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Studies on physico-chemical properties of skim milk powder sold in Maharashtra

M.R. Patil*, C.D. Khedkar, S.D. Chavan and P.S. Patil

Department of Dairy Chemistry, College of Dairy Technology,
Warud (Pusad), Yavatmal-445 204, (M.S.), India.

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ABSTRACT

Twenty five market skim milk powder samples obtained from various regions of Maharashtra were analysed for their chemical composition, physico-chemical properties and microbiological quality to access their suitability in terms of national and international standards. It was observed that the moisture, fat, protein, lactose and ash content of SMP samples obtained from various regions showed significant difference ($P < 0.05$). It was also revealed that the scorched particle content, solubility index, dispersibility, wettability properties of samples varied significantly in different regions for different brands. Similarly, the NPN and true protein content in SMP samples of different regions were significantly different from each other. The average free fat content in the samples from Vidarbha was significantly higher than that of the other regions of the state. The titratable acidity and lactate content of various brands of SMP samples were ranged from 0.97-1.08 and 75-550 mg/100 g, respectively. It was observed that three brands out of twenty five samples were found positive for alkali neutralizers. Wide variation was observed in standard plate count and coliform counts of all the SMP samples of various brands collected from five different regions of Maharashtra.

Key words: Microbiological quality of SMP, Milk powder, National and international standards, PFA standards, Skim milk powder.

INTRODUCTION

India has emerged as the largest milk producing country in the world with present level of annual milk production estimated as 144 million tonnes. India's milk production has been continuously increasing over the past six decades. In most of the countries including India where milk production has become highly organized, the dairy industry has to face great seasonal variations in the milk supply. Therefore the most important way of dealing with the surplus milk in the flush season is to dry it. During lean season, it is often necessary to "stretch" the milk by adding powder (Knipschildt and Andersen, 1994). Under commercial conditions, raw milk of varying chemical and bacteriological quality is available for the manufacture of dried milk. The raw milk may have high-developed acidity and such high acidic milk when neutralized with alkali and converted into powder, shows high lactate content which is one of the important parameters be analyzed before exporting the powder. In order to meet the demand of market supply of milk uniformly throughout a year and in places of scarce milk production, it is necessary to use milk powders for preparation of recombined milk or reconstituted milk to supplement the shortage of fresh milk. Much of milk powder that is sold in India is sold by dairies to other dairies for

reconstitution of milk during lean season. At present mostly recombined milk is prepared from skim milk powder (SMP) and butter oil/white butter.

To gain access to foreign markets and sustain our presence, we shall have to meet the quality standards and specifications of milk products prevailing in these markets especially whole milk powder (WMP) and SMP, which are exported. The importing countries usually insist for International Standards and milk powder samples are subjected to rigorous quality analysis before placing the orders. Apart from this, the menace of adulteration in our country has created a panic among the people. The existing Indian standards for milk powders are not complete in all respects and do not cover some parameters like true protein, non protein nitrogen content, wettability, dispersability, etc. which are important from quality assurance point of view. Therefore, it was considered worthwhile to generate information on the physico-chemical quality of SMP manufactured in various dairies and sold in Indian market with special reference to International Standards. The present investigation was planned to elicit information on physico-chemical parameters and microbiological quality of skim milk powder samples.

*Corresponding author's e-mail: madhavpatil34@gmail.com and address: Department of Dairy Chemistry, College of Dairy Technology, Udgir, Latur-413 517, India.

MATERIALS AND METHODS

The present investigation was undertaken to study the SMP samples obtained from various regions of Maharashtra for their physico-chemical parameters and microbiological quality. Suitability of these powders was evaluated to check whether it meets the national and international standards. The incidence of adulterants, especially the neutralizers was also investigated in these powder samples. Twenty-five samples of SMP of different brands were collected from five regions of the state namely, Vidarbha, North Maharashtra, Western Maharashtra, Marathwada and Mumbai. The samples were purchased from market or from dairies and stored in dry place at room temperature. Looking to the integrity and to maintain the confidentiality of the brands coding was done. The coding of the samples was executed and is mentioned as follows;

Coding of skim milk powder

Sample	Region	Code
SMP	Vidarbha	VSMP (V1, V2, V3, V4, V5)
	North Maharashtra	NMSMP (NM1, NM2, NM3, NM4, NM5)
	Western Maharashtra	WMSMP (WM1, WM2, WM3, WM4, WM5)
	Marathwada	MRSMP (MR1, MR2, MR3, MR4, MR5)
	Mumbai	MBSMP (MB1, MB2, MB3, MB4, MB5)
	North Maharashtra	NMSMP (NM1, NM2, NM3, NM4, NM5)

The powder samples were analyzed for its physico-chemical properties by using standard procedures, viz. fat (IS: 11721, 1986), moisture, true protein, ash (SP 18 Part-XI, 1981), lactose (SP 18 Part-XI, 1981; Lane-Eynon method), acidity (IS: 11765, 1986), lactate (IS:11202, 1984), free fat (NIRO Atomizers, Research Lab, 1978), dispersability (ADMI Bulletin, 915, 1965), solubility index (IS:12759, 1989), wettability (XVI International Dairy Congress, 1962), scorched particles (ADMI Bulletin, 916, 1971) and neutralizers (SP:18 Part-XI, 1981). All the reagents used in chemical analyses were of Analytical Grade (AR Grade). The reagents were prepared by using glass distilled water. Skim milk powder samples were also examined for standard plate count and coliform counts according to BIS methods as mentioned in SP: 18, Part-XI (1981).

The data obtained in the present investigation were suitably analyzed as completely randomized design (CRD) (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Chemical composition of market SMP: A detailed study on chemical composition of 25 brands of SMP was carried out. The samples purchased from market or from dairies were analyzed for the chemical composition and presented in Table

1. The data obtained was statistically analyzed and the results are expressed in terms of mean with standard error in Table 2. It can be seen from the content of Table 1 that the moisture, fat, protein, lactose and ash content (%) of various brands of SMP ranged from 1.98-4.08(3.3464), 1.23-1.64 (1.4016), 31.80-39.84 (35.722), 46.99-56.37(51.791) and 7.17-8.24 (7.6136), respectively. From the results pertaining to the moisture content, it is revealed that the average moisture content in SMP samples was 3.22-4.06 (V), 2.0-4.06 (NM), 3.12-4.08 (WM), 2.98-4.02 (MR), and 1.99-3.88 (MB).

From the ANOVA (Table 2) it is clear that the moisture content of SMP samples of different brands differs significantly ($P < 0.05$). Moreover, the same difference was also observed within the region. The results obtained in present study are at par with the values obtained by Kumar (2000). Shakeel *et al.*, (2003) studied the effect of multiwall kraft paper or plastic bags on physico-chemical changes in milk powder during storage at high temperature and humidity and reported that the moisture of SMP in paper bags increased on average by 26.5% during the 90 days of storage at 37°C and 90% RH. Baldwin *et al.*, (1980) observed that as the -viscosity of the concentrate changed from 0.7 to 6.8 poise, there was small increase in the moisture content from 2.1 to 2.6%.

The fat content (%) in SMP samples ranges from 1.23-1.43 (V), 1.24-1.52 (NM), 1.29-1.56 (WM), 1.35-1.64 (MR) and 1.37-1.52 (MB). It could be seen (Table 2) that fat content of SMP samples varies significantly ($P < 0.05$) with highest mean values in SMP samples of Western Maharashtra (1.436) followed by Maratawada (1.434), Mumbai (1.401), North Maharashtra (1.378) and Vidarbha (1.316). Although the fat content of SMP samples of different regions varies significantly but there was no significant difference within the various brands of same region. In contest to the protein content of SMP samples, significant difference was observed in the samples from different regions, being highest in Western Maharashtra (36.004) and lowest in Vidarbha (35.012). The mean protein content of North Maharashtra, Maratawada and Mumbai were 36.004, 35.55 and 35.602, (%) respectively. From the Table 2 it could be seen that the significant difference was observed not only in the regions but also in the brands within the region. Walley and O'Connor (1980) reported a regular seasonal variation in protein concentration of SMP manufactured in Ireland. From the Table 1, it is reveled that the lactose (%) in SMP samples was ranged from 49.66-55.32 (52.58) in Vidarbha, 46.99-55.22 (51.17) in North Maharashtra, 48.03-54.72 (50.85) in Western Maharashtra, 48.56-54.63 (51.75) in Marathwada and 49.16-56.37 (52.59) in Mumbai SMP samples. It is indicative that SMP samples of Mumbai region had significantly ($P < 0.05$) higher lactose content than that of other regions of the states. In addition to this significant difference in lactose content was also observed within the

Table 1: Chemical compositions of spray-dried SMP*

Brand	Moisture	Fat	Protein	Lactose	Ash
————— (% by wt.) —————					
Vidarbha					
V1	3.38	1.43	35.01	52.65	7.53
V2	3.42	1.23	38.05	49.66	7.64
V3	3.98	1.35	33.76	53.29	7.62
V4	3.22	1.26	32.87	55.32	7.33
V5	4.06	1.31	35.37	52.02	7.24
Average Mean	3.612	1.316	35.012	52.588	7.472
North Maharashtra					
NM1	3.32	1.24	31.98	55.22	8.24
NM2	3.66	1.29	34.57	52.59	7.89
NM3	2.42	1.45	36.62	51.97	7.54
NM4	4.06	1.39	37.46	46.99	7.28
NM5	2	1.52	39.39	49.08	8.01
Average Mean	3.092	1.378	36.004	51.17	7.792
Western Maharashtra					
WM1	4.08	1.52	37.51	49.12	7.77
WM2	3.98	1.46	37.25	49.68	7.63
WM3	3.38	1.35	39.84	48.03	7.4
WM4	3.12	1.56	34.57	52.71	8.04
WM5	3.52	1.29	33.05	54.72	7.42
Average Mean	3.616	1.436	36.444	50.852	7.652
Marathwada					
MR1	2.98	1.35	33.14	54.63	7.9
MR2	3.68	1.64	33.32	53.95	7.41
MR3	4.02	1.38	35.82	51.41	7.37
MR4	3.66	1.42	36.62	50.23	8.07
MR5	3.26	1.38	38.85	48.56	7.95
Average Mean	3.52	1.434	35.55	51.756	7.74
Mumbai					
Mb1	2.78	1.52	31.8	56.37	7.53
Mb2	3.88	1.37	37.96	49.16	7.63
Mb3	2.66	1.45	36.53	52.19	7.17
Mb4	1.98	1.49	34.12	54.9	7.51
Mb5	3.46	1.39	37.6	50.33	7.22
Average	2.952	1.444	35.602	52.59	7.412
Overall Mean	3.3464	1.4016	35.722	51.791	7.6136
S. E.	0.060011	0.034678	0.28427	0.13277	0.2311
C. D.	0.16608*	0.10095*	0.78673*	0.36743*	0.63957*

*Values are average of three replications

Table 2: Statistical analysis of the data on chemical composition of SMP

Source	Degree of Freedom	Moisture	Fat	Protein	Lactose	Ash
Region	4	1.6041*	0.044682*	4.3083*	9.5332*	0.41239
Brand	4	0.494*	0.004542	22.045*	18.101*	0.27694
Region X Brand	16	1.1437*	0.3647*	18.119*	23.769*	0.2279
Error	50	0.01804*	0.003992	0.24243	0.05288	0.16022
Total	74					

*Significant at P<0.05

brands and regions of the state. Our results are in well agreement with those reported by Rotkiewicz *et al.* (1978). It could further be seen from the content of Table 1 and 2 that there is significant difference (P<0.05) in ash content of SMP samples with highest values for North Maharashtra and lowest values for Mumbai samples. The statistical analysis

of data (Table 2) indicates that there was significant difference (P<0.01) between the regions with respect to the moisture, fat, protein, lactose and ash content in SMP samples. The variation in composition of SMP may be due to the wide variation in various constituents of skim milk (especially fat and protein). Kumar (2000) studied the

physico-chemical quality of SMP manufactured and sold in India and reported same trend for chemical composition of SMP. The values reported in present investigation are in well agreement with the values reported by Kadian *et al.*, (1998); Arora, (1989); and Sarmah *et al.*, (1990).

Physical properties of market SMP samples: The SMP samples of different brands were analyzed for the different physical properties such as scorched particles, wettability, dispersibility and solubility index. The data obtained was analyzed and the results obtained were expressed in the form of average of three replications. The results for the physical properties of SMP samples are given in Table 3. From the content of table it could be seen that the scorched particles, dispersibility, wettability and solubility index of various brands of SMP ranged from Disc A to Disc 0, 26.40 to 39.36 g (28.626) 10 to 264 sec (80.12) and 0.85 to 1.8 ml (1.348), respectively. Regarding the scorched particle content it could be seen that the scorched particles (in mg) was higher for SMP samples of Vidarbha, North Maharashtra and Western Maharashtra. This may be due to the uncontrolled processing conditions viz. defective atomization, inadequately maintained inlet air filters and deposits of powder in inaccessible areas subject to high temperature during manufacture (El-Samragy *et al.*, 1993). The overall dispersibility (%) of SMP samples of Vidarbha was ranging from 27.44-39.36 (30.48) and that from North Maharashtra, Western Maharashtra, Marathwada and Mumbai were 26.4-29.47 (27.806), 27.22-29.47 (28.114), 27.5-28.76 (28.232) and 27.31-29.84 (28.498), respectively. It could be concluded from the contents of Table 4, that there was significant ($P < 0.05$) difference in dispersibility of SMP samples of different region and different brands. It is seen from the Table 3 that the wettability (Sec) of SMP samples of Mumbai region was ranged from 26-205 (112.4), which was higher than that of other regions i.e. Vidarbha, 30-210 (112.4 sec), North Maharashtra, 10-78 (46.8), Western Maharashtra, 48-264 (108.8), and Marathwada, 15-48 (30.4). It could be observed that the wettability of SMP samples of Mumbai was significantly higher (Table 4) than that of other regions of the state. The wide variation in wettability and dispersibility can be due to a number of processing factors, which are difficult to control (Verney, 1972). It is further observed from the Table 3 that the solubility index was in the range of 0.9-1.7 (1.28), 0.95-1.8 (1.34), 0.95-1.75 (1.35), 0.95-1.7 (1.41) and 0.85-1.7 (1.36) for SMP samples from Vidarbha, North

Table 3: Physical properties of SMP*

Brand	Scorched particles (disc)	Dispersibility (in g)	Wettability seconds	Solubility index (ml)
Vidarbha				
V1	B	27.44	30	1.3
V2	A	39.36	55	1.4
V3	C	28.66	210	1.1
V4	D	27.92	126	0.9
V5	B	29.03	90	1.7
Average Mean		30.482	102.2	1.28
North Maharashtra				
NM1	B	26.4	60	1.8
NM2	B	27.08	54	1.2
NM3	A	28.36	32	1.3
NM4	C	27.72	10	1.45
NM5	D	29.47	78	0.95
Average Mean		27.806	46.8	1.34
Western Maharashtra				
WM1	A	27.64	48	1.75
WM2	A	27.58	264	1.3
WM3	C	28.66	58	0.95
WM4	B	29.47	84	1.5
WM5	B	27.22	90	1.25
Average Mean		28.114	108.8	1.35
Marathwada				
MR1	A	27.5	26	0.95
MR2	B	28.36	28	1.35
MR3	A	28.12	48	1.6
MR4	B	28.42	35	1.45
MR5	B	28.76	15	1.7
Average Mean		28.232	30.4	1.41
Mumbai				
Mb1	A	27.32	78	1.45
Mb2	A	29.46	64	1.2
Mb3	B	29.84	26	1.6
Mb4	C	28.56	189	0.85
Mb5	B	27.31	205	1.7
Average Mean		28.498	112.4	1.36
Overall Mean		28.626	80.12	1.348
S.E.		0.08631	3.8262	0.10296
C.D.		0.23886*	10.589*	0.28493*

*Values are average of three replications

Maharashtra, Western Maharashtra, Marathwada and Mumbai, respectively. From these data it is clear that the solubility index of SMP samples of Marathwada were significantly ($P < 0.05$) higher than that of other regions. The statistical analysis of physical properties (Table 4) of SMP samples showed that all the properties are showing significant differences ($P < 0.05$) among the brands as well as among

Table 4: Statistical analysis of the data on physical properties of SMP

Source	Degree of Freedom	Dispersibility	Wettability	Solubility Index
Region	4	17.066*	22254*	0.03255
Brand	4	18.848*	5682.5*	0.15630*
RegionXBrand	16	16.945*	13562*	0.32167*
Error	50	0.022348	43.920	0.0318
Total	74			

*Significant at $P < 0.05$

the regions of the state. Arora (1989) and Kadian *et al.*, (1998) studied the solubility index of SMP samples and reported that the values for different brands were in the range of 0.1-1.5 ml, which is at par with the values reported in the present study. According to Woodham and Murray, (1974), raw milk used for the manufacture of dried milk must be fresh, as the developed acidity will lead to higher insolubility index. Jensen and Hansen (1974) observed that increase in the total solids (TS) content of the concentrate deteriorates the solubility index of both SMP and WMP. Kumar and Seth (2003) studied the physical properties of SMP manufactured in India and it was observed that the scorched particles, wettability, dispersibility and solubility index of various brands of SMP samples ranged from disc A to Disc D, 10-300 sec, 22.18-29.47 g and 0.05-0.31 ml, respectively. The results obtained in the present study are in agreement with the values reported by Kumar (2000). In addition to this Shakeel *et al.*, (2003) reported that the Insolubility Index, dispersibility of SMP in paper bags was increased and decreased, respectively during the storage at 37°C and 90% RH. According to Verney (1972) and Knipschiedt (1986), during manufacture of SMP, when the inlet air temperature was raised from 120 to 150°C, there is increase in the vacuole volume, moisture content and solubility index of the powder. The increase in solubility index was attributed to the formation of hard particle surface of powder due to higher inlet temperature. The wide variation in the physical properties of SMP samples could be attributed to the quality of milk and drying conditions, and variation in the processing factors, which are difficult to control.

Chemical quality of market SMP: The chemical quality of market SMP samples was evaluated and presented in Table 5 and 6 to elucidate the qualitative differences of SMP of various brands. From the Table 5 it could be seen that the NPN content of SMP samples varied in the range of 0.189-0.630 with average mean values of 0.323 (V), 0.321 (NM), 0.4292 (WM), 0.389 (MR) and 0.420 (MB). On the other hand, the true protein content in SMP samples are showing apposite trend, *i.e.* Vidarbha SMP samples showed higher values than that of North Maharashtra, Western Maharashtra, Marathwada and Mumbai. It could be seen that the true protein content of SMP samples ranged from 31.17-39.871% with the mean values 34.689 (V), 36.247 (NM), 36.014 (WM), 35.161 (MR) and 35.16 (MB). It could be clear from the data (Table 6) that true protein content of North Maharashtra was higher ($P<0.05$) than that of other regions. As shown in Table 5 formal titre values and total protein contents of SMP of various brands were compared. The Pyne's constant was calculated by dividing the total protein contents as in Kjeldahl method by the respective formal titre value of SMP. The Pyne's constant was found to be 2.12-2.16 for Vidarbha, 2.13-2.16 for North Maharashtra, 2.12-2.17 for Western Maharashtra, 2.11-2.17 for Marathwada and 2.12-2.16 for Mumbai. The overall mean of Pyne's

constant for SMP was 2.1453. From the content of tables 5 it is clear that the free fat content of skim milk powder was ranging from 0.036 to 0.354 with the average value of 0.259, 0.114, 0.121, 0.085 and 0.140 for different regions of the state *viz.* Vidarbha, North Maharashtra, Western Maharashtra, Marathwada and Mumbai, respectively. It could be seen from Table 6 that the average free fat content in SMP samples from Vidarbha was significantly ($P<0.05$) higher than that of the other regions of the state. Further the free fat in SMP samples collected from Marathwada and North Maharashtra were significantly ($P<0.05$) lower than that of Mumbai and Western Maharashtra. The results obtained in present study are in general agreement with that of the results obtained by Kumar (2000). The decrease in free fat content might be due to homogenization of concentrate. Buma (1971) reported that homogenization of concentrated milk prior to spray drying results in powders with much less free fat than is found in powders from un homogenized concentrated milk. In addition to this Knipschiedt (1986) observed that increasing inlet air temperature from 170-225°C and keeping the outlet temperature constant at 90°C caused decrease in free fat content. The increase in solubility index and decrease in free fat content was attributed to the formation of hard particle surface of powder due to higher inlet temperature.

From the content of Table 7, it could be seen that titratable acidity (% LA) and lactate content of various brands of SMP samples were ranged from 0.97-1.08 and 75-550 mg/100 g, respectively. The mean values of acidity of SMP samples of Vidarbha (1.332), Marathwada (1.314) were significantly higher (Table 8) than North Maharashtra (1.251), Western Maharashtra (1.26) and Mumbai (1.269). Coulter *et al.*, (1951) attributed such increase in titratable acidity to the possible tying of amino groups of protein with lactose during storage. The results obtained in the present study are in agreement with those reported by Kumar (2000) and Shakeel *et al.*, (2003). In addition to this, vast differences in the lactate content (mg/100 g) of SMP samples of different regions were reported in Table 7. The average lactate content (mg/100 g) of SMP samples were 101.6 for Vidarbha, 330.0 for North Maharashtra, 264.0 for Western Maharashtra, 123 for Marathwada and 96.8 for Mumbai. The data presented in Table 8 shows that Mumbai and Vidarbha SMP samples had significantly lower lactate content ($P<0.05$) as compared to other regions. All the chemical parameters of SMP samples from different regions of the state showed variations. This could be due to variation in the initial quality of milk used for manufacture of SMP and processing treatments.

It was observed from Table 8 that two brands out of five from North Maharashtra, Western Maharashtra and Mumbai and one brand out of five (in each case) from Marathwada were positive for alkali neutralizers. However, none of the SMP samples from Vidarbha were positive. On

Table 5: Chemical quality of SMP*

Brand	NPN	True protein	Formal Titre value	Pyne's constant	Free Fat	Free fat (% of total fat)
Vidarbha						
V1	0.289	34.721	16.5	2.12	0.126	8.814
V2	0.319	37.731	17.8	2.14	0.234	19.034
V3	0.429	33.331	15.8	2.14	0.256	18.973
V4	0.219	32.651	15.3	2.15	0.324	25.732
V5	0.359	35.011	16.4	2.16	0.354	27.043
Average Mean	0.323	34.689	16.36	2.142	0.259	19.919
North Maharashtra						
NM1	0.289	31.691	14.8	2.16	0.186	15.006
NM2	0.339	34.231	16.1	2.15	0.156	12.097
NM3	0.379	36.241	17.1	2.14	0.054	3.725
NM4	0.409	39.871	17.5	2.14	0.098	7.052
NM5	0.189	39.201	18.5	2.13	0.078	5.132
Average Mean	0.321	36.247	16.8	2.144	0.114	8.602
Western Maharashtra						
WM1	0.369	37.141	17.6	2.13	0.088	5.791
WM2	0.509	36.741	17.3	2.15	0.056	3.836
WM3	0.239	39.601	18.4	2.17	0.042	3.111
WM4	0.42	34.15	16.3	2.12	0.156	10.003
WM5	0.609	32.441	15.4	2.15	0.264	20.477
Average Mean	0.4292	36.0148	17	2.144	0.121	8.643
Marathwada						
MR1	0.309	32.831	15.7	2.11	0.128	9.484
MR2	0.269	33.051	15.4	2.16	0.066	4.025
MR3	0.389	35.431	16.7	2.14	0.078	5.653
MR4	0.449	36.171	17.1	2.14	0.036	2.535
MR5	0.529	38.321	17.9	2.17	0.116	8.408
Average Mean	0.389	35.161	16.56	2.144	0.085	6.021
Mumbai						
Mb1	0.63	31.17	14.7	2.16	0.128	8.423
Mb2	0.519	37.441	17.7	2.14	0.098	7.155
Mb3	0.289	36.241	17.1	2.14	0.066	4.552
Mb4	0.369	33.751	15.9	2.15	0.242	16.250
Mb5	0.42	37.18	17.7	2.12	0.164	11.803
Average	0.445	35.16	16.62	2.142	0.140	9.637
Overall Mean	0.37867	35.453	16.664	2.1453	0.14376	10.565
S. E.	0.00667	0.66647	0.16152	0.026667	0.0027031	0.33508
C. D.	0.0185*	1.8445*	0.44701*	0.073801	0.007481*	0.92734*

*Values are average of three replications

Table 6: Statistical analysis of the data on chemical quality of SMP

Source	Degree of Freedom	NPN	True Protein	Formal Value	Pyens Constant	Free Fat	Free Fat (% of total fat)
Region	4	0.047433*	6.4640*	1.0182*	0.0014667	0.067870*	437.08*
Brand	4	0.012133*	20.408*	4.6575*	0.0021333	0.02256*	125.01*
Region X Brand	16	0.040133*	21.664*	4.1035*	0.00405	0.013276*	85.111*
Error	50	0.0001333		0.07827	0.0021333	0.0000219	0.33683
Total	74						

*Significant at P<0.05

the same line Vallestrisco *et al.*, (1981) tested and found eight market samples of SMP were positive for sodium carbonate. While Kadian *et al.*, (1998) reported that two brands out of three were positive for carbonates. In order to confirm the above observations, the acidity, lactate and ash

content were compared and the results are presented in Table 7. It could be seen that the acidity of SMP samples in which neutralizers detected were lower as compared to other brands. Similarly the lactate and ash content of same SMP samples had higher values as compared to other brands. Thus it

Table 7: Chemical properties of different brands of SMP*

Brand	Neutralizer	Acidity LA %	Lactate mg/100g	Ash (% by wt.)
Vidarbha				
V1	Negative	1.44	130	7.53
V2	Negative	1.35	135	7.64
V3	Negative	1.26	90	7.62
V4	Negative	1.35	78	7.33
V5	Negative	1.26	75	7.24
Average Mean		1.332	101.6	7.47
North Maharashtra				
NM1	Positive	1.125	550	8.24
NM2	Negative	1.44	410	7.89
NM3	Negative	1.26	300	7.54
NM4	Negative	1.35	210	7.28
NM5	Positive	1.08	180	8.01
Average Mean		1.251	330	7.79
Western Maharashtra				
WM1	Negative	1.44	250	7.77
WM2	Negative	1.26	380	7.63
WM3	Negative	1.35	100	7.4
WM4	Positive	1.17	315	8.04
WM5	Positive	1.08	275	7.42
Average Mean		1.26	264	7.65
Marathwada				
MR1	Negative	1.395	90	7.9
MR2	Negative	1.26	80	7.41
MR3	Negative	1.44	75	7.37
MR4	Positive	1.17	250	8.07
MR5	Negative	1.305	120	7.95
Average Mean		1.314	123	7.74
Mumbai				
Mb1	Negative	1.44	110	7.53
Mb2	Negative	1.26	105	7.63
Mb3	Positive	1.17	95	7.17
Mb4	Negative	1.35	85	7.51
Mb5	Positive	1.125	89	7.22
Average		1.269	96.8	7.41
Overall Mean		1.2863	183.08	7.6137
S.E.		0.050818	10.390	0.23098
C.D.		0.14064*	28.754*	0.63923

*Values are average of three replications

can be inferred from the above findings that there is a great need to monitor the quality of SMP production in India at each stage starting from the procurement of milk till its packaging.

Microbiological quality of market samples of SMP: Initial bacterial count of the milk powder depends on the bacterial load of raw milk used, conditions of preheat-treatment and

drying of milk. However, the bacterial activity is inhibited in dried milk powders because of its low moisture content. In the present study an attempt was made to investigate the microbiological quality of few brands of SMP manufactured or sold in different regions of Maharashtra state.

The results obtained are presented in Table 9, 10. It could be seen from the data that there is wide variation in total and coliform counts of all the SMP samples of various brands collected from five different regions of Maharashtra. It was observed that standard plate count of SMP samples was ranged from 1100 to 49700, which is lower than the maximum of 50,000/g permitted by BIS, indicating that the SMP samples were of good microbiological quality. The mean SPC (cfu/g) of Western Maharashtra was lower than that of Mumbai, Vidarbha, North Maharashtra and Marathwada with mean values of 30040, 30520, 33000 and 34360, respectively. The coliform counts of market SMP samples ranged from nil to 87 cfu/g, which was lower than that of the standards prescribed by BIS and FSSAI. The mean coliform count (cfu/g) of Vidarbha, North Maharashtra, Western Maharashtra, Marathwada and Mumbai samples was 23.6, 43.2, 25.4, 39.4 and 39.4, respectively. Significant difference ($P < 0.05$) was observed within brands and within region for SPC and coliform counts of SMP. Fresh raw milk with a low bacterial load is ideal for obtaining high quality dairy products including dried milk. But in practice under commercial conditions, varying initial quality would be available for manufacturing dried milk (Findley *et al.*, 1946). Arora and Sudarshan (1986) found that the SPC was 21.262×10^3 in SMP samples while, Ruckert *et al.*, (2004) reported the viable counts of SMP and WMP from different countries which was ranging from the lowest with 88 cfu/g and the highest 2.2×10^5 . Arora (1989) studied the microbial quality of market SMP and found that some of the samples showed higher SPC and coliform counts than those prescribed by BIS and FSSAI.

Comparative appraisal of quality of SMP with national and international standards: It could be seen from the contents of Table 1 that the moisture in SMP samples of different brands was below the levels prescribed by FSSAI (5.0% max.). As per the standards prescribed by BIS for extra and standard grades most of the samples fulfill the requirements except a few i.e. V5, NM4, WM1, MR3. In addition to this as per ADPI standards, most of the samples

Table 8: Statistical analysis on chemical properties of different brands of SMP

Source	Degree of Freedom	Acidity	Lactate	Ash
Region	4	0.021033	17185*	0.41169
Brand	4	0.082615*	2711.7*	0.27785
Region X Brand	16	0.038093*	2341.1*	0.22764
Error	50	0.007747	323.84	0.16005
Total	74			

*Significant at $P < 0.05$.

Table 9: Microbiological quality of SMP*

Brand	Standard Plate Count (cfu/g)	Coliform Count(cfu/g)
Vidarbha		
V1	34300	0
V2	37900	24
V3	43700	55
V4	35600	39
V5	1100	0
Average Mean	30520	23.6
North Maharashtra		
NM1	45300	85
NM2	11500	0
NM3	41800	75
NM4	23600	0
NM5	42800	56
Average Mean	33000	43.2
Western Maharashtra		
WM1	24500	14
WM2	36200	45
WM3	46700	68
WM4	1230	0
WM5	16800	0
Average Mean	25086	25.4
Marathwada		
MR1	41700	87
MR2	26700	32
MR3	18400	0
MR4	47200	78
MR5	37800	0
Average Mean	34360	39.4
Mumbai		
Mb1	45900	72
Mb2	12500	0
Mb3	34500	43
Mb4	7600	0
Mb5	49700	82
Average	30040	39.4
Overall Mean	30601	34.2
S.E.	5637.3	8.0117
C.D.	15601	22.172*

*Values are average of three replications

were well within the limits i.e. 3.0-4.0 (non-instant). As per FSSAI and BIS the fat content of SMP samples were within the limits, however samples NM5, WM1, WM4, MR2, MB1 were showing slightly higher values. According to ADPI and BIS standards the fat content of extra grade SMP should not be more than 1.25% which was fulfilled by V2 and NM1 samples only. All samples of SMP, except WM3, MB2 meets the requirements of BIS for ash content i.e. not more than 8.2 and 7.3% ash (on dry matter basis), for standard and extra grades, respectively. It was found that all the samples of SMP except V1, WM5 and MR5 were confirmed to prescribe standard (1.5% lactic acid max.) of PFA and BIS with respect to acidity. However, out of 25 brands of SMP, only 6 were found not conforming to BIS specifications for lactate (1.5 mg/g max.). According to the FSSAI and BIS the Solubility Index of SMP should not be more than 2.0 ml and all the samples investigated in the present study meets

Table 10: Statistical analysis of data on microbiological quality of SMP

Source	Degree of Freedom	Standard Plate Count	Coliform Count
Region	4	189830000*	1218.3*
Brand	4	715940000*	3206.1*
Region X Brand	16	805600000*	3983.8*
Error	50	95338000	192.56
Total	74		

*Significant at $P < 0.05$

that requirement. The scorched particles of SMP in the present study were in the range as per ADMI specifications i.e. 15.0 mg (Disc B), however, V3 and V4 from Vidarbha, NM4 and NM5 from North Maharashtra, WM3 from Western Maharashtra and MB3 were not meeting the standard. Vallestrisco *et al.*, (1981) analyzed 8 samples of SMP imported from European Economic Community (EEC) and observed that one sample contained 6% moisture exceeding the legal limits and solubility <90 percent (below the legal standards). Arora (1989) reported that out of 52 SMP samples, 12 were failed to attain the ISI specifications for moisture, 7 for fat and 13 for acidity. Kadian *et al.*, (1998) also reported that out of 3 brands of SMP manufactured in Haryana had the moisture content higher than the PFA standards, while all the three brands contained acidity above the prescribed standards (1.5% max.).

In connection with the microbial analysis all of the samples were confirming the standards for SPC and coliform counts as prescribed by FSSAI and BIS. Some of the samples were also confirming the standards of Extra grade SMP.

CONCLUSION

It can be concluded from the results obtained in present study that the SMP samples collected from various region are showing significant ($P < 0.05$) difference in its constituents. The observed variation can be attributed to the wide variation in the composition of skim milk used. The studies on different physical properties revealed that the scorched particle content, dispersibility, wettability of SMP samples from one region was varying significantly with that of other regions. The wide variation in wettability and dispersibility can be due to number of processing factors, which are beyond the control of processors. In the present study an attempt was also made to investigate the microbiological quality SMP manufactured or sold in different regions of the state and it can be concluded that the samples were of standard microbiological quality. So as evident from the literature and duly substantiated by the results of the present investigation, the manufacturer of SMP needs improvement in the quality of milk for conversion into good quality SMP. Similarly processing conditions should be controlled so as to maintain the physico-chemical qualities of SMP to meet the FSSAI and BIS standards as well as International Standards.

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