Original Research

Assessment of the Quality and Adulteration Level of Raw Milk Collected from Consumer Table in Himachal Pradesh

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Abstract

A total of 200 raw milk samples were collected directly from consumers to assess the quality and adulteration level in various agroclimatic zones I, II, III of Himachal Pradesh. Total 74 percent milk samples in case of specific gravity, 69.5 percent samples for fat percentage, 82.5 percent samples for solids-not-fat (SNF), and 73.5 percent samples for total solids (TS) were found to be below the minimum prescribed standards of Food Safety and Standards Authority of India (FSSAI). In zone-wise analysis with respect to specific gravity and SNF there was no significant difference ($p>0.05$) between Zone I and Zone II whereas, there was significant difference ($p<0.05$) of Zone III with Zone I and Zone II. Assessment of adulteration level depicted that water was the most common adulterant (74 percent) found in the milk samples followed by salt (18 percent), alizarin (13.5 percent), skim milk powder (9.5 percent), detergent (3 percent), sucrose (1.5 percent), glucose (1 percent), formalin (1 percent), and neutralizers (1 percent). None of the individual sample was found positive for all the synthetic ingredients required for production of synthetic milk.

Key words: Himachal Pradesh, Milk Adulteration, Physicochemical Quality, Raw Milk

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Introduction

India is the largest producer of milk in the world with estimation production of 165.4 million tonnes during 2016-17 (NDDB 2017), with annual growth rate of 6.28 percent. Milk production in Himachal Pradesh during 2017-18 is 1392 ('000 tonnes) and per capita availability of milk is around 542 grams per day. Despite being the largest producer of milk in the world the act of internationally debasing the quality of

milk has emerged as one of the major problems to India's dairy industry. Possible reasons behind it may include- demand and supply gap during festive season, perishable nature of milk, low purchasing capability of customer and lack of suitable detection tests (Kamthania *et al.*, 2014). Milk is one of the products, which can be adulterated in many ways affecting the quality of further dairy products. Economically Motivated Adulteration (EMA) is defined as "the fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production" (FDA 2009). As per FDA, dairy products stand on the second most reported category of adulterated food products among all scholarly records of adulterated foods (Moore *et al.*, 2012).

Adulteration of food products specially milk is a major problem and may lead to severe health problems. Water is an adulterant in milk which is often added to increase the volume of milk which in turn decreases the nutritive value of milk which if contaminated poses a health risk especially to infants and children (CSE 2006). Detergents cause gastro–intestinal complications. Urea is added to milk to provide whiteness, increase the consistency of milk and for levelling the contents of solids-not-fat (SNF) as are present in natural milk. The presence of urea in milk overburdens the kidneys as they have to filter out more urea content from the body (Kandpal *et al.*, 2012). Gastrointestinal problems like gastric ulcer, colon ulcer, diarrhoea and electrolytes disturbance may be caused by neutralizers in milk (Beall and Scofield, 1995). Hydrogen peroxide is also added to milk to prolong its freshness, but peroxides damage the gastro intestinal cells, which can lead to gastritis and inflammation of the intestine (Singuluri and Sukumaran, 2014). Damages of liver and lung tissues and increasing of total oxidant capacity by formalin was stated by Aydin *et al.* (2015). High amount of starch addition in milk may cause diarrhoea due to the effects of undigested starch in colon. Its accumulation in body may prove fatal for the diabetic patients (Afzal *et al.*, 2011). Salts in adulterated milk can cause critical illnesses like heart disease, problems of kidney, raised blood pressure, gastro-intestinal disturbance and allergies in human being (Kharat and Arak, 2013).

According to National Survey on milk adulteration conducted by FSSAI (India) in 2011, water was the most common adulterant followed by detergent in milk. A survey by FSSAI in 2012, 68 percent milk samples was found to be adulterated in which 31 percent were from rural areas. Of these 16.7 percent were packet or branded milk and rest were loose milk samples from dairies. In the urban areas, 68.9 percent milk was found to be adulterated with water, detergent, urea and skim milk powder. Adulteration of milk is one of the challenging problems that the dairy sector of India is facing nowadays, which not only causing major economic losses for the dairy industries but is health threatening for consumers. In FSSAI survey in 2011, 59 percent samples from Himachal Pradesh were found to be non-conforming to food safety and standards regulations and further, scanty research data about the milk quality in Himachal Pradesh leads to design the present study to assess the milk quality with reference to adulteration.

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Materials and Methods

Collection of Milk Samples

A total of 200 raw market milk samples were directly collected from the consumers in 100 ml screw capped clean and sterilized plastic bottles from different places of Himachal Pradesh. Each bottle was coded and subjected to laboratory techniques in an isothermal box to access the quality and adulterants present in milk. All the glassware was thoroughly washed with labolene, properly rinsed with distilled water and dried in hot air oven. Before use, these glasswares were again rinsed with organic solvents to make them free from residual contamination, if any. The collected samples were analysed for specific gravity, fat, solid not fat and total solids by set laboratory procedure. Further the samples data were analysed according to agro-climatic zones of Himachal Pradesh. The samples were collected from three zones Zone I (Subordinate and low hills), Zone II (Mid-hills), Zone III (High hills) except Zone IV which included very high hilly areas of Himachal Pradesh and it was difficult to cover that area during study period.

Estimation of Specific Gravity, Fat, Solids-not-fat and Total Solids

The specific gravity estimation was done using standard procedure using a lactometer and the fat percent estimation in collected samples was performed using the Gerber method (Indumathi and Obula Reddy, 2015). The determination of solids-not-fat content was calculated using modified Richmond's formula:

$$\% \text{ SNF} = \text{CLR}/4 + 0.22F + 0.72; \quad \text{where F is the Fat content in milk}$$

$$\text{Total Solids } \% = \text{Fat}\% + \text{SNF}\%$$

Detection of Adulterants in Milk

A standard Milk adulteration kit consisting of A and B manufactured by Himedia laboratories, was used for detection of adulterants, neutralizers, preservatives and thickening agents. Kit part A (K088A) was used for detection of alizarin, formalin, urea, starch, neutralizers, detergents, sodium chloride, skim milk powder, sucrose, glucose (dextrose) and hydrogen peroxide. Kit part B (K088 B) was used for detection of cellulose, maltose, ammonium sulphate, boric acid and pond water.

Water

Adulteration of milk with water was checked by lactometer reading. The raw milk was poured into a (100 ml) measuring cylinder and a lactometer was dropped in the milk to slowly sink down. Further, the lactometer reading was taken and recorded in lactometer degree (°L). If the reading was below the standard then it was considered to be adulterated with water **(**Bari *et al.*, 2015)

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Percent-Added Water

Addition of water decrease the milk solids-not-fat contents specially proteins so, calculation of added water percentage relies on determination of milk solids-not-fat (Moore et al., 2012 and Santos *et al.,* 2013). Percent-added water calculated by using the following formula by Indumathi and Obula Reddy (2015).

$$\text{Percent Added water} = \frac{\text{Standard SNF} - \text{Sample SNF}}{\text{Standard SNF}} \times 100$$

Further, the percentage of added water was summarised into three categories.

Range of Percentage of Added Water in Milk	
Category	**Range**
Low	5-25
Medium	25-50
High	>50

Statistical Analysis

The data was analysed using computerized statistical package i.e. INSTAT.

Results and Discussion

Specific Gravity, Fat, Solids-not-fat, Total Solid

Specific Gravity

The specific gravity of milk samples ranged from 1.010-1.032 with an average value 1.022±0.07 which was less than the minimum prescribed standards of FSSAI i.e. 1.028 for cow milk in Himachal Pradesh (Table1). Out of 200 samples 148 (74 percent) samples were found below the standards indicating dilution with water and skimming practices. The mean specific gravity of Zone I and Zone II was equal 1.021±0.00, and in case of Zone III it was 1.024±0.00. There was significant difference ($p<0.05$) of Zone III with Zone I and Zone II (Table 2). The reason for such difference in particular zone III may be due to lower demand and supply gap. Other thickening agents salt, skim milk powder, sucrose and glucose which were present in some of the samples tested might also affect the specific gravity by increasing the viscosity of milk. Earlier study conducted by Bari *et al.* (2015) in Tangail district of Bangladesh reported that the mean specific gravity of raw milk samples was ranged from 1.019 to 1.021.

Table 1: Determination of Physico-chemical parameters of Market milk samples(n=200)

Parameters	Range	Average ± SE	Below standards	FSSAI standards for raw cow milk (min)
Specific gravity	1.010-1.032	1.022±0.005	148 (74%)	1.028
Fat	1.0-9.2	3.5±0.10	139 (69.5%)	3.50
SNF	3.6-12.8	7.01±0.10	165 (82.5%)	8.50
TS	4.6-19.2	10.54±0.17	147 (73.5%)	12.00

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Fat

The fat percentage of milk samples ranged from 1.0-9.2 with wide variations. However, an average value 3.5±0.10 which were just matching the minimum prescribed FSSAI standards i.e. 3.5 for cow milk in Himachal Pradesh (Table 1). Out of 200 samples 139 (69.5 percent) samples were found below the standards. Similarly mean value of fat percentage in Zone I, II, and III were 3.3±0.19, 3.67±0.18, and 3.53±0.17 respectively. No significant ($p<0.05$) difference was observed between Zone I, Zone II and Zone III (Table 2). The lower fat content of market milk samples might be due to water adulteration which reduces the fat content of milk samples and also due to the skimming of the fat from milk samples showed its direct correlation with lowered specific gravity (74 percent) of tested milk samples in present study. In one of the study similar findings were reported by Rahman *et al.* (2017) for market raw milk.

Solids-not-Fat

The solids-not-fat percentage of milk samples ranged from 3.6-12.8 with an average value 7.01 ±0.10 which was also less than the minimum prescribed standards of FSSAI i.e. 8.5 for cow milk in Himachal Pradesh (Table 1). Out of 200 samples 165 (82.5 percent) were found below the standards. The mean value of percent SNF in case of Zone I was 6.7±0.18, in case of Zone II was 6.8±0.19, and in case of Zone III 7.52±0.16 (Table 2). There was significant difference ($p<0.01$) of Zone III with Zone I and of Zone III with Zone II ($p<0.05$). Addition of water decreases the milk solids-not-fat contents of milk showed its positive correlation with lowered specific gravity of milk samples (74 percent) in present study. Similar results were reported by Moore *et al.* (2012) and Santos *et al*. (2013). SNF content of the milk samples was also influenced by thickening agents, SKM, etc., which were found in analysed milk samples in the present study.

Total Solids

The total solids percentage of milk samples ranged from 4.6-19.2 with an average value 10.54±0.17 which was also less than the prescribed standards of FSSAI i.e. 12.00 for cow milk in Himachal Pradesh (Table 1). Out of which 73.5 percent samples were below the standards. The mean value of percent TS in case of Zone I was 10.0±0.30, in case of Zone II was 10.4±0.32, and in case of Zone III 11.06±0.27 (Table 2). No significant difference ($p<0.05$) was observed between Zone I, Zone II, and Zone III. Adulteration of milk with water and also skimming of milk might resulted in lowering of total solids. Similar interpretation was reported by Fahmid *et al.* (2016). The results of present study were comparable with the results of Indumathi and Obula Reddy (2015) who reported that milk samples collected from milk producers, milk collector, milk vendors were 11.61, 10.84, 10.39 and 10.44 respectively.

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Table 2: Zone-wise determination of Physico-chemical parameters of market milk samples (n=200)

	Zone I (n=62)		Zone II(n=70)		ZONE III(n=68)	
Parameters	**Average±SE**	**Below standard**	**Average±SE**	**Below standard**	**Average±SE**	**Below standard**
Specific Gravity	1.021±0.00[a]	50 (80.6%)	1.021±0.00[a]	54(77.1%)	1.024±0.00[b]	44(64.7%)
Fat	3.3±0.19	47(75.8%)	3.67±0.18	50(71.4%)	3.53±0.17	42(61.7%)
SNF	6.7±0.18[a]	56 (90.3%)	6.8±0.19[a]	59(84.2%)	7.52±0.16[b]	50(73.5%)
TS	10.0±0.30	51 (82.2%)	10.4±0.32	53(75.7%)	11.06±0.27	48(70.5%)

Values with different superscripts within the row differ significantly (p<0.05)

Detection of Different Adulterants in Market Milk Samples

Water

The present study revealed the most common adulterant in milk samples was water. Out of 200 milk sample studied, 148 (74 percent) milk samples were adulterated with water as also indicted by lowered specific gravity, fat percentage, SNF and TS content of analysed milk samples. Further in case of Zone I (n=62) 80.6 percent samples, in case of Zone II (n=70) 77.1 percent samples, and in case of Zone III (n=68) 64.7 percent samples were adulterated with water. This might be due to the easy availability of water and convenience of its mixing to increase the volume. This finding was comparable with the findings of Kandpal *et al.* (2012) and Beniwal and Khetarpaul (1999) who found 80, 70 percent of samples positive for water. Percentage of added water in milk was calculated in all the samples, which were positive for water adulteration (Table 3). Out of 148 samples which were positive for water adulteration 75 (50.6 percent) samples were lying in low range, 66 (44.6 percent) in medium and 7 (4.7 percent) in high range. Earlier study conducted by Shaker *et al.* (2015) reported that 84 percent of milk samples collected from dairy shops had added water content of different percentages ranged between 1.1 to 56.8 percent whereas, 80 percent of street vendors milk samples had added water content ranged between 2.7 to 61.4 percent. In one of the recent study conducted by Amin (2016) reported that 42 percent raw cow's milk samples collected from dairy shops had added water content ranged between 2.5 to 21.73 percent whereas, 68 percent of the street vendors milk samples had added water ranged between 5.96 to 23.84 percent.

Table 3: Percentage of added water in milk (N=148)

Range	No. of samples	Percentage
Low (5-25)	75	50.6%
Medium (25-50)	66	44.6%
High (>50)	7	4.7%

Alizarin

Out of 200 milk samples 27 (13.5 percent) samples were positive for alizarin test (Table 4) out of which 4 samples were acidic and 23 were alkaline in nature. Acidic nature of samples might be due to production of lactic acid due to storage of milk for long time. The alkalinity nature of milk might also be considered

due to subclinical mastitis (Swetha *et al.*, 2014). In case of Zone I number of samples 1/8(1.6/12.9 percent), in case of Zone II 2/7(2.8/10 percent), and in case of Zone III 1/8(1.4/11.7 percent) (Table 5) were positive for acidity/alkalinity respectively. Earlier study conducted Swetha *et al.* (2014) reported that 28.26 and 9.78 percent of samples were alkaline and acidic in nature respectively.

Formalin

The adulteration of milk samples with formalin was found to be 1 percent (Table 4, Fig.1). Formalin were generally used to enhance shelf life of milk. None of the samples were positive for formalin in Zone I and Zone II whereas in case of Zone III, 2(2.8 percent) were positive for formalin (Table 5, Fig.1). Earlier study conducted by Swetha *et al.* (2014) in and around Tirupati reported that 2.2 percent of samples were positive for formalin.

Negative Positive

Fig. 1: Formalin Test

Neutralizers

According to present study the neutralizers adulterated milk samples were 1 percent (Table 4, Fig.2). Neutralizer**s** were generally used to mask the effect of acidity in milk preserved for long duration so as passing it off as fresh milk (Kumar *et al.*, 2015). None of the samples were positive for neutralizers in Zone I and Zone II whereas in case of Zone III 2(2.8 percent) (Table 5) were positive for neutralizers. Earlier study conducted by Swetha *et al.* (2014) and Ramya *et al.* (2015) reported that 8.7 percent and 6 percent milk samples were positive for neutralizers respectively.

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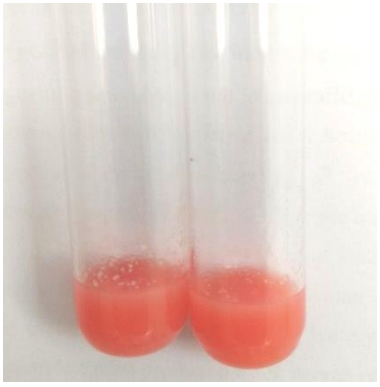

Negative

Positive

Fig. 2: Neutralizers Test

Table 4: Determination of extent of different adulterants in market milk (n=200)

Adulterants	Total number of Positive samples	Total number of Negative samples	Overall percentage of positive samples	Overall percentage of negative samples
Water	148	52	74	26
Alizarin (Acidity/ Alkalinity)	4/23	173	2/11.5	86.50
Formalin	2	198	1	99
Neutralizers	2	198	1	99
Detergent	6	194	3	97
Sodium chloride	36	164	18	82
Skim milk powder	19	181	9.5	90.5
Sucrose	3	197	1.5	98.5
Glucose	2	198	1	99

**Other adulterants tested were urea, starch, hydrogen peroxide, maltose, cellulose, ammonium sulphate, protein, boric acid, pond water/nitrate which were not detected in any of the samples.*

Table 5: Zone-wise determination of extent of different adulterants in market milk

Adulterants	Zone I (n=62) No of Positive samples	Zone II (n=70) No of Positive samples	Zone III (n=68) No of Positive samples
Water	50 (80.6%)	54 (77.1%)	44(64.7%)
Alizarin (Acidity/ Alkalinity)	1/8(1.6/12.9%)	2/7(2.8/10%)	1/8(1.4/11.7%)
Formalin	-	2(2.8%)	-
Neutralizers	-	2(2.8%)	-
Detergent	3(4.8%)	3(4.2%)	-
Sodium chloride	14(22.5%)	15(21.4%)	7(10.2%)
Skim milk powder	3(4.8%)	7(10%)	9(13.2%)
Sucrose	1(1.6%)	1(1.4%)	1(1.4%)
Glucose	1(1.6%)	1(1.4%)	-

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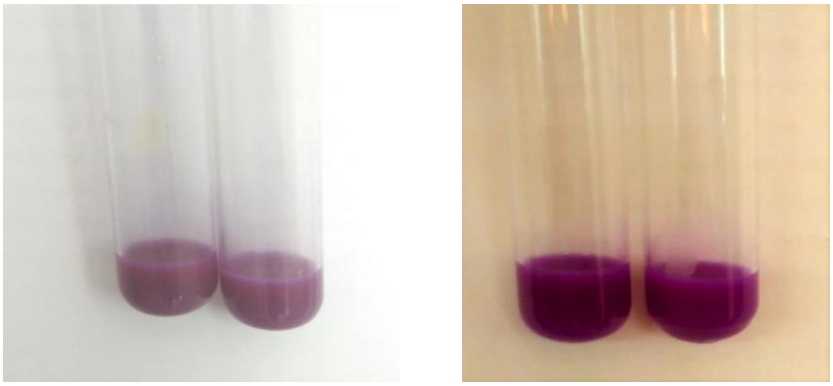
Detergent

Out of 200 milk samples 6 (3 percent) samples were positive for detergent (Table 4, Fig. 3). The presence of detergents in milk samples might be due to low maintenance of containers (Kumar *et al.*, 2015). Total 3 (4.8 percent) samples in Zone I,3 (4.2 percent) in Zone II and none in Zone III were found to be positive for detergent (Table 5). Detergents like adulterants seems to be used to enhance the emulsification and dissolve the oil in water giving a frothy solution.



Negative Positive

Fig. 3: Detergent test

Sodium Chloride

The adulteration of milk with sodium chloride was found to be 18 percent (Table 4, Fig.4). Total 14 (22.5 percent), 15(21.4 percent), and 7 (10.2 percent) (Table 5) samples were positive for sodium chloride in Zone I, II and III respectively. Sodium chloride was added in milk to mask the effect of higher water content to increase the lactometer reading and milk solid not fat (SNF) content of the milk (FSSAI, 2014). Use of sodium chloride as a thickening agent was common. The mineral content of milk was also affected by physiology and health condition of animal. Chloride content was found high in colostrum, lowest at peak milk yield, and then gradually increases with progress of lactation (Iyengar, 1982). The increase in sodium chloride content of milk might be due to sub-clinical mastitis. (Kitchen, 1981).

Glucose

According to present study, the glucose adulterated milk samples were 1 percent (Table 4, Fig.5). Total 1(1.6 percent), 1 (1.4 percent) and none samples were positive for glucose in Zone I, II and III respectively. Glucose was added as a thickening agent to increase the viscosity of milk. The result of present study was comparable with the findings of Swetha *et al.* (2015) who reported that 1.09 percent samples were adulterated with glucose.

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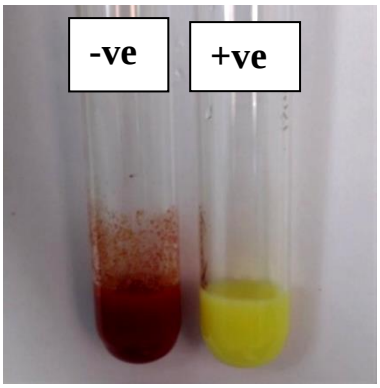

Fig. 4: Sodium chloride test

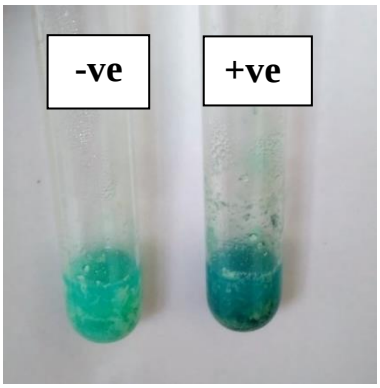

Fig. 5: Glucose test

Skim Milk Powder

Out of 200 milk samples, 19 (9.5 percent) samples were positive for skim milk powder (Table 4, Fig.6). Total 3(4.8 percent), 7(10 percent), and 9(13.2 percent) (Table 5) samples were positive for skim milk powder in Zone I, II and III respectively. Skim milk powder was added as a thickening agent to maintain the viscosity of milk. The result of present study is comparable with the findings of Singh *et al.* (2015) who reported that 10 percent samples were adulterated with skim milk powder.

Negative Positive

Fig. 6: Skim milk powder test

Sucrose

In current study sucrose adulterated milk samples were found to be 1.5 percent (Table 4, Fig.7). Total 1(1.6 percent), 1(1.4 percent), and 1(1.4 percent) milk samples were positive for sucrose in Zone I, II and III respectively (Table 5). Sucrose might be also added as thickening agent to maintain the viscosity of milk and to mask the effect of added water. Sucrose was used to restore the normal analytical values of adulterated milk in physicochemical tests (Santos *et al.*,2013b, Zhang *et al.*,2014).

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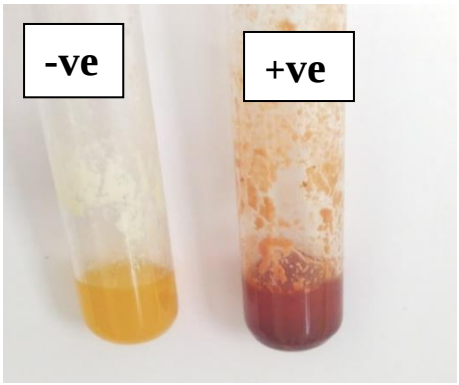

Fig. 7: Sucrose test

Conclusion

The observations clearly indicate that a large number of samples procured did not confirm to the legal standards prescribed by the Food Safety and Standards Authority of India (FSSAI). The quality of milk was not good as there is addition of water, skimming of fat, and other adulterants which were common practices used by milk vendors. The general public must aware of these malpractices in milk marketing and its effect on their health and more awareness should bring about the rules and regulation against milk adulteration.

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