in the control whole milk. Whole cow's milk as well as low fat milks (1.8 and 0.9% milk fat) were heated to 72 °C far 15. s., cooled to 40 °C and incorporated with $CaCl_2$ at a level of 0.02%.

Low fat milks (1.8 or 0.9% milk fat) were divided into five portions and incorporated with the suitable amounts of denatured whey protein preparation which provides low fat milk with whey proteins equal to 0, 25, 50, 75 and 100% of the reduced of the fat. Rennet coagulation time was determined in low fat milks (50 ml) with or without whey proteins as well as in whole cow's milk as a control. The time from the addition of the required amount of rennet till the appearance of tiny specks clotted milk was recorded in seconds (El Hawary, *et al.*, 1982). Curd syneresis was determined according to (Lawernce, 1959). The percentages of drained whey volume to the original milk volume was taken as indices for curd syneresis.

Cheese Manufacture

Cheese milk containing either 1.8 or 0.9% fat was heated at 72 °C for 15 s., cooled and to 40 °C incorporated with $CaCl_2$ at a level of 0.02%. Low fat milk were incorporated with the calculated amounts of denatured whey protein preparations which provides low fat milk with an amount of whey proteins equal to 50% of the reduced fat. This level of whey protein addition was selected in the light the preliminary trial results.

The cheese making process was completed essentially as described by Fahmi and Sharara (1950). The fresh yield was determined and the reduced or low fat cheese of each treatment was divided into 2 parts. The first part was pickled in fresh whey while the second part was pickled in old brine from good quality pickled Domiati cheese. The salt contents of the pickling media was adjusted to 10%, heated at 95 °C for 1 min and cooled to 40 °C before being used.

A control cheese was made from whole cow's milk following the traditional method and used as a control.

Analysis of Cheese Milk and Brines

Milk samples were analysed for total solids, fat total nitrogen, non casein nitrogen as described by Ling (1963).

Old and fresh brines were analysed for total N, non protein N (Ling 1963) as well as for total volatile acidity according to Kosikowski (1978).

Analysis of Cheese

Cheese samples were taken when fresh and periodically after 15, 30 and 45 days of pickling. Cheese samples were analysed for moisture, fat, salt, acidity, total N and non protein N as described by Ling (1963). Formol value was determined according to Tawab and Hofi (1966). Total volatile acidity were determined as given by Kosikowski (1978). Cheese samples were organoleptically examined as described by El Koussy, *et al.*, (1976). Maximum score points for flavour and body characteristics were 60 and 40 respectively.

Free Fatty Acids

Free fatty acid were extracted from cheese of each treatment as described by Metcalfe and Schmitz (1961) and determined by gas liquid chromatography using pye unicam series 104. The conditions of separation were as follows :

- Column type: polythelene glycol adipate or succinate.
- Carrier gas: helium or nitrogen.
- Flow rate: 50 mg /min.
- Column Temp : 80 - 200°C
- Loading : 0.1 – 0.2 ul
- Detector Temp : 210 – 220°C
- Programming gradient: 8°C/ min.
- Comparison : against samples of known identify.
- Statistical analysis:

Results were statistically evaluated by a splite-point ANOVA to determine the effect of all treatments were performed according to the method described by (Bulmer, 1967). The means were tested for differences using Duncan multiple range test (1955).

RESULTS AND DISCUSSION

Renneting Properties of Milk as Affected by Using Whey Proteins as Fat Replacer

The effect of replacing milk fat with whey proteins on the renneting properties of milk was shown in Table 1. From these results it could be noticed that replacing milk fat with whey proteins at levels reaching 100% of the reduced fat, significantly ($P<0.05$) prolonged milk clotting time. This observation was more remarkable at replacing level more than 50%. Meanwhile, this treatment significantly ($P<0.05$) decreased curd syneresis particularly at the high replacing level. The obtained results could be explained on the basis that using whey proteins as a fat replacer decreased the casein: total protein ratio and that the use of whey proteins to replace more than 50% of the reduced fat disturb the regular rennet gel. Meanwhile replacing fat with whey proteins at levels higher than 50% resulted in the blokage of casein. Thus the rennet induced aggregation is impeded and reduces the amount of connections in the casein network. Also, it is well known that denaturation of whey proteins increased its water binding capacity and make it highly hydrated. This condition in turn obstruct curd syneresis, so that less water drains off during the cheese making process.

Table 1: Clotting time of cheese milk and curd syneresis as affected by replacing reduced fat by different levels of whey proteins

Treatments		Clotting time (s)		Curd syneresis (% of whey volume to original milk volume)	
		$\overline{X}$	SD±	$\overline{X}$	SD±
Control (3.6% fat)		108.0	7.211	31.00[a]	1.000
Milk with 1.8 % fat	A	105.0[e]	5.000	29.33 [a]	1.155
	B	122.3[de]	3.215	26.33 [b]	1.528
	C	140.7[de]	9.238	24.33 [bc]	2.082
	D	300.0[c]	10.000	16.33 [e]	0.577
	E	545.3[b]	980.220	12.33 [f]	1.530
Milk with 0.9 % fat	A	109.3[e]	3.055	29.33 [a]	1.528
	B	131.3 [de]	5.508	23.00 [cd]	2.66
	C	150.7 [d]	9.504	20.67 [d]	1.155
	D	321.7 [c]	16.503	12.67 [f]	1.155
	E	663.3 [a]	47.258	9.00 [g]	1.000
L.S.D		32.93		2.484	

A, B,C,D, E : Whey proteins was used to replace 0, 25, 50, 75 and 100% of reduced fat respectively.

Means having different letters in the same column significantly differ at $P \leq 0.05$.

Similar observations were recorded by Lucey, *et al.* (1994); Waungana, *et al.* (1996); Steffi, *et al.* (1999) and Hinrichs (2001).

In conclusion milk fat could be replaced with whey protein at replacing level reaching 50% of the reduced fat in low fat milk without adverse affect on both milk clotting time and curd syneresis.

Cheese Yield

From the results presented in Table 2 it could be seen that cheese made from whole milk (3.6% fat) gave the highest yield being 22.10. Reduction of milk fat in cheese milk was associated with lower yield. This was more pronounced when cheese was made from milk with the lowest fat content (0.9%). The loss in yield was found to be 23.53 and 20.36% of the control one when cheese was made from milk containing 0.9 and 1.8% fat. The lower yield in cheese made from low fat milk could be explained on the basis that the composition of milk for manufacturing low fat cheese differ markedly from that of full fat milk in a number of ways (Table 2). The total fat content of milk is lower, and the percentage of total proteins in milk is slightly higher. Thus the net result is lower total solids in low fat milk. The ratio of casein to fat is much higher in milk for low fat cheese making. This condition facilitate the contraction of casein network and expulsion of whey resulting in a cheese with less moisture and less yield (Mistry 2001).

Replacing the reduced milk fat with denatured whey proteins at a level of 50% significantly increased the yield of cheese made from milk containing 1.8 and 0.9% fat.

Incorporation of low fat milk with whey proteins enabled to achieve a partial recovery of the decrease in the yield of low fat cheese without added whey proteins. The decrease loss was reduced from 20.36 to 9.50 and 23.53 to 14.48% in case of making cheese from milk containing 1.8 and 0.9 % fat respectively.

The positive effect of whey protein on cheese yield was recorded in many investigations (Steffi, 1999; Hinrichs, 2001 and El Sheikh, *et al.*, 2001).

Gross Chemical Composition

The effect of replacing milk fat with whey proteins and pickling media on the

Table 2: Main chemical composition of cheese milk and cheese yield

Chemical properties	Control (3.6% fat)		Cheese made from low fat milk with: 1.8% fat, A		1.8% fat, B		0.9% fat, A		0.9% fat, B		L.S.D
	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	
Chemical composition of milk											
Total solids %	12.01^{a}	2.000	10.26^{bc}	1.000	11.16^{ab}	1.000	9.35^{c}	2.000	10.63^{b}	1.000	1.031
Total protein %	3.28^{b}	2.000	3.30^{b}	1.000	4.19^{ab}	1.000	4.31^{ab}	2.000	4.52^{a}	2.000	1.031
Casein %	2.59	2.000	2.61	1.000	2.60	1.000	2.63	2.000	2.60	1.000	-
Fat %	3.60^{a}	1.000	1.80^{b}	0.100	1.80^{b}	0.10	0.90^{c}	0.100	0.90^{a}	0.100	0.7578
Casein/fat ratio	0.65^{b}	0.390	1.43^{b}	0.477	1.43^{b}	0.477	2.78^{a}	1.925	2.83^{a}	0.802	1.207
Casein/protein%	78.63^{b}	1.528	78.09^{c}	1.000	62.05^{d}	1.000	79.45^{a}	1.000	57.52^{e}	1.000	0.4874
Cheese yield											
Fresh yield	22.1^{a}	0.200	17.6^{d}	0.252	20.0^{b}	0.115	16.9^{e}	0.058	18.9^{c}	0.265	0.4038
Decrease in yield%	-		20.36		9.50		23.53		14.48		

A : without whey proteins.
B : 50% of reduced fat was replaced with whey proteins.
Means having different letters in the same raw significantly differ at P≤ 0.05.

compositional quality of low fat cheese is shown in Table 3 . From these results in could be concluded that moisture contents of soft cheese made from whole milk (3.6% fat) was higher than that of cheese of other treatments. This indicate the role of milk fat in the formation of adequate net work which can retain more moisture and other solids not fat (Wijesundera and Drury,1999 and Mistry, 2001). The moisture contents of soft cheese made from milk containing 1.8 or 0.9% fat without added whey proteins were significantly ($P<0.05$) lower than the corresponding cheese with added whey proteins. This could be explained on the basis that manufacturing of cheese from low fat milk gave curd that contracted more easily. This was associated with a more explusion of whey and less moisture in the cheese (Pundidadas, *et al.*, 2000). Replacing 50% of reduced milk fat with whey protein enhanced the capacity of the curd to retain more moisture due to the high water binding capacity of whey proteins. Also whey protein particles might be trapped in renneted gel in the same manner as fat and might inpart effects similar to fat on the final product characteristics (Pundidadas, *et al.*, 1999). The moisture contents of the cheese from each treatment showed gradual significantly decrease during ripening. Pickling cheese in fresh whey or old brine did not considerably affect the moisture contents of cheese during the whole period of ripening. Similar trend was reported by Baldwin, *et al.* (1986) concerning the changes in moisture during pickling.

The fat contents of the cheese from different treatments showed slight gradual increase during the whole period of pickling. As expected cheese made from whole milk showed the highest fat contents followed by other treatments. This is due to the reduction of fat content of milk used in low fat cheese making.

Also the results showed that the fat contents of cheese made from low fat milk using whey proteins as a fat replacer were somewhat lower than that of low fat cheese without whey proteins. This could be attributed to the increase in cheese proteins, so that the fat content of the cheese was lower compared with cheese made from low fat without whey proteins. Pickling media had no significant effect on the fat

Table 3: The gross chemical composition of low fat soft cheese as affected by replacing milk fat with whey proteins and pickling media

Chemical composition	Pickling period (days)	Control (3.6% fat)		Cheese made from low fat milk with																L.S.D
				1.8% fat								0.9% fat								
				A				B				A				B				
				Fresh brine		Old brine		Fresh brine		Old brine		Fresh brine		Old brine		Fresh brine		Old brine		
		$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	
Moisture %	0	61.77^{a}	0.234	57.37^{d}	0.321	57.13^{d}	0.231	59.45^{b}	0.218	59.03^{bc}	0.058	56.33^{e}	0.321	56.33^{e}	0.321	58.60^{c}	0.520	58.60^{c}	0.520	0.4580
	15	60.03^{a}	0.058	56.05^{d}	0.050	56.03^{d}	0.058	58.23^{b}	0.153	58.10^{b}	0.173	55.37^{e}	0.208	55.10^{f}	0.100	57.10^{c}	0.153	57.23^{c}	0.153	0.2257
	30	58.67^{a}	0.252	54.67^{c}	0.416	54.47^{cd}	0.145	57.01^{b}	0.010	57.00^{b}	0.000	54.03^{d}	0.153	54.10^{d}	0.10	56.70^{b}	0.153	56.63^{b}	0.153	0.4580
	45	57.80^{a}	0.162	53.47^{d}	0.723	53.3^{d}	0.577	56.17^{b}	0.289	56.00^{b}	0.000	52.47^{e}	0.451	52.23^{e}	0.153	54.43^{c}	0.551	53.63^{d}	0.551	0.7303
Fat / DM %	0	42.11^{a}	0.129	21.17^{b}	0.015	21.0^{b}	0.123	20.38^{c}	0.344	20.01^{d}	0.220	10.83^{e}	0.126	10.83^{e}	0.126	10.00^{f}	0.250	10.00^{f}	0.250	0.3096
	15	42.70^{a}	0.087	21.66^{b}	0.180	21.75^{b}	0.098	20.75c	0.310	20.28^{d}	0.171	11.42^{e}	0.268	11.28^{e}	0.150	10.95^{f}	0.135	10.83^{f}	0.135	0.3096
	30	43.30^{a}	0.267	22.20^{b}	0.180	22.36^{b}	0.195	21.71^{c}	0.266	21.63^{c}	0.240	12.47^{d}	0.122	12.48^{d}	0.102	11.88^{e}	0.352	11.68^{f}	0.352	0.4059
	45	44.52^{a}	0.505	23.21^{bc}	0.029	23.35^{b}	0.146	22.81^{c}	0.269	22.87^{c}	0.266	13.31^{d}	0.175	13.21^{d}	0.156	12.87^{de}	0.240	12.58^{e}	0.240	0.4310
Acidity (% of lactic acid)	0	0.40^{a}	0.020	0.34^{c}	0.035	0.34^{c}	0.035	0.39^{ab}	0.012	0.38^{b}	0.020	0.30^{d}	0.015	0.29^{d}	0.012	0.27^{e}	0.012	0.27^{e}	0.012	0.0173
	15	0.87^{a}	0.023	0.55^{cd}	0.042	0.60^{c}	0.020	0.70^{b}	0.006	0.71^{b}	0.023	0.50^{d}	0.020	0.54^{d}	0.020	0.68^{b}	0.020	0.72^{b}	0.020	0.05474
	30	1.12^{a}	0.106	0.69^{e}	0.012	0.71^{de}	0.015	0.81^{c}	0.015	0.84^{c}	0.020	0.68^{e}	0.053	0.78^{cd}	0.020	0.98^{b}	0.050	1.050^{ab}	0.050	0.07741
	45	1.44^{a}	0.035	0.800^{e}	0.020	0.81^{e}	0.015	0.99^{de}	0.010	1.21^{b}	0.031	0.97^{e}	0.012	1.03^{d}	0.031	1.13^{c}	0.053	1.200^{b}	0.053	0.05474
Salt/ Moisture %	0	10.61^{c}	0.276	12.65^{a}	0.136	12.65^{a}	0.136	11.00^{c}	0.000	11.00^{c}	0.000	11.00^{c}	0.557	11.00^{c}	0.557	11.70^{b}	0.200	11.70^{b}	0.200	0.5164
	15	11.52^{e}	0.055	13.67^{a}	0.058	13.73^{a}	0.058	11.80^{de}	0.100	11.97^{d}	0.058	11.87^{d}	0.153	12.05^{cb}	0.050	12.33^{c}	0.436	12.70^{b}	0.436	0.2998
	30	12.06^{d}	0.025	13.95^{a}	0.127	13.97^{a}	0.115	12.03^{d}	0.058	12.05^{d}	0.04	12.60^{c}	0.529	12.91^{c}	0.101	13.47^{b}	0.451	13.57^{ab}	0.451	0.4580
	45	12.95^{d}	.046	14.77^{a}	0.153	14.89^{a}	0.145	12.94^{d}	0.057	12.96^{d}	0.067	13.05^{d}	0.129	13.31^{d}	0.153	13.80^{c}	0.053	14.04^{b}	0.053	0.2120

A : without whey proteins.
B :50% of reduced fat was replaced with whey proteins.
Means having different letters in the same raw significantly differ at P≤ 0.05.

contents of the resultant low fat cheese.

The salt contents of all cheese (Calculated as percentages of salt in moisture) showed slight increases during the whole period of pickling. This could be due to the loss in water as a result of water exudation during pickling which in turn lead to a more salt concentration. Some differences could be seen between the salt contents of cheeses made from milk containing 1.8 or 0.9% fat and pickled in fresh or old brine and these could be attributed to the differences in moisture content of these cheeses.

Control cheese made from whole milk (3.6% fat) showed the higher acidity compared with cheese of other treatments. Acidity in low fat cheese developed to some extent at a slow rate in low fat cheese without whey protein compared with other treatment. Meanwhile replacing milk fat with proteins to a level of 50% of the reduced fat had some stimulating effect on the development of acidity. This could be explained by the higher moisture in low fat cheese made from low fat milk with added whey proteins which in turn enhanced cheese flora and formation of lactic acid.

The general trend of the obtained results is in agreement with that reported by several investigators (Ibrahim, *et al.*, 2001).

Ripening Indices

Soluble nitrogen (SN), non protein N (NPN), formol values and total volatile fatty acids (TVFA) were taken as indices for cheese ripening during pickling (Table 4). Control cheese made from whole cow's milk (3.6% fat) showed the highest levels of soluble N, non protein N, formol values and total volatile fatty acids compared with other treatments. On the other hand protein breakdown and accumulation of volatile fatty acids took place in low fat cheese without added whey proteins at a relatively slow rate compared with control cheese and low fat cheese in which whey proteins were used as a fat replacer. Replacing 50% of reduced fat with denatured whey proteins enhanced the formation of soluble nitrogenous compounds and volatile fatty acids. The increased level of moisture in cheese with added whey proteins stimulated cheese flora and proteolysis. Meanwhile the more accumulation of soluble nitrogenous compounds particularly free amino

Table 4: Some ripening indices of low fat soft cheese as affected by replacing milk fat with whey proteins and pickling media

Chemical composition	Pickling period (days)	Control (3.6% fat)		Cheese made from low fat milk with																L.S.D
				1.8% fat								0.9% fat								
				A				B				A				B				
				Fresh brine		Old brine		Fresh brine		Old brine		Fresh brine		Old brine		Fresh brine		Old brine		
		$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	
Soluble N. (% of total N)	0	7.63^{a}	0.058	5.33^{c}	0.115	5.33^{c}	0.115	6.10^{b}	0.100	6.10^{b}	0.100	3.60^{d}	0.150	3.60^{d}	0.150	3.80^{d}	0.100	3.80^{d}	0.100	0.2048
	15	12.83^{a}	0.153	6.23^{e}	0.153	6.77^{d}	0.265	8.27^{c}	0.115	9.47^{d}	0.416	4.53^{g}	0.153	4.54^{g}	0.139	5.57^{f}	0.351	5.83^{ef}	0.252	0.4240
	30	15.97^{a}	0.379	7.83^{cd}	0.115	8.27^{c}	0.208	10.37^{b}	0.321	10.83^{b}	0.289	6.17^{f}	0.208	6.73^{e}	0.241	7.57^{d}	0.493	8.17^{c}	0.208	0.4740
	45	17.63^{a}	0.252	9.73^{d}	0.208	10.10^{d}	0.100	12.20^{c}	0.173	13.37^{b}	0.462	7.43^{g}	0.441	8.17^{f}	0.379	8.40^{f}	0.529	9.12^{e}	0.106	0.6046
Non protein N. (% of total N)	0	1.98^{a}	0.000	1.08^{c}	0.012	1.03^{c}	0.012	1.24^{b}	0.038	1.24^{b}	0.038	0.91^{d}	0.042	0.91^{d}	0.04	1.03^{c}	0.058	1.03^{c}	0.058	0.0547
	15	3.77^{a}	0.133	1.15^{f}	0.031	1.73^{d}	0.070	1.90^{c}	0.085	2.06^{b}	0.122	1.03^{g}	0.030	1.11^{fg}	0.090	1.43^{e}	0.058	1.62^{d}	0.040	0.1095
	30	5.00^{a}	0.100	1.57^{d}	0.081	1.77^{c}	0.042	2.96^{b}	0.035	3.03^{b}	0.031	1.22^{f}	0.106	1.39^{e}	0.023	1.60^{d}	0.020	1.82^{c}	0.053	0.09481
	45	6.95^{a}	0.042	2.03^{e}	0.058	2.64^{d}	0.320	4.05^{c}	0.042	4.93^{b}	.0076	1.47^{f}	0.064	1.66^{f}	0.053	2.07^{e}	0.153	2.76^{d}	0.295	0.2448
Formal values	0	17.33^{a}	0.1528	8.00^{de}	1.000	8.00^{de}	1.000	12.33^{b}	0.577	12.33^{b}	0.577	6.67^{e}	1.155	6.67^{e}	0.155	9.00^{cd}	1.000	10.67^{bc}	1.155	1.694
	15	26.67^{a}	0.155	11.00^{e}	1.000	13.00^{d}	1.000	17.33^{c}	0.155	20.67^{b}	0.577	7.67^{f}	0.577	9.00^{f}	1.000	11.00^{e}	1.000	12.67^{d}	1.155	1.645
	30	39.00^{a}	1.000	17.33^{d}	0.577	19.67^{c}	1.155	27.00^{c}	1.000	28.00^{b}	0.000	11.33^{f}	1.155	13.33^{e}	1.155	16.67^{d}	1.155	19.00^{c}	1.000	1.408
	45	44.67^{a}	1.155	20.33^{e}	0.577	22.67^{de}	2.309	33.33^{c}	3.055	37.33^{b}	1.155	13.67^{f}	1.155	15.67^{f}	1.155	21.33^{de}	1.528	24.00^{d}	1.000	2.970
T.V.F.A. (ml 0.1 N NaOH/ 100g)	0	5.23^{a}	0.321	3.20^{c}	0.346	3.20^{c}	0.346	3.90^{c}	0.100	3.87^{b}	0.231	1.97^{e}	0.058	1.97^{e}	0.058	2.37^{d}	0.153	2.37^{d}	0.153	0.3931
	15	9.16^{a}	0.265	5.20^{d}	0.200	5.87^{c}	0.058	5.67^{c}	0.208	6.77^{b}	0.231	3.67^{f}	0.208	3.90^{f}	0.265	3.93^{f}	0.153	4.43^{e}	0.208	0.3752
	30	11.40^{a}	0.529	6.06^{ef}	0.006	6.83^{d}	0.115	8.03^{c}	0.015	9.00	0.173	4.37^{h}	0.153	5.07^{g}	0.252	5.63^{f}	0.473	6.30^{e}	0.721	0.5307
	45	14.3^{a}	0.551	8.27^{d}	0.115	8.97^{c}	0.115	9.83^{b}	0.058	10.14^{b}	0.225	5.57^{g}	0.351	6.27^{f}	0.115	6.90^{f}	0.100	8.07^{d}	0.666	0.5662

A : without whey proteins.

B :50% of reduced fat was replaced with whey proteins.

TVFA : Total volatile fatty acids.

Means having different letters in the same raw significantly differ at P≤ 0.05

acids (as indicated by higher formol values in cheese containing whey proteins served as precursors for the formation of certain volatile fatty acids through specific metablic pathways (Nakae and Elliott 1965) and Yvon and Rijnen (2001).

Several investigators have shown that the incorporation of cheese milkwith denatured whey proteins stimulated the breakdown of proteins in cheese during ripening. Lo and Bastian (1998) have shown that low fat UF-cheese manufactured from milk that had been heated to 85°C for 17 s to achieve partial denaturation of whey proteins had comparable rates of protein degradation to cheese made by traditional method. Meanwhile, several investigators studied the effect of whey proteins on proteolysis. They showed that native whey proteins reduced the rate of proteolysis but denatured whey proteins did not affect proteolysis in cheese (Guinee, *et al.,* 1995 & Iyer and Lolievre 1987).

Meanwhile, Lo and Bastian (1998) showed that denatured whey proteins enhanced the rate of proteolysis as indicated with the higher rate of α_{S1} caseins breakdown.

Pickling low fat cheese in old brine showed some stimulating effect on both soluble N formation and volatile fatty acid accumulation in the resultant cheese. This was more pronounced when whey proteins were used as a fat replacer. This could be explained on the basis that old brine contained a considerable amounts of soluble N and total volatile fatty acids (NPN = 0.469% & TVFA = 2.8 ml NaOH/100 ml brine). These compounds might be diffused from the old brine into the cheese, thus increased the levels of both soluble N and total volatile fatty acids. Similar conclusions were reported by Magakian (1982).

Free Fatty Acids

Low fat cheese made from milk containing 1.8% fat and with added whey proteins equal to 50% of the reduced milk fat and pickled in old brine was selected at the end of pickling for the determination of individual free fatty acids. The results were compared with the free fatty acids content of whole milk cheese made from milk with 3.6% fat (Table 5).

The obtained results showed that the pattern of free fatty acids in both low and full fat cheese samples was found to be the same. The percentage of total volatile fatty acid in low fat cheese was found to be very similar to that of whole fat milk cheese. These results could be attributed to the effect of both whey protein and old brines on the formation and accumulation of both soluble nitrogenous compounds and total volatile fatty acids coupled with the development of good flavour and body characteristics. Magakian (1982) showed that old brine of good quality could be used to enhanced cheese flavour formation of volatile fatty acids in soft cheese during pickling.

Table 5 : Free fatty acids of soft cheese after 45 days pickling

Free fatty acids	Control cheese (from whole milk) 3.6% fat	Cheese made from milk with 1.8% fat*
C_6	3.6	4.5
C_8	4.1	4.9
C_{10}	13.8	16.5
C_{12}	2.6	3.1
C_{14}	1.8	2.2
C_{16}	34.9	33.7
$C_{16:1}$	7.3	11.1
C_{18}	1.1	0.1
$C_{18:1}$	4.9	4.6
$C_{18:2}$	18.8	16.1
$C_{18:3}$	5.0	2.6
$C_{20:1}$	1.6	0.2

* whey proteins replaced 50% of reduced fat and cheese was pickled in old brine.

Organoleptic Properties

Studying the score points given for the cheese of different treatments, (Table 6) it could be seen that it was possible to obtain good quality low fat soft cheese when the reduced fat was replaced with whey proteins at a level equal to 50% of the reduced fat. This was more remarkable when cheese was made from milk containing 1.8 fat whereas cheese gained scores for flavour and texture which were comparable to that of

Table 6: Organolepitc properties of low fat soft cheese as affected by replacing milk fat with whey proteins and pickling media

Pickling period (days)	Orgaroleptic properties		Control (3.6% fat)		Cheese made from low fat milk with: 1.8% fat, A, Fresh brine		1.8% fat, A, Old brine		1.8% fat, B, Fresh brine		1.8% fat, B, Old brine		0.9% fat, A, Fresh brine		0.9% fat, A, Old brine		0.9% fat, B, Fresh brine		0.9% fat, B, Old brine		L.S.D
			$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	$\overline{X}$	SD±	
	Flavour	60	48.0^{a}	0.577	34.0^{c}	0.000	34.0^{c}	0.000	38.0^{b}	0.000	38.0^{b}	0.000	28.0^{e}	0.577	28.0^{e}	0.557	32.0^{d}	1.000	32.0^{d}	1.000	0.2048
Fresh	Body&texture	40	34.0^{a}	0.000	24.0^{c}	0.000	24.0^{c}	0.000	28.0^{b}	0.000	28.0^{b}	0.000	21.0^{d}	0.577	21.0^{d}	0.557	25.0^{c}	1.000	25.0^{c}	1.000	0.4240
	Total	100	82.0^{a}	0.577	58.0^{c}	0.000	58.0^{c}	0.000	66.0^{b}	0.000	66.0^{b}	0.000	49.0^{d}	0.000	49.0^{d}	0.000	57.0^{c}	1.732	57.0^{c}	1.000	0.6046
	Flavour	60	50.0^{a}	0.000	38.0^{d}	0.000	38.0^{d}	0.000	41.0^{c}	0.000	42.0^{b}	0.000	31.0^{h}	1.000	32.0^{g}	1.000	35.0^{f}	1.000	36.0^{e}	0.577	0.0547
15	Body&texture	40	35.0^{a}	0.000	25.0^{d}	0.000	25.0^{d}	0.577	31.0^{b}	0.000	32.0^{b}	0.000	22.0^{e}	1.000	22.0^{e}	2.000	26.0^{d}	1.000	28.0^{c}	0.577	0.1095
	Total	100	85.0^{a}	0.000	63.0^{d}	0.000	63.0^{d}	0.577	72.0^{c}	0.000	74.0^{b}	0.000	53.0^{f}	1.732	54.0^{f}	2.646	61.0^{e}	0.000	64.0^{d}	0.000	0.2448
	Flavour	60	54.0^{a}	0.577	39.0^{c}	1.732	40.0^{c}	0.000	43.0^{b}	0.000	44.0^{b}	0.000	33.0^{e}	1.000	34.0^{e}	0.577	36.0^{d}	1.000	37.0^{d}	1.000	1.694
30	Body&texture	40	37.0^{a}	0.000	25.0^{e}	0.577	25.0^{e}	0.577	33.0^{c}	0.000	35.0^{b}	0.577	23.0^{f}	1.000	23.0^{f}	1.155	28.0^{d}	1.000	29.0^{d}	1.000	1.645
	Total	100	91.0^{a}	0.577	64.0^{d}	2.000	65.0^{d}	0.577	76.0^{c}	0.000	79.0^{b}	0.577	56.0^{e}	3.055	57.0^{e}	0.577	64.0^{d}	1.732	66.0^{d}	2.000	2.970
	Flavour	60	56.0^{a}	0.577	40.0^{c}	0.577	41.0^{c}	1.000	46.0^{b}	0.000	47.0^{b}	0.000	36.0^{e}	1.528	37.0^{de}	1.000	38.0^{d}	1.000	40.0^{c}	2.000	0.3931
45	Body&texture	40	38.0^{a}	1.000	25.0^{ef}	0.577	25.0^{e}	1.155	34.0^{b}	0.000	35.0^{b}	0.000	24.0^{f}	1.000	25.0^{ef}	1.000	28.0^{d}	1.000	30.0^{c}	1.000	0.3752
	Total	100	94.0^{a}	0.000	65.0^{d}	1.000	66.0^{d}	2.082	80.0^{b}	0.000	82.0^{b}	0.000	60.0^{f}	2.517	62.0^{e}	1.732	66.0^{d}	1.732	70.0^{c}	3.000	0.5662

A : without whey proteins.

B :50% of reduced fat was replaced with whey proteins.

TVFA : Total volatile fatty acids.

Means having different letters in the same raw significantly differ at $P \leq 0.05$.

control cheese made from whole milk (3.6% fat). The flavour and texture of cheese made from milk containing 0.9% fat and incorporated with whey proteins as a fat replacer were acceptable particularly when cheese was pickled in old brine. Cheese made from low fat milk without added whey proteins tended to become hard during pickling especially when cheese was made from milk containing 0.9% milk fat indicating that the use of whey proteins as a fat replacer in low fat cheese making compensated the loss of water and enhanced both flavour and body qualities in the resultant cheese.

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بروتينات الشرش كبديل للدهن فى صناعة الجبن الطرى المنخفض فى الدهن

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أجريت محاولة لإنتاج الجبن الطرى منخفض الدهن ذو جودة مقبولة باستخدام بروتينات الشرش كبديل للدهن.

أجريت دراسة أولية لتحديد حدود استبدال الدهن المنزوع فى اللبن المنخفض فى الدهن ببروتينات الشرش وقد أشارت النتائج أن استبدال أكثر من ٥٠% من الدهن المنزوع ببروتينات الشرش قد أدى إلى إطالة زمن التجبن وخفض قدرة الخثرة على طرد الشرش وفى ضوء ذلك فقد تم تعديل الدهن فى اللبن البقرى إلى ١,٨% ، ٠,٩% دهن. وتم استبدال ٥٠% من الدهن المنزوع فى الحالتين ببروتينات الشرش وتم تصنيع الجبن الطرى منخفض الدهن مع تخزينه فى محلول تخليل طازج أو محلول تخليل قديم جيد. وقد تم مقارنة الجبن الناتج بالجبن الكنترول المصنع من اللبن البقرى كامل الدسم (٣,٦% دهن). وقد تبين من النتائج أن استبدال ٥٠% من الدهن المنزوع ببروتينات الشرش قد أدى إلى تحسين المحصول والحصول على جبن جيد ذو جودة مقبولة من اللبن المحتوى على ١,٨ ، ٠,٩% دهن. وقد كان لتخزين الجبن فى محلول التخليل القديم أثر جيد حيث أدى إلى تحسين النكهة وخواص القوام كما ساعدت هذه المعاملة على سرعة تحلل البروتين وتكوين الأحماض الدهنية خلال التسوية. وقد كان الجبن المنخفض فى الدهن خاصة المصنع من لبن يحتوى على ١,٨% دهن والمخزن فى محلول التخليل القديم الجيد مقاربا لصفاته من الجبن الكنترول.