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Common milk adulterants in developing country Nepal: A short review

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ABSTRACT

Milk is almost a complete food containing essential nutrients required for growth and maintenance of the body. Milk is a high-risk commodity that can be adulterated in numerous ways and turn affects milk quality. The quality and safe milk production are one of the biggest problems faced by developing countries like Nepal, where milk adulteration is a serious concern and is at higher risk due to lack of government system to implement the policies. The reason behind milk adulteration is more for economic concerns, but the root cause of adulteration is the increased milk demand during the lean season in developing countries and the existing supply chain. Water being cheaper, is the most common adulterant added in the milk that decreases the nutritional content of milk. Milk producer also adds preservatives to increase the shelf life of milk, caustic soda to reduce the milk acidity and materials like urea, starch, sugar and milk powder to increase the SNF content. Such milk adulterants can possess serious public health hazards leading to fatal diseases. This review shows the common milk adulteration practices in Nepal and their impacts on food safety and human health and emphasize potential strategies for control of such adulteration practices.

Introduction

Dairy farming is one of the major components of the farming system in Nepal and contributes 31% of AGDP (CBS, 2001). Agriculture contributes 27.1 percent of GDP of Nepal (CBS, 2013), of which livestock sector contributes 11.5 percent of total GDP (MoALD, 2019) and 25.7 percent of AGDP (MoAD, 2014). The dairy subsector is the crucial component of the livestock sector and contributes almost two third (63%) ofthe livestock GDP. Annual milk production of Nepal is about 2.168 million metric tones of which about 65 percentage contribution is made by buffaloes and rest is by cattle (NDDB, 2020)Dairy farming is major source of cash income, source of family nutrients, source of manure for agricultural land. In Nepal, there are two milk channels, formal and informal. The formal markets, for collection of raw milk produced by farmers, are public sector dairy *viz.* the Dairy Development Cooperation (DDC), private dairies and the farmers' cooperatives, either the milk producers' cooperatives or milk producer cooperatives' unions. There exist an informal channel where the producer farmers sell milk to the urban consumer and tea shops which are significant. The milk gets contaminated at various stages, including the cow itself, the milking man, extraneous dirt or unhygienic water (Lues *et al.,* 2003). Raw milk quality is one of the inevitable components in assessing the performance of dairy supply chains. Milk is defined as the mammalian secretion, free from colostrum, obtained by the complete milking of a healthy animal, 5days after and 15 days before parturition, which contains minimum prescribed SNF and milk fat (Khalid, 2006).

Milk is considered to be a complete food as it contains almost all the nutrients required by both children and adult human. It is a valuable source of carbohydrate, protein, fat, vitamin and minerals (Salih and Yang, 2017). Despite the nourishing and wholesome effect of milk, milk produced and handled under unhygienic condition can be a source of several diseases. In some cases, milk may render serious human health hazards. Therefore, it is very essential to control production, processing and

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marketing of milk at all stages (Yadav *et al.,* 1993). Lack of clean milk production and good manufacturing practices (GMP) during milk production has been a major issue. Besides this, chances of transmission of zoonotic diseases and milk adulteration practices are the other important issues to be taken under consideration. The major causes of adulteration are increased consumer demand, aqueous and opaque properties of the milk, unscrupulous producers/traders, perishable nature of milk, and lack of effective legal standards and enforcement, and lack of reliable and rapid milk adulteration detection kit (Kamthania *et al.,* 2014). All these lead to the unhygienic and inferior milk causing serious health hazards. Milk adulteration is a major issue in developing countries that necessitates a need to investigate as potential food safety and public health concerns (Spink and Moyer, 2011). Although the adulteration is more for economic reason, the public health risk is at stake. The condition is much serious in developing countries due to the absence of better monitoring and government policies (Tanzina and Shoeb, 2016). Thus, the objective of the study is to review the common milk adulteration practices in Nepal and identify the knowledge gaps.

Adulteration in milk

Adulterated milk has limited nutritional value leading to serious health issues and underdevelopment in infants (Lateef *et al.,* 2009). Adulteration is one of the major issues faced by developing countries which cause serious health issues in consumers. Thus, the consumer needs to know the common adulterants and their impact on human health (Faraz *et al.,* 2013)

Typical adulterants in milk

Adulterations for financial gain include the addition of vegetable protein, milk from different species, whey and watering (Fischer *et al.,* 2011; Singh and Gandhi, 2015). Such types of practices do not pose any severe health risk. However, some adulterants have adverse effects. Major adulterants in milk having serious adverse health effect are urea, formalin, detergents, ammonium sulphate, and boric acid, caustic Soda, benzoic acid, salicylic acid, hydrogen peroxide, sugars and melamine.

List of common milk adulterants and their harmful effects

Water

It is the most common practice of adulterating milk (Barham *et al.,* 2014a). It increases the milk volume and reduces the nutritional value of milk. Milk is most commonly diluted with water, which not only reduces its nutritional value, but contaminated water can also cause additional health problems. Thus, quality control tests for milk are very important to assure adulterant free milk for consumption.

Urea

Urea is a natural constituent that contains the major portion of non-protein nitrogen in milk. The maximum allowable limit for urea in milk is 70 mg/100 mL according to FSSAI act 2006 and PFA rules 1955 (Sharma *et al.,* 2012). Milk can be adulterated with urea in two ways – by intentional addition of urea and by addition of unspecified synthetic milk to natural milk. Urea provides whiteness and also used to increase the SNF value. Major health hazard includes kidney failure and it is also harmful to vital organs (Trivedi, 2009). Besides, the urea is a very common milk adulterant used to increase the shelf life and is also used for the preparation of artificial milk.

Preservatives

To increase the shelf life of the milk, preservatives like formalin, Salicylic acid, Benzoic acid and Hydrogen peroxide are added in the milk (Singh and Gandhi, 2015). Milk adulterated with preservatives like formalin causes serious health hazards like liver and kidney damage due to its toxicity. On other hand, Benzoic and Salicylic acid are added to increase the shelf life for long-distance transportation. The harmful effects of these adulterants include increased asthma problem and hyper activities in children.

Sugar

It increases the milk quality and SNF% but is fatal for the diabetic patient (NDDB, 2016)

Neutralizers

Carbonates and Bi- Carbonates are used as a neutralizer in the milk that masks the pH and acidity values of badly preserved milk to pass it as fresh milk. Such adulterants can cause disruption in hormone affecting regular development and reproduction.

Adulteration test of raw milk

Urea detection:

First take 2 ml of milk sample and add 2ml of urea reagent and mix well. The final result is a distinct yellow colour which is indicative of urea added to milk. Other methods like Near-infrared Raman spectroscopy has been used to quantify the presence of urea without requiring any preprocessing (Khan *et al.,* 2014). Liquid Chromatography has been used to quantify urea as an adulterant in milk (Dai *et al.*, 2012).

Sugar/Sucrose:

Take 1 ml milk sample and add 1 ml of sugar reagent.Thereafter, place it in boiling water for 3-5 minutes and the red colour is obtained that indicates the sugar has been added to milk.

Salt detection:

Add 5 ml Salt Reagent-I and add a few drops of salt reagent II. Finally, add 1 ml milk and mix well. The yellow colour is observed which is indicative of salt added to milk.

Neutralizers Detection:

First take 2 ml of milk and then add 2 ml of Neutralizer reagent and mix them well. The Rose red/ Pink colour is observed which indicates that neutralizer is added to the milk(NDDB/C/RFP/2072-73/01)

Microbiological test of milk

Total Plate Count / Standard Plate Count

The Standard Plate Count (SPC) is used extensively in both regulatory and premium testing programs. The SPC gives an estimated count of the total bacteria in a sampleThe Standard Plate Count (SPC) of raw milk indicates the total number of aerobic bacteria present in the milk at the time of pickup. The milk samples are plated in a semi-solid nutrient media and then incubated for 48 hrs at 32°C (90°F) to encourage bacterial growth. Singlebacteria (or clusters) grow to become visible colonies that are then counted. All plate counts are expressed as the number of colony-forming units per millilitre (CFU/ml) of milk. The nutrient agar system remains the gold standard. Aseptically collected milk from clean, healthy cows generally has an SPC less

than 1,000 CFU/ml. Higher counts suggest that bacteria are entering the milk from other possible sources. Although it is impossible to eliminate all sources of contamination, counts of less than5,000 CFU/ml are possible, while counts of 10,000 CFU/ml should be achievable by most farms. The most frequent cause of a high SPC is poor cleaning of the milking system. Sources of high SPC include the dirt on the equipment surfaces that act as a medium for bacterial growth, dirty udders, unhygienic milking and housing environment, and mastitis cow that shed bacteria.(NDDB/C/RFP/2072-73/01)

Coliform count

Coliform tests are conducted following pasteurization primarily to detect bacterial recontamination of the milk. Retail milk products must have a coliform count less than 10/ml or gram.The Coliform Count (Coli Count) procedure selects for bacteria that are most commonly associated with manure or environmental contamination. Milk samples are plated on a selective nutrient media that encourages the growth of coliform bacteria, while preventing the growth of others. Although coliform is often used as indicators of fecal contamination, there are strains that commonly exist in the environment. Coliform may enter the milk supply as a result of milking dirty cows or the claw becoming soiled with manure during milking. Generally, counts greater than 100 cfu/ml would indicate poor milking hygiene or other sources of contamination. Higher coliform counts more often result from dirty equipment and in rare cases, result from milking cows with environmental coliform mastitis.

Milk adulteration in Nepal

The dairy sector is one of the major components of livestock farming system in Nepal and accounts a share of 31% of AGDP (CBS, 2001). The dairy sector provides cash income to farmers. Besides this, it provides nutritious foods, drafts power and manure. It is one of the highest income contributors to rural farmers (55%) in Nepal (Chaudhary and Upadhyaya, 2015). Dairy subsector contributes almost 63 percent of livestock GDP (NDDB, 2020). Cattle and buffaloes are major sources of income for marginalized farmers (Nakao, 2005). Although the dairy sub-sector is the major contributor to the national economy, the quality and safety issues have been the major challenges.

The rapid urbanization, changing food habits and preference, consumer's improved purchasing power due to the increased remittance, and better economic status has created a huge demand for milk products in Nepal. Although modern farming has led to increased milk production, the country is facing aserious milk deficit. The country spends billions of rupees annually to import dairy products. It is vivid that the country imports about 45,734 MT of fluid milk annually, which is equivalent to the daily import of 125,000 litres of milk (NDDB, 2014). As reported by NDDB, Nepal imported 7572.30 MT of milk and milk products during July 2018 to July 2019 whereas exported 288.75 MT during same period (NDDB, 2020).

The quality and safe milk production are one of the biggest problems faced by developing countries, and Nepal is one of them. Dairy farmers unable to comply with food safety measures at the farm level was the major and the first stage of bacterial contamination in the formal milk chain (NDDB, 2013). Supply chain issue is another reason for bacterial contamination of milk as the milk collected in certain areas takes much time to reach the chilling centres and pasteurizing units that check bacterial growth.

Besides, raw milk quality is also degraded due to adulteration practices like the addition of water, sodium bicarbonates, starch, urea and sugar (FAO, 2010). The findings of the study on behavioral practices of supply chain actors on quality maintenance of raw milk indicated that only 8% of the households reported mixing of materials in milk for its preservation and/or fat/Solids Not Fats (SNF) improvement (Tiwari and Paudel, 2018).It is reported that the intentional milk adulteration by various supply chain actors has led to quality issues in raw milk in developing countries (Mu *et al.,* 2013).A study indicated that the mean total bacterial count (TBC) was nine times higher at farm level and 104 times higher in processing plants when compared to the international standard (Dahal *et al.,* 2010). Value chain stakeholders like cooperatives and processors frequently bleat about the low quality of milk delivered by producers and consumers also have the same concerns. A study found that 16.85 per cent of consumers perceived water adulteration in milk, 12.54 per cent considered milk to have a bad odour, and 18.64 per cent indicated that milk was tasteless (NDDB, 2014). Smallholder farmers are the major milk producers and they are still unaware of the importance of quality milk production, have not received basic training on hygienic milk production, and received a bonus to produce hygienic milk. The government of Nepal released the code of practices for the dairy industry in 2004. The government institutions like NARC and DLS have been providing training to smallholder farmers regarding hygienic milk production. The government and concerned organizations and line agencies must diligently monitor and strictly execute the code of dairy practices to ensure food safety which ultimately has a beneficial effect on human health (Kumar*et al*., 2016)

Discussion

It is found that milk is adulterated with various adulterants like water, urea, detergents, sugar and preservatives. A study on the quality of raw milk from different places of Western Chitwan, Nepal indicated that most of the milk samples were adulterated with salt and sugar. However, not a single milk sample was found to be adulterated with starch, neutralizer and urea (Bastola, 2016). In a survey carried to access the raw milk quality in Nepal, the adulteration of starch and soda was more prominent with the milk sold loose in the market. This practice is done to extend the shelf life of milk and increase the SNF content of milk as milk is paid based on fat and SNF content by the milk vendors to the producers.

In a study carried out in Pakistan, results showed that 97% and 93% of the milk samples collected from canteens of educational institutes and public places were adulterated with water. Urea adulteration was present in 63% and 87% samples; formalin adulteration was present in 23% and 27% samples while 87% and 97% samples showed cane sugar adulteration from various canteens of educational institutes and public places, respectively. Hydrogen peroxide adulteration was found in 3% of the milk samples from various canteens of public places whereas no sample was found to be adulterated with starch, detergent and oil from canteens of both the places. The results obtained were similar to those mentioned by Lateef *et al.,* (2009). It is also concluded that milk sold at various canteens of educational institutes and public places were extensively put to malpractices such as skimming and adulteration with water (Khan *et al*., 1991) and (Lateef *et al*., 2009). Different adulterants present in the milk like water, urea, formalin, hydrogen peroxide and cane sugar threatened the wholesomeness of milk. It is very unfortunate that the students in educational institutes and the public at public places, especially passengers are enforced to consume that milky coloured fluid which is extensively put to adulteration.

A surveillance study, The National Survey on Milk Adulteration (Executive Summary on National Survey on Milk Adulteration, India 2011) was conducted by the Food Safety and Standards Authority of India (FSSAI) to ascertain the quality of milk and identify different sources of adulteration in the liquid milk throughout the country. The study indicated that water was the most commonly added adulterant used in milk and the survey result also showed that powdered milk was reconstituted to meet the demand for milk without any labelling.

In 2011, the department of food and quality control found about 16% of food has some kind of adulteration. Milk led the share of adulterated products among the different food commodities. According to the media reports, coliform bacteria were found in processed milk and outdated sugar was used for producing a dairy product (Rijal, 2016). About 55% of the tested milk samples were adulterated with soda whereas 10% of themilk samples were adulterated with table sugar at Kathmandu Valley, Nepal (Astha *et al*., 2018). In contrast, the added soda percentage was more than that reported in western Chitwan by Bastola, 2016.

Adulteration with detergents is usually due to negligence while cleaning of the utensils by the milkman. It was reported that detergent was at maximum of 40% samples collected from Faridabad (Delhi) (Brototy *et al*. 2017) and in milk samples of other regions such as Dehradun (Kandpal *et al*., 2012) and Hyderabad (Singuluri and Sukumaran, 2014). Milk sugar primarily consists of lactose (Pandya *et al*., 2013). It gives sweet taste to the milk. Usually, sugars other than lactose are added to give diluted milk its characteristic sweetness and also increase milk thickness. Glucose is added in the milk as reported in many studies (Nirwal *et al*., 2013; Barham *et al*., 2014a).

In China, the milk is adulterated with milk powders to increase the protein content of milk. It was found that the milk samples from different regions like Gurgaon, Noida and West Delhi were found to be adulterated with SMP. Similarly, hydrogen peroxide and gentamycin were added as preservatives, vegetable oils to increase the fat value. Since only 20% of farmers used disinfectants before milking, milk was found highly contaminated with microbes (Gale and Hu, 2009). Starch is a common adulterant that has been reported in milk samples from different places (Ahmed, 2009; Barham, 2014b). However, the milk samples collected from Hyderabad, (Singuluri and Sukumaran 2014) Delhi and NCR (Singh *et al*., 2015) were found to be not adulterated with starch.

In Brazil, adulterants such as starch, whey, and sucrose were the most frequently used to adulterate milk (Borin *et al*., 2006). Similarly, melamine is also added to increase protein content (Liu *et al*., 2012). Melamine is also added to milk powder as an adulterant, and also in many other foods like wheat gluten, chicken feed, and processed foods (Ingelfinger, 2008; Lin *et al*., 2008). Although it is not carcinogenic, it may cause renal failure and infant death in extreme cases (Cheng *et al*., 2010)

In 2018, the incidence of melamine adulteration of milk and dairy products led to the ill health of many infants and casualties (Gossner *et al*., 2009). Similar adulteration practices were reported in Ethiopia (Desissa *et al*., 2013). Such reports of adulteration practices frighten consumers and reduce their preference to consume milk and milk products. A study of the effect of milk fraudulence on food safety and nutrition, with emphasis on developing countries, outlined the adverse health effects of adulterated milk on the consumer (Handford *et al*., 2016)

Conclusion

The increased demand for milk has made milk more prone to adulteration. Milk is ahigh-risk commodity that can be adulterated using chemicals like formalin, detergents, caustic soda and other materials like water, urea, salt, sugar and milk powder. Such malpractices degrade the nutritional quality of milk to such an extent that it can cause serious public health issues. The review illustrates that adulteration practices in the dairy sector in Nepal are unchecked and needs strict quality check of milk and dairy products. Thus, the government must empower its institution and human resources to execute legal enforcement of adulteration test of raw milk and marketed milk.

It should establish a pricing scheme based on the protein content of milk rather than traditional fat and SNF content. The incentive systems for better quality milk on competitive basis could be suggested around the collection centers. Further, farmer level training and awareness programs related to high-quality milk production should be increased. Milk collection centers and chilling centers should also improve their existing facilities and organize the milk collection schedule so that the milk collected at farm reaches the chilling center within 3 hours of milking, which checks bacterial growth and discourages the actors adulterating milk to correct the compromised milk quality. In the long run, appropriate labelling, packaging, and storage methods, as well as separate pricing for cattle and buffalo milk, could be practised together with the facilities for avoiding milk adulteration. In addition to it, more analytical study is required to develop awareness among the milk consumers about the malpractices and their hazardous effects of adulterated milk on the public health.

Declaration of Interest:

The author(s) declare that there is no conflict of interest with regards to the research, authorship and/or publication of this article.

References

Adam, A.A.H. 2009. Milk adulteration by adding water and starch at Khartoum state. Pakistan Journal of Nutrition, 8(4): 439-440.

Barham, G.S., M. Khaskheli, A.H. Soomro, Z.A Nizamani.. 2014a. Extent of extraneous water and detection of various adulterants in market milk at Mirpurkhas, Pakistan. Journal of Agriculture and Veterinary Science, 7(3): 83-89.

Barham, G.S., M. Khaskheli, A.H. Soomro, Z.A Nizamani. 2014b. Detection and extent of extraneous water and adulteration in milk consumed at Hyderabad, Pakistan. Journal of Food and Nutrition Sciences, 2(2): 47-52.

Bastola, K.P., D.B. Nepali. 2016. Quality of raw milk supplied to organized milk collection Centers of Western Chitwan. International Journal of Thesis Projects and Dissertations, 4 (1): 1-19.

Borin, A., M.F.Ferrao, C. Mello, D.A. Maretto, R.J. Poppi. 2006. Least-squares support vector machines and near infrared spectroscopy for quantification of common adulterants in powdered milk. Analytica Chimica Acta, 579(1): 25-32.

CBS Central Bureau of Statistics. 2013. National Report; National Planning Commission Secretariat: Kathmandu, Nepal.

CBS, N.2011. Statistical year book of Nepal. Central Bureau of Statistics.

Chaudhary, B., M. Upadhyaya. 2013. Socio-economic impacts of dairy cooperative. Economic Journal of Development Issues, 15&16(1-2): 15-23.

Cheng, Y., Y. Dong, J. Wu, X. Yang, H. Bai, H. Zheng, D.Ren, Z. Yundong , M. Li. 2010. Screening melamine adulterant in milk powder with laser Raman spectrometry. Journal of Food Composition and Analysis, 23(2): 199-202.

Dahal, L.R., D.B.N. Karki, R.Shah. 2010. Total bacterial counts of raw milk in Eastern Terai of Nepal. Journal of Agriculture and Environment, 11: 46-50.

Dai, X., Y.Zhao, M. Li, X. Fang, X. Li, H. Li, B. Xu. 2012. Determination of urea in milk by liquid chromatography-isotope dilution mass spectrometry. Analytical Letters, 45(12):1557-1565.

Desissa, F., K. Makita, A. Teklu, D. Grace. 2012. Contamination of informally marketed bovine milk with Staphylococcus aureus in urban and peri urban areas of Debre-Zeit, Ethiopia. African Journal of Microbiology Research, 6(29): 5852-5856.

Executive Summary on National Survey on Milk Adulteration. 2011. Food safety and standards authority of India.www.fssai.gov.in/Portals/0/Pdf/sample_analysed (02-01-2012).pdf. Accessed on January7, 2021.

FAO. 2010. Dairy Sector Study of Nepal. Food and Agriculture Organization of the United Nations (FAO).

Faraz, A., M. Lateef, M.I. Mustafa, P. Akhtar, M. Yaqoob, S. Rehman. 2013. Detection of adulteration, chemical composition and hygienic status of milk supplied to various canteens of educational institutes and public places in Faisalabad. JAPS, Journal of Animal and Plant Sciences, 23(1 Supplement): 119-124.

Fischer, W.J., B. Schilter, A.M. Tritscher, R.H. Stadler. 2011. Contaminants of milk and dairy products: contamination resulting from farm and dairy practices. Encyclopedia of Dairy Sciences, 2: 887-97.

Gale Jr, H.F., D. Hu. 2009. Supply chain issues in China's milk adulteration incident.Conference: International Association of Agricultural Economists. doi:10.22004/ag.econ.51613.

Gossner, C.M.E., J. Schlundt, P.Ben Embarek, S.Hird, D.Lo-Fo-Wong, J.J.O. Beltran, K.N.Teoh, A.Tritscher.2009. The melamine incident: implications for international food and feed safety. Environmental health perspectives, 117(12):1803-1808.

Handford, C.E., K. Campbell, C.T. Elliott. 2016. Impacts of milk fraud on food safety and nutrition with special emphasis on developing countries. Comprehensive Reviews in Food Science and Food Safety, 15(1):130-142.

Ingelfinger, J.R. 2008. Melamine and the global implications of food contamination. New England Journal of Medicine, 359(26): 2745-2748.

Kamthania, M., J. Saxena, K. Saxena, and D.K. Sharma. 2014. Methods of Detection & Remedial Measures. International Journal of Engineering and Technical Research,1:15– 20.

Kandpal, S.D., A.K. Srivastava, , K.S. Negi. 2012. Estimation of quality of raw milk (open & branded) by milk adulteration testing kit. Indian journal of Community Health, 24(3):188-192.

Khalid, A. 2006. Milk production in Sudan. Conference paper, Kh Sudan: 1-3 pp.

Khan, B.B., M.I. Mustafa, M. Abdullah, M. Yaqoob.1991. Chemical and hygienic quality of milk supplied to canteens of various hospitals in Faisalabad city. Pakistan Journal of Agricultural Sciences, 28(4): 404-7.

Khan, K.M., H. Krishna, S.K. Majumder, P.K. Gupta. 2015. Detection of urea adulteration in milk using near-infrared Raman spectroscopy. Food Analytical Methods, 8(1): 93-102.

Kumar, A., G. Thapa, P.K. Joshi, D. Roy. 2016. Adoption of food safety measures among Nepalese milk producers: Do smallholders' benefit? (Vol. 1556), Intl Food Policy Research Institute.

Lateef, M., A. Faraz, M.I. Mustafa, P. Akhtar, M.K. Bashir. 2009. Detection of adulterants and chemical composition of milk supplied to canteens of various hospitals in Faisalabad city. Pakistan Journal of Zoology, 9: 139-142.

Lin, M., L. He, J. Awika, L. Yang, D.R Ledoux,. H.A. Li, A. Mustapha. 2008. Detection of melamine in gluten, chicken feed, and processed foods using surface enhanced Raman spectroscopy and HPLC. Journal of Food Science, 73(8): T129-T134.

Liu, Y., EED. Todd, Q. Zhang, JR. Shi, XJ. Liu. 2012. Recent developments in the detection of melamine. J. Zhejiang Univ. Sci. B (Biomed and Biotechnol),13(7): 525–32.

Lues, J.F.R., P. Venter, H. Van der Westhuizen. 2003. Enumeration of potential microbiological hazards in milk from a marginal urban settlement in central South Africa. Food Microbiology, 20(3): 321-326.

MoAD. Statistical Information on Nepalese Agriculture 2013/14; Ministry of Agricultural Development, Agri-business Promotion and Statistics Division: Singhdurbar, Kathmandu, Nepal, 2014.

MoALD.2019.Nepal Agricultural Statistics 2074/75; Ministry of Agriculture and Livestock Development: Singhdurbar, Kathmandu, Nepal.

Mu, L., M. Dawande, V. Mookerjee. 2014. Improving the milk supply chain in developing countries: Analysis, insights, and recommendations. Production and Operations Management, 23(7): 1098-1112.

NDDB. 2020. Five years Dairy Development Plan FY 2077/78-2081/82; National Dairy Development Board; Kathmandu, Nepal.

NDDB. 2014. Final Report on Study on Cost of Milk Production. Hariharbhawan, Lalitpur, India

NDDB/C/RFP/2072-73/01. Final Report on "Benchmark Survey on Quality of Raw and Processed Milk in Nepal".

Nirwal, S., R. Pant, N. Rai. 2013. Analysis of milk quality, adulteration and mastitis in milk samples collected from different regions of Dehradun. International Journal of PharmTech Research, 5(2): 359-364.

Pandya, A.V., D. Joshi, S. Vora, A. Vishwakarma. 2013. Estimation of the type and quantity of sugar in milk. Journal of Chemical, Biological and Physical Sciences (JCBPS), 3(4): 2623.

Parajuli, A., P. Rimal, R. Maharjan, R. Chaudhary, S.B. Chaturwedi. 2018. Quality analysis of milk in Kathmandu Valley. Tribhuvan University Journal of Microbiology, 5: 7-10.

Pouranik, M. A. Siddiqua. 2017. Adulteration in Local Available Milk Samples of Jabalpur Regions–A Comparative Study.

Rijal, P. 2016."Water, Oil, Ghee and Milk Most Adulterated Items". The Kathmandu Post. https://kathmandupost.com/money/2016/08/18/water-oil-ghee-and-milk-most-adulterated-items Accessed on June 1, 2016.

Roy, B., J. Singh, S. Sunsunwal, G. Dayal, B. Yadav, C. Bhardwaj, A. Teotia. 2017. Detection of harmful adulterants in milk supplied to Delhi, India. Current Science, 112: 2316-2320.

Salih, M.A.M., S. Yang. 2017. Common Milk Adulteration in Developing Countries: Cases Study in China and Sudan: A review. Journal Advances in Dairy Research, 5: 192. doi:10.4172/2329-888X.1000192

Sharma, R., Y. S. Rajput. 2012. Detection of adulterants in milk, A laboratory manual. NDRI,Karnal.

Singh, J., B. Roy, G. Dayal, S. Sunsunwal, B. Yadav, C. Bhardwaj, A. Teotia. 2015. Detection of common adulterants in milk from Delhi and NCR. DU Journal of Undergraduate Research and Innovation, 1(1):152-156.

Singh, P., N. Gandhi. 2015. Milk preservatives and adulterants: processing, regulatory and safety issues. Food Reviews International, 31(3): 236-261.

Singuluri, H., M. K Sukumaran.2014. Milk adulteration in Hyderabad, India-a comparative study on the levels of different adulterants present in milk. Journal of Chromatography & Separation Techniques, 5(1): 1.

Spink, J., D.C.Moyer. 2011. Defining the public health threat of food fraud. Journal of food science, 76(9): R157-R163.

Statistical Pocket Book of Nepal.2004. Kathmandu, Nepal: His Majesty's Government of Nepal, 1- 39.

Tanzania, A., A. Shoeb. 2016. Common milk adulteration and their detection techniques. International Journal of Food Contamination, 3: 22. doi:10.1186/s40550-016-0045-3.

Tiwari. U., K. Paudel. 2018. Behavioural practices of supply chain actors on quality maintenance of raw milk in Nepal. Journal of Agriculture and Forestry University, (2): 79-89.

Trivedi, U.B., D. Lakshminarayana, I.L.Kothari, N.G. Patel, H.N. Kapse, K.K. Makhija, P.B. Patel, C.J. Panchal.2009. Potentiometric biosensor for urea determination in milk. Sensors and Actuators B: Chemical, 140(1): 260-266.