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Full length Research paper

Risk of Adulteration in Market Milk Supplied to Public Sector

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Most of the milk from production to ultimate consumption is marketed under traditional pattern, whereby unethical activities of adulteration in market milk occurs. In this regards, 900 market milk samples from different milk marketing channels at three different zones of Sindh province were screened for adulterants. Results indicated 745 (82.78%) samples were found positive for different adulterants. Twenty adulterants were detected from raw market milk where samples with extraneous water were comparatively (P<0.05) high and with salicylic acid the low, while with detergent at second top followed by with rice flour, cane sugar, starch, sodium chloride, caustic soda, formalin, skimmed milk powder, urea, hydrogen peroxide, vegetable oil, glucose, ammonium sulfate, boric acid, arrowroot, dalda ghee, sorbitol and hypochlorite. In conclusion, among all milk marketing channels, water adulteration was noticed remarkably high at retail level followed by milk collector, middleman, processor and producer level among all three zones of Sindh, Pakistan.

Keywords: Adulterants, Consumption, Milk, Water adulteration

INTRODUCTION

Among top five dairy hubs of the globe; after India, USA and China, Pakistan is at 4th position followed by Brazil. The present milk production of the country is 56.080 million tons, though the foremost milk contributors are buffalo and cattle. Country naturally blessed with high yielding buffalo breeds *i.e.* Nilli Ravi, Kundhi and Aza Kheli, their current population is 37.7 million heads, which make up to 47% of total dairy animal's population and sharing more than 61% in total milk production (Farooque, 2017). Milk is preferred as food commodity in Sindh province of Pakistan and it is consumed as fresh, boiled, powdered and in processed form like tetra pack, yogurt, ghee, lassi, butter, cheese, ice cream, sweets and in other confectioneries (Magsi, 2017). Although, milk is rich in food value and supplies nutrients like good quality proteins, fat, carbohydrates, vitamins and minerals in significant amount than any other single food (Neumann et al., 2002). Unfortunately, in Pakistan its production and distribution systems are still very traditional and underdeveloped. Out of total milk production in the country, only 3-5% of milk is marketed through formal channels and the remaining 95-97% is marketed in raw form by informal agents in the marketing chain. These informal agents are directly involved in the unethical activities of milk adulteration (Zia, 2006). In this regard, some inferior substances are intentionally admixed or substituted in milk to extend the shelf life, resulting health hazards as it may contain various toxic chemicals. For example, carbonate in milk may produce gastrointestinal problems including gastric ulcer, diarrhea, colon ulcer and electrolytes disturbance (Beall and Scofield, 1995; Rideout, 2008). While, the hydrogen peroxide disturbs the antioxidants in the body and disturbing the natural

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immunity hence increasing aging (Clare et al. 2003). High level of chloride in the milk disturbs the acid base balance and blood pH in the body and the addition of ammonia in the milk may cause regression, loss of acquired immunity, kidney problems and sensory disturbances (Ayub et al., 2007). Formalin causes vomiting, diarrhea and abdominal pain. It also affects the optic nerves and cause blindness and is one of the potent carcinogens (Gwin et al., 2009).

Boric acid causes nausea, vomiting, diarrhea, kidney damage, acute failure of circulatory system and even death (See et al., 2010). Benzoic acid produces adverse effects such as asthma, urticaria, metabolic acidosis and convulsions in sensitive persons (Mota et al., 2003; Saad et al., 2005).

Moreover, melamine an industrial chemical is also used in the milk adulteration and its contamination in milk causes the urinary tract problems in infants and children (Li et al., 2009).

Another unethical activity of milk dealers is dilution of milk with extraneous water to increase the volume of milk and/or extraction of valuable component like milkfat in term of cream from whole milk to maximize their profit margin (FDA, 1995). As a consequence, the physico-chemical, microbiological, nutritional and sensory qualities of milk may be degraded, which may have ill effects on palatability, proper growth and development of human body. In this context, thickening agents like starch, rice flour, arrowroot etc., and/or constitutional agents like glucose, cane sugar, sodium salts, urea etc. and other adulterants are also added to mask the physico-chemical, nutritional and sensory qualities of adulterated milk.

For instance, the detergents are found to be used as emulsifiers and to enhance the cosmetic nature of water diluted milk. Calcium thioglycolate or Potassium thioglycolate and urea are added for whitening of milk, and to maintain the protein level.

Only few grams of urea are sufficient to bring milk in its original state. Urea is also known to be added in milk to enhance its heat stability (Manish et al., 2000a; Walker et al., 2004); vegetable oil and/or Mobil oil is admixed in milk to increase the fat level.

Sodium salt is added to water diluted milk to enhance the ash level and specific gravity. On the other hand, quality of milk may be deteriorated through microbial contamination that is generally a consequence of addition of contaminated water. (FAO, 2008; Rizvi, 2002).

Unfortunately, due to unorganized and non-regulated marketing systems, the milk supplied to consumers is very crucial and hardly be a wholesome in the country (Javaid et al., 2009).

Thus, in the present investigation, the study area was scattered on three zones of Sindh province of Pakistan, which are structured on milk marketing and consumption basis whereby milk samples from different intermediaries involved in milk marketing in each zone were screened for adulteration.

MATERIALS AND METHODS

Sample collection

A total of 900 market milk samples, three hundred (n=300) from each zone (southern, central and northern) and one hundred eighty (n=180) samples from each milk intermediary (producer, milk collector, middleman, processor and retailer) at Sindh province were collected. All the collected milk samples from different milk marketing intermediaries were screened for various adulterants like extraneous water, thickening agents, chemical preservatives, constitutional adulterants and neutralizing agents at the Dairy analytical laboratory of Department of Animal Products Technology, Faculty of Animal Husbandry and Veterinary Science, Sindh Agriculture University Tandojam, Pakistan.

Detection of extraneous water

Presence of extraneous water in market milk was observed according to the method of Association of Official Analytical Chemists (AOAC, 2000). The depression of freezing points of market milk and authentic milk samples (as freezing point base) was recorded using Cryoscope. The observed values of freezing point of market milk greater than that of authentic sample was assumed as presence of extraneous water in market milk.

Qualitative detection of adulterants

Thickening agents (starch, arrowroot and rice flour), chemical preservatives (formalin, hydrogen peroxide, boric acid and salicylic acid), constitutional adulterants (urea, cane sugar, sodium chloride/salt, skimmed milk powder, dalda ghee, vegetable oil and sorbitol), neutralizing agents (ammonium sulfate and caustic soda), detergent and hypochlorite in market milk were detected by using milk adulteration testing (MAT) kit method as reported by Tipu et al. (2007) and Khaskheli (2010).

Experimental procedure

Market milk sample (1ml) was taken into MAT kit tube and 1ml standard reagent was added to it for the analysis of each adulterant. Development of colour in milk was matched with MAT kit colour chart for each adulterant presumed to be positive (+ve) or negative (-ve).

Detection of skimmed milk powder (SMP)

Market milk sample (5ml) was taken into test tube and concentrate nitric acid (10 drops) was added to it. Development of orange colour in milk was presumed to be positive (+ve) SMP and the yellow colour for negative (-ve).

Detection of vegetable oil

Market milk sample (1ml) was taken into test tube and absolute alcohol (9 ml) was added to it. Then it was left to stand for 5 min. floating of fat globules on the top was considered as natural fat of milk, and that which sunk in the bottom was assumed as addition of vegetable oil in the milk sample.

Detection of dalda ghee

Market milk sample (3ml) was taken into test tube and 10 drops of hydrochloric acid and one tea spoon of sugar was added to it. It was left for 5 minutes and colour was noted. Development of red colour in milk was presumed as positive (+ve) to dalda ghee.

Extent of extraneous water in market milk

Extent of extraneous water in market milk was observed from the depression of freezing point (through Cryoscope) and calculated by subtracting the observed freezing point of market milk from that of freezing point of base (control) and thereafter by dividing it with freezing point of base (AOAC, 2000) using following formula.

$$\text{Extent of extraneous water} = \frac{\text{Freezing point base} - \text{observed freezing point}}{\text{Freezing point base}} \times 100$$

Statistical analysis

The data so obtained was gathered and tabulated as per various treatment combinations to observe the significance of different adulterants in market milk within three different zones of Sindh province.

In this context the computerized statistical package *i.e.* Student Edition of Statistix (SXW), Version 8.1 (Copyright, 2005, Analytical Software, USA) was approached.

The data was analyzed through statistical procedure of analysis of variance (Factorial ANOVA) to observe the significant differences among the variables and in case of the significant differences appeared among the means; the least significant difference (LSD) test at 5% level of probability was applied.

RESULTS AND DISCUSSION

Milk adulteration observed at Sindh province

Over 900 market milk samples, 745 (82.78%) samples found positive for adulteration, while 155 (17.22%) were observed as negative.

Further, the manifestation of positive milk samples over 900 samples, the adulteration of milk appeared more at central zone (279 numbers; 31.00%) followed by southern zone (239 numbers; 26.56%) and northern zones (227 numbers; 25.22%) of Sindh province (Figure-1). Similar status of milk adulteration was reported by Nirwal et al*.,* (2013) at Dehradun region of India (80% positive milk samples), while Aziz (2014) and Awais (2013) found 100% positive milk samples at Badin and Hyderabad districts of Sindh province.

Percent of milk samples deteriorated with various adulterants at three zones of Sindh province

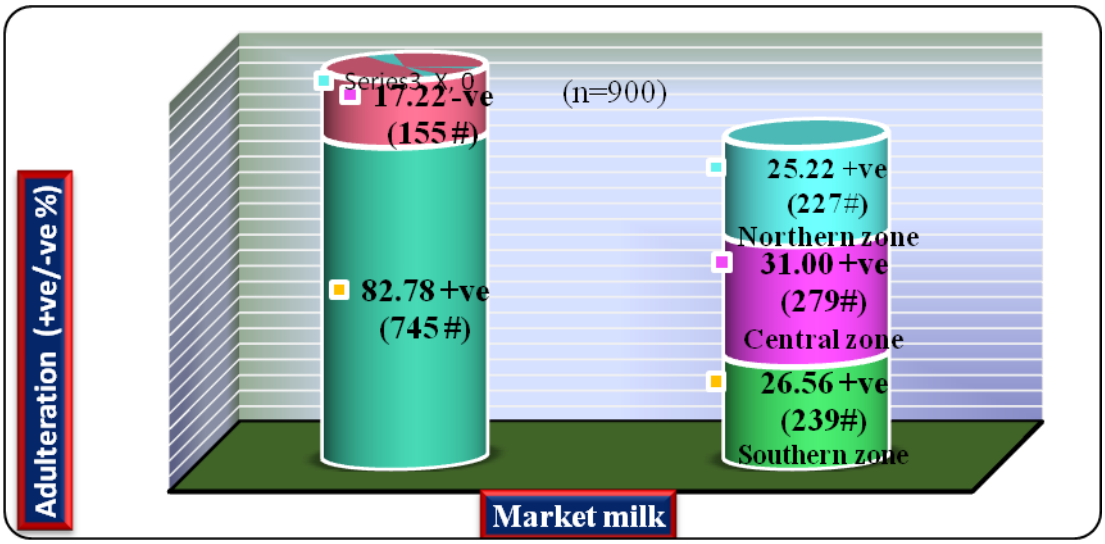
Among southern, central and northern zones extraneous water was most common adulterant followed by detergent, rice flour, cane sugar, caustic soda, sodium chloride, starch, skimmed milk powder, formalin, hydrogen per oxide, urea, vegetable oil, ammonium sulfate, glucose, dalda, arrowroot, boric acid, sorbitol, salicylic acid and hypochlorite were detected from market milk at central zone except dalda and salicylic acid at northern zone (Table 1).

It is of interest to note that majority of these adulterants were dominant in adulteration of milk at central zone, whereby adulteration of milk with extraneous water (78.99%) was comparatively ($P<0.05$) high at central zone contrast to that of southern (71.00%) and northern (60.66%) zones of Sindh province, Pakistan.

Water adulteration in milk might be varied place to place and it has been reported by different researchers **(**Awais, 2013; Aziz, 2014; Chanda et al., 2012; Nida et al., 2013), for instance 100% milk samples were found positive with water at Hyderabad, Latifabad, Qasimabad and Badin cities of Pakistan and at Barisal district of Bangladesh.

The findings of Eman et al. (2015) and Lateef et al. (2009) were varied with the results of present study; they found 84 and 93.33% water adulterated milk samples at Sohag Governorate state of Egypt and Faisalabad city of Pakistan. Significant percent of milk samples ($P<0.05$) adulterated with detergent (29.66%), cane sugar (22.30%) and boric acid (8.00%) was recorded at central zone compared to that of northern zone (18.00, 15.66 and 2.00%, respectively), but did not statistically varied ($P>0.05$) from that of southern zone (26.66, 22.00 and 3.66%, respectively).

Detergents are surfactants which help foreign fat or vegetable oil to blend in water, and also produce foaming



X = Adulteration (+ve/-ve %) in market milk samples observed at Sindh province
Y = Adulteration percent over positive milk samples observed at three zones of Sindh province
Figure 1: Milk adulteration observed at Sindh province

Table 1: Percent of milk samples adulterated with various adulterants at southern, central and northern zones of Sindh province, Pakistan

Adulterant	Milk samples (+ve %)		
	Southern	Central	Northern
Water	71.00^{b}	78.99^{a}	60.66^{c}
Detergent	26.66^{de}	29.66^{d}	18.00^{f-j}
Rice flour	23.66^{ef}	18.33^{f-j}	19.66^{f-u}
Cane sugar	22.00^{e-h}	22.30^{e-g}	15.66^{i-l}
Caustic soda	18.33^{f-j}	14.00^{i-o}	9.00^{n-u}
Sodium chloride	17.33^{g-k}	14.66^{i-n}	11.33^{l-r}
Starch	13.00^{j-p}	18.33^{f-j}	16.33^{h-l}
Skimmed milk powder	6.66^{q-s}	15.33^{i-m}	6.33^{q-y}
Formalin	5.66^{r-z}	14.33^{i-n}	11.66^{k-q}
Hydrogen peroxide	5.33^{s-z}	12.66^{j-p}	7.33^{p-w}
Urea	5.00^{t-z}	11.00^{l-s}	9.66^{m-t}
Vegetable oil	4.00^{u-z}	11.66^{k-q}	4.66^{t-z}
Ammonium sulfate	4.33^{u-z}	8.33^{p-v}	4.33^{u-z}
Glucose	5.33^{s-z}	6.33^{q-y}	6.33^{q-y}
Dalda	5.66^{r-z}	-	6.33^{q-y}
Arrowroot	4.00^{u-z}	3.33^{u-z}	4.66^{t-z}
Boric acid	3.66^{u-z}	8.00^{p-v}	2.00^{w-z}
Sorbitol	3.00^{v-z}	2.66^{v-z}	1.33^{x-z}
Salicylic acid	2.00^{w-z}	1.33^{x-z}	-
Hypochlorite	1.33^{x-z}	1.66^{w-z}	0.66^{yz}

Means with different letters in same row and column varied significantly from one another.
LSD (0.05) = 5.8112
SE± = 2.9590

properties in milk to mask the water adulteration. This trend has been supported by Manish et al. (2000b) and Kandepal et al. (2012) they reported excessive use of detergents (20mg) for the preparation of synthetic milk and to emulsify and dissolve the oil in water giving the frothy solution, the characteristic white colour of milk in India. Lateef et al. (2009) and Faraz et al. (2013) reported 93.33 and 97% samples positive to cane sugar at Punjab province of Pakistan. Eman et al. (2015) found 40% milk sample positive for boric acid at Sohag

Governorate state of Egypt. Similarly, the formalin (14.33% of samples), hydrogen peroxide (12.66% of samples) and urea (11.00% of samples) were detected from considerable number of milk samples at central zone of Sindh province contrast to those of at southern zone (5.66, 5.33 and 5.00%, respectively), but statically not differ (P>0.05) from those of at northern zone (11.66, 7.33 and 9.66%). For instance, Latif et al. (2009) reported the 46.66% formalin positive milk samples at Faisalabad and in an Indian study, 2% milk samples were found to be adulterated with formaldehyde was reported by Sanjeevani et al. (2011). While, 34% and 10% milk samples were detected positive for formalin in Hyderabad, Pakistan and Andhra Pradesh India by Awais (2013) and Ramaya et al. (2015), respectively; 8% in Multan, Pakistan by Awan et al. (2014), and 15% in Sohag Governorate state of Egypt by Eman et al. (2015). Ramaya et al. (2015) reported that 26% milk samples were found positive for hydrogen peroxide adulteration in India. Researchers reported from different parts of world; Kenya and Sohag Governorate China (5.05 and 3.4%), respectively (Wangala and Wafula, 2007; Eman et al., 2015). However, in India the trend of results for the presence of hydrogen peroxide in milk is contrary with the observations of current study. Regardless, the starch (18.33% of samples), glucose (6.33% of samples) and hypochlorite (1.66% of sample) found abundant in milk samples at central zone compared to that of southern zone (13.00, 5.33 and 1.33%, respectively) and northern zone (16.33, 6.33 and 0.66% of milk samples), the differences among them were non-significant (P>0.05). Nevertheless, the inadequate usage of starch and cereal flours for the adulteration in milk varies widely from country to country and/or region to region being highest at where quality assurance is ineffective (Shitandi, 2004). Although, Adam (2009) reported 35.3% market milk samples positive for starch at Khartoum state of Sudan. Ramaya et al. (2015) at Andhra Pradesh India whereby 24 and 10% milk samples adulterated with urea and glucose, and in another study reported by Latif et al. (2009) and Nirwal et al. (2013) 86.66% of milk samples were detected positive to urea at the Faisalabad, Pakistan and 80% out of 100 milk samples were found positive for glucose in milk from different regions of Dehradum, India. Urea in milk samples collected from central zone was noted as 11.33 followed by northern zone (9.66%) and southern zones (5.00%). Friedle et al. (2012), who detected 0.20 mg/kg hypochlorite/quaternary ammonium compounds in raw milk and it, may pose fetal effects on human health. Moreover, the adulteration of milk with caustic soda (18.33%) and sodium chloride (17.33%) was considerably (P<0.05) high at southern zone compared to that of at northern zone (9.00 and 11.33%, respectively), while contrast to that of at central zone (14.00 and 14.66%, respectively), it was not significant (P>0.05). In another study Melame et al. (2014) reported that in India the addition of caustic soda/sodium hydroxide is frequently used as neutralizer by the milk dealers to prevent the spoilage of milk by neutralizing the pH and natural acidity of milk. It is afraid to say that such trend of addition of caustic soda in milk, which already contains sodium work as slow poison for the patients of hypertension and heart ailments and it also alters the utilization of lysine by body, an essential amino acid in milk, which is mandatory for the better growth in infants (Oliver et al., 2005). The results of Abbas et al. (2013) are in accordance with the results of present study, who reported approximately similar (16.67%) percentage of salt adulterated milk samples collected from different areas of Peshawar city. In matching salt/sodium chloride was detected by Wadekar et al. (2011b) in India, they reported that 8% samples in summer, 4% in rainy and 3% in winter season found positive for salt/sodium chloride among total 120 samples analyzed in 3 different seasons. The presence of salt in milk was also confirmed by Pitty (2011) in samples collected from Assam area Awan et al. (2014). Further, results (Table-4.1) reFveal that deterioration of milk with rice flour (23.66%), sorbitol (3.00%), and salicylic acid (2.00%) at southern zone and with dalda ghee (6.33%) and arrowroot (4.66%) at northern zone was high but not statistically different (P>0.05) from that of their corresponding zones.

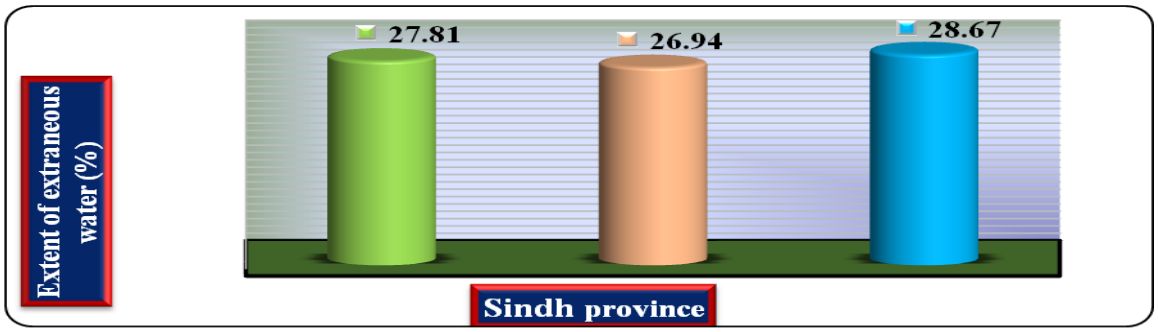
Further, in the present study 11.66, 4.66 and 4.00%, and 6.66, 5.66 and 0.00% percent of milk samples were adulterated with the vegetable oil and dalda at different zones (central, northern and southern) of Sindh province. However, the presence of vegetable oil and dalda in milk observed during present study was supported by Zia (2007) who reported in Pakistan to maintain the fat ratio in milk most of the milk dealers admixed vegetable oil and/or dalda to it, in supporting Gale and Hu (2007) Sorbitol is a non-nutritive artificial sweetener which resembles with sugar and it is used throughout the world by milk venders to mask the poor quality of milk and milk products as an adulterant (Codex, 1995).

This high number of milk samples (15.33, 6.66 and 6.33%) found positive for skimmed milk powder collected from different zones (central, southern and northern) of Sindh province.

Result of present study is not in line with the study conducted by Awais (2013), who found 8% milk samples positive for skimmed milk powder at Hyderabad, Sindh, whilst samples 6% positive milk samples were recorded by Pitty (2011) from Mizoram and Nagaland. The high incidence of skimmed milk powder in milk samples collected from different zones of Sindh province investigated under current study is not in agreement with Gahlawat et al. (2013), they reported that the milk samples collected from all the directions of Delhi; north, south, east and west, Delhi, India were found negative of skimmed milk powder adulteration.

Extent of extraneous water in market milk at different zones of Sindh

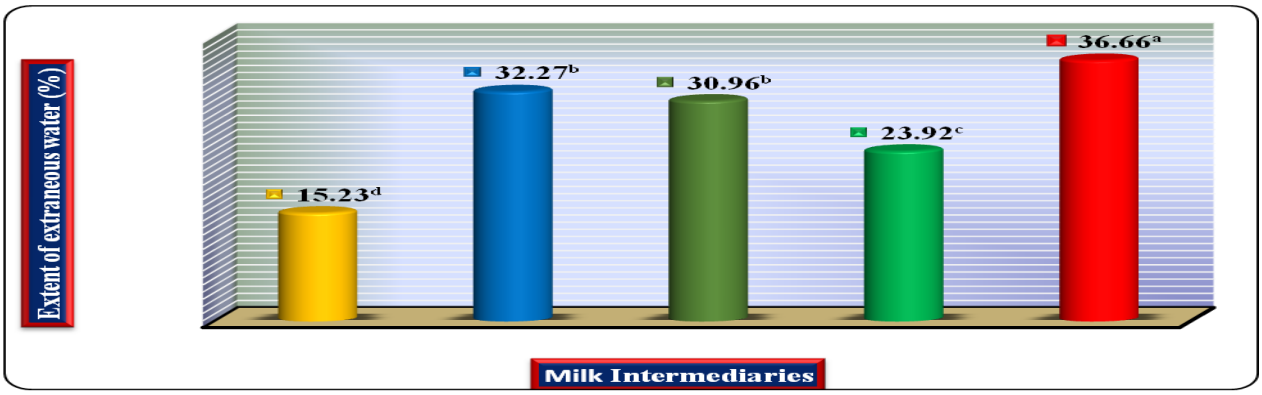
Numerically the extent of extraneous water (28.68%) in market milk appeared high at northern zone of Sindh province and low at central zone (26.94%), and southern zone found at intermediate stage (27.81%), but Statistical analysis revealed non-significant variation in extent of extraneous water among all three (southern, central and northern) zones of Sindh, Pakistan (Figure 2).



LSD (0.05): All-pairwise comparison

Zone	V/S	Zone	LSD (0.05)	Significance
Southern zone	×	Central zone	0.878	NS
Southern zone	×	Northern zone	0.858	NS
Central zone	×	Northern zone	1.737	NS

Figure 2: Extent of extraneous water (%) in market milk at different zones of Sindh



LSD (0.05): All-pairwise comparison

Channel	V/S	Channel	LSD (0.05)	Significance
Milk producer	×	Milk collector	17.0383	*
Milk producer	×	Middleman	15.729	*
Milk producer	×	Processor	8.687	*
Milk producer	×	Retailer	21.432	*
Milk collector	×	Middleman	1.309	NS
Milk collector	×	Processor	8.351	*
Milk collector	×	Retailer	4.394	*
Middleman	×	Processor	7.042	*
Middleman	×	Retailer	5.703	*
Processor	×	Retailer	12.745	*

Figure 3: Extent of extraneous water (%) in market milk handled by various milk intermediaries

Water adulteration in milk might be varied place to place and it has been reported by different researchers **(**Nida et al., 2013; Awais, 2013; Aziz, 2014; Chanda et al., 2012), for instance 100% milk samples were found positive with water at Hyderabad, Latifabad, Qasimabad and Badin cities of Pakistan and at Barisal district of Bangladesh. The findings of Lateef et al. (2009) and Eman et al. (2015) were varied with the results of present study; they found 93.33 and 84% water adulterated milk samples at Faisalabad city of Punjab, Pakistan and Sohag Governorate state of Egypt.

Extent of extraneous water in market milk handled by different milk marketing intermediaries at Sindh

Figure 3 indicates that the extent of extraneous water in market milk handled by retailer (36.66%) was comparatively ($P<0.05$) high followed by milk handled by milk collector (32.27%), middleman (30.96%), processor and/or producer (23.92 and 15.23%, respectively). In accordance Nida et al. (2013); Bhatti et al. (2010) reported that the extent of extraneous water was found to be higher in market milk samples as compared to dairy farms and at producer level, in continuation Wadekar and Menkudale (2011) reported that the vendors and dairy shop keeper are highly adulterated the milk with water to increase their profit. In favour of present findings, Barham et al. (2015); Zia (2007); Tariq (2008) noticed that milk dealers also add dirty ice to increase the shelf life of milk which is also one of the reasons of elevated level of extraneous water in market milk.

CONCLUSIONS

It could be concluded from the study that adulteration, a dirty practice is dominant at the central zone of Sindh province.

However, overall average percent of adulterants clearly support the former statement, whereby average percent of adulterated milk samples over 745 positive samples, at central zone appeared comparatively ($P<0.05$) high followed by southern zone and northern zone. Raw milk marketing chain at Sindh province noted to be void with HACCP system under which hazard and CCPs are identified. Implementation of HACCP based on its principles is suggested to eliminate the risk of adulterants in milk.

The regulatory authorities should strictly enforce monitoring of milk on regular basis at each channel to ensure the wholesome/hygienic supply of milk to the consumers.

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