Sudan University of Science and Technology

Collage of Graduate studies

Adulteration of Cow Milk In Khartoum State

الغش فى لبن الأبقار بولاية الخرطوم

By

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Dedication

This thesis is dedicated to the memory of my father Mohammed Taha, and my mother Sadiea who were instrumental in helping me to become a doctor. They passed away before this research but wanted me to complete my study, till the end of their lives. It is also dedicated to my husband, Saber and baby Suliman for whom my study became as much a part of their life as mine. It is also dedicated to my brothers and sisters

With love

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Abstract

This study was conducted to evaluate the physicochemical properties of raw milk from different marketing channels in Omdurman, Bahri and Khartoum, Sudan from 1st June – 1st July, 2018. A total of 36 samples of raw milk were collected from distribution channels (pick-up trucks, venders on donkeys cart farms) in each town, and subjected to physicochemical analysis (starch, density, acidity and neutralization). Physicochemical properties of milk samples collected from Omdurman, Bahri and Khartoum demonstrated that the mean values of density of milk collected from Omdurman 1.03± 0.001 g/cm^3, Bahri 1.02±0.002g/ cm^3 and Khartoum 1.03±0.001g/cm^3 . Acidity in milk samples collected from Omdurman, Bahri and Khartoum was 0.17±.026%, 0.15± .027% and 0.17± .019% respectively. There was no significant difference (P>0.05) between the three locations. Starch and Formalin was zero in this results. There was adulteration of milk by addition neutralizer mainly at Khartoum.

In conclusion, it is important to have an efficient and reliable quality control system that will regularly monitor, combined efforts from scientific communities and the regulatory authorities. The human and technology interface, awareness and access to information can play vital role in irradication of the milk adulteration.

Arabic abstract

أجريت هذه الدراسة لتقييم الخواص الفيزيائية والكيميائية للحليب الخام من قنوات التسويق المختلفة في أم درمان ، بحري والخرطوم (السودان) .تم جمع مجموعه 36 عينة من الحليب الخام من قنوات التوزيع (شاحنات البيك آب والباعة في مزارع عربات الحمير) في كل منطقة ، وخضعت للتحليل الكيميائي الفيزيائي (النشا والكثافة والحموضة والتحييد). أظهرت الخواص الفيزيائية والكيميائية لعينات الحليب المجمعة من أم درمان وبحري والخرطوم أن القيم المتوسطة لكثافة الحليب المجمعة من أم درمان هى 1.03 ± 0.001 جم / سم 3 ، بحري 1.02 ± 0.002 جم / سم 3 والخرطوم 1.03 ± 0.001 جم / سم 3 . بلغت نسبة الحموضة في عينات اللبن المجمعة من أم درمان والبحري والخرطوم 0.17 ± .026 ٪ و 0.15 ± .027 ٪ و 0.17 ± .019 ٪ على التوالي. لم يكن هناك فرق كبير (P> 0.05) بين المواقع الثلاثة. النسب المئوية للنشا والفورمالين لوحظت (صفر ٪) في هذه النتائج. توضح نتائج هذه الدراسة أن العدد الإجمالي للعينات كان سلبياً في تحييده باستثناء وجود غش في اللبن عن طريق إضافة النيوتروليزر في الخرطوم. يمكننا أن نستنتج أنه من المهم أن يكون هناك نظام فعال وموثوق لمراقبة الجودة يراقب بانتظام مع تضافر الجهود من جانب المجتمعات العلمية والسلطات التنظيمية. يمكن للواجهة البشرية والتكنولوجية والوعي والوصول إلى المعلومات أن تلعب دوراً حيوياً في علاج غش الحليب.

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Introduction

Food Adulteration is an act of intentionally debasing the quality of food offered for sale either by the admixture or substitution of inferior substances or by the removal of some valuable ingredient. Food Adulteration takes into account not only the intentional addition or substitution or abstraction of substances which adversely affect nature, substances and quality of foods, but also their incidental contamination during the period of growth, harvesting storage, processing, transport and distribution. "Adulterant" means any material which is or could be employed for making the food unsafe or sub-standard or misbranded or containing extraneous matter (Aishwarya and Duza, 2017).

Food adulteration is a global concern and developing countries are at higher risk associated with it due to lack of monitoring and policies (Azad and Ahmed, 2016).

Milk is the normal mammary secretion derived from complete milking of healthy mulch animal without either addition there to or extraction there from (Aishwarya and Duza, 2017).

Milk adulteration is a social problem. It exists both in the backward and advanced countries. Consumption of adulterated milk causes serious health problems and a great concern to the food industry (Das *et al*., 2016).

Milk adulteration is a very common food fraud and is posing a big social problem in today's world. Apart from the ethical and economical issue, it also creates health hazards (Hattersley, 2000). Some of them are renal and skin disease, eye and heart problem and may also leads to cancer (Baynes *et al*., 1999; Tolentino *et al*., 2005; Sadat *et al*., 2006; Trivedi *et al*., 2009). So, for preventing these, determination of milk adulteration is very important.

A large number of research papers have been published on milk adulteration and detection, including some review papers (Azad and Ahmed, 2016; Das *et al*., 2016; Poonia *et al*., 2016; Aishwarya and Duza, 2017). However, there is virtually lack of data on the milk adulteration in Sudan (Elsheikh *et al*., 2015).

In Khartoum State, milk is distributed through irregular marketing channels such as venders on donkeys or by cars in addition to collection centers and some consumers buy milk directly from the farms. These informal channels make milk uncontrollable and could influence the nutritional value of milk in case of adulteration.

Objectives

The present study is carried out:

1. To determine the chemical composition of the raw milk available in the three areas (Omdurman, Bahri and Khartoum) in Khartoum State.
2. To detect adulteration in milk (starch, density, acidity and neutralization) in the study area.
3. To determine the physical evaluation of milk.
4. To contribute towards the common knowledge base regarding possible milk adulterants.

Chapter One

Literature Review

Animal resources in the Sudan comprise sheep, goat, cattle, camel, poultry and wild-game animals. Most of the animals in the Sudan are raised on natural pastures by nomadic tribes. In irrigated projects and the areas of mechanized farming animals feed on crops by-products. So, Sudanese animals are almost free from feed additives, hormonal and chemical residues, which give special preference to the Sudanese animal products (Salih and Yang, 2017).

Food and agricultural organization (FAO, 2006) reported that the fresh milk produced in the Sudan was 7.1 tons from local breeds and most of the yield (95%) is produced by nomads and 5% in urban area while the producing cross bred cows about 500,000 head distributed in the towns and cities of the country and produce 95% milk yield produced in urban area of the total milk yield and this shows the potentiality of cross bred cows report (Khalid, 2006).

Milk is a dynamically balanced mixture and a perishable food. It is one of few foods consumed in the natural form throughout the world. Milk contains 87% water, 3.3% protein, 3.9% fats, 5% lactose and 0.7% ash (Renny *et al.*, 2005).

Fresh milk is considered as a complete diet because it contains the essential nutrients such as lactose, fat, protein, minerals and vitamins in balanced ratio rather than the other foods (Renny *et al*., 2005; Hossain and Dev, 2013). Moreover, milk can be considered as a source of macro and micro-nutrients, and contains a number of active compounds that play a significant role in both nutrition and health protection (Ceballos *et al*., 2009). The solid components of milk mainly fat and protein make milk an economically and nutritionally important asset (Negash *et al*., 2012). Milk is more widely influenced by environmental and genetic factors than any other biological fluid (Mohamed and Elzubeir, 2007). Negash *et al*. (2012) reported that the factors responsible for variations in milk composition include breed and individuality of cow, strain, interval between milking, stage of lactation, age and health of the cow, feeding regime and completeness of milking. Adulteration means substitution of cheaper ingredients to impress the buyer to think that product is more valuable or better quality (Kandpal *et al*., 2012). Materials such as extraneous water, foreign proteins, whey proteins, melamine and urea, vegetable or animal fats, plus many minor constituents of milk fat have been added as potential adulterants in milk and milk products (Poonia *et al*., 2016). The practice of adulteration of milk invariably reduces its quality and may introduce hazardous substances into the dairy supply chain jeopardising consumers' health. Various instances of adulteration of milk have been reported

globally (Poonia *et al*., 2016; Aishwarya and Duza, 2017). Adulteration refers to all non-accidental preventable changes to dairy and dairy products /processes that reduce quality or create avoidable risks. Milk adulteration also refers to marketing a product as milk deliberate adulteration is motivated by economic greed. For obvious reasons milk adulteration negatively affects the consumer and the industry (Pouranik *et al.*, 2017).

Milk and dairy product adulteration came into global concern after breakthrough of melamine contamination in Chinese infant milk products in 2008 (Xin and Stone, 2008). However, Adulteration of milk and other dairy products has existed from old times. That is why it was necessary to stipulate regulatory standards against adulteration in food and develop methods or tests to detect adulteration particularly adulteration of milk with cheaper and sometimes toxic chemicals is matter of serious concern (Astrid *et al*., 2010) history of milk adulteration is very old. Swill milk scandal has been reported in 1850 which killed 8000 infants in New York alone . Milk is considered to be the 'ideal food' because of its abundant nutrients required by both infants and adults (Azad and Ahmed, 2016).

Sometimes the regulations or the standard specifications of the country help those adulterators by indirect ways which lead to the appearance of adulterated and low nutritional value dairy products in the market protected by these regulations or standard specifications. A survey

has been done on some available cheese especially white soft cheese and processed cheese in the local market of Egypt (Elaaser, 2011).This study covered some types off adulteration in milk like :-

1.1. Water

Water is the most common adulterant in milk (Barham *et al*., 2014; Roy *et al*., 2017). The major percentage of natural milk contains water (87%), but milk with added water is a serious concern. In one hand it decreases the nutritious value; on the other hand chemicals are added to compensate the density and colour after dilution with water. Since addition of water is the easiest way and cheap source for adulteration of milk (Adam, 2009; Salih and Yang, 2017). If the water added is contaminated, there is a high risk to human health because of potential waterborne diseases (Kandpal *et al*., 2012). Other common adulterants of milk are urea, starch, formalin and boric acid (El-Loly *et al*., 2013).

Milk adulteration has been widely reported in developing countries such as China, Pakistan, Brazil and India (Pouranik *et al*., 2017). In China milk dealer's water down milk due to high demand and limited supply. Then additional of synthetic powders to increase the protein value, Hydrogen peroxide and gentamycin as preservatives, vegetable oils to increase the fat value. Microbial contamination of milk was also high because only 20% of the small scale backyard farmers use disinfectants prior to milking. This decreases the shelf life of milk. This adulterated milk

increased the number of patients with kidney stones (Gale and Hu, 2007; Kandpal *et al*., 2012; Kauser and Swathi, 2015). Pandya *et al*. (2013) have also reported presence of various adulterants in milk samples in different regions of India. In Pakistan, Shehzadi *et al*. (2016) reported that the NaCl and Carbonate were the most common adulterants (100%) found to be in all of milk samples, followed by quaternary ammonium compound (90%), formalin (50%), cane sugar (20%), starch and detergent (10%). While urea, boric acid, sorbitol, hydrogen peroxide and hypochlorite were not found in any sample.

1.2. Acidity

The normal acidity of individual cow Milk ranges from 0.10 to 0.26% lactic acid. Milk having titratable acidity more than 0.18% Lactic acid is not suitable to prepare heat treated products as the milk will coagulate at or above that acidity. Heated milk will show an increase in acidity due to the changes in the casein complex and formation of acids by the degradation of lactose (Sarma, 2012).

1.3. Starch

Starch is used to increase solid-not-fat and if high amounts of starch are added to milk, this can cause diarrhoea due to the effects of undigested starch in colon. Its accumulation in the body may prove very fatal for diabetic patients (Singuluri and Sukumaran, 2014).

1.4. Formalin

Formalin is used as an antiseptic, disinfectant and preservative. It is used as an adulterant in milk to increase the shelf life for long distance transportation of milk without refrigeration, saving the supplier a neat packet by cutting electricity costs. That is highly toxic causes liver and kidney damages. It is a 37% aqueous solution of the pungent gas formaldehyde and has the chemical formula HCHO and is a potentially hazardous toxic or injurious substance. It is a potent carcinogen (Gwin *et al*., 2009)

1.5. Neutralizers

Neutralizers are added to prevent curdling and thereby, increase the shelf life of milk (Pouranik *et al*., 2017). The neutralizers like hydrated lime, sodium hydroxide, sodium carbonate or sodium bicarbonate are added in milk which are generally prohibited. Caustic soda is often used in synthetic milk to neutralize the acidic effect (Kasemsumran *et al*., 2007; Das, *et al*., 2016). Caustic soda contains sodium, acts as slow poison for those suffering from hypertension and heart ailments. Caustic soda deprives the body from utilizing lysine, an essential amino acid in milk, which is required by growing babies. Such artificial milk is danger for all, but is more harmful for pregnant women. As a substitute of milk fat, refined oil is mixed; and to dissolve the oil in water and to give a frothy solution, detergents are used. Carbonates and bicarbonates are added to

milk which can cause disruption in hormone signalling and regulate development and reproduction (Manual of Methods of Analysis of Foods: Milk and Milk Products 2005).

Typical Adulterants affect milk quality and their health hazards on humans like:

Sugar which generally is mixed in the milk to increase the solids not fat content of milk i.e. to increase the lactometer reading of milk, which was already diluted with water (Reddy *et al*., 2017).

Many food colorants are also added to improve the appearance and have hazardous effects on health (Reddy *et al*., 2017).

Antibiotics are used mainly to treat a variety of diseases and 80% of veterinarians use antibiotics for treatment of mastitis disease. These antibiotics in the form of antimicrobial residues are found in milk. Presence of tetracycline, aromatic amines, gentamicin residue after mastitis treatment, neomycin residues, sulfamethazine residues, chloramphenicol residues, aflatoxin M1 contamination etc. are also a deep concern as milk adulterants (Das *et al.*, 2016) .

Urea is added to milk to provide whiteness, increase the consistency of milk, increase no protein nitrogen content and for levelling the contents of solid-not-fat are present in natural milk. Urea is also used to prepare synthetic milk. Health hazards associated are acidity, indigestion, ulcers and cancers. Urea is harmful to heart, liver especially for kidneys as the

kidneys have to do more work to remove urea from the body (Kandpal *et al*., 2012).

Pesticides are also used to kill the microorganisms present in milk and to resist its further growth or in other words it is used to preserve milk. Their presence in milk poses serious health hazards due to its toxicity or carcinogenicity (Reddy *et al.*, 2017).

Preservatives Development of microorganism spoils the milk and spoiled milk is not good for health. Boric acid, Formalin, Sodium carbonate (Na2CO3), Sodium bicarbonate (NaHCO3), Salicylic acid, Benzoic acid, Sodium azides can preserve the milk for long time and has poisonous effect which can lead to death (Poisonous milk for pupils, 1905) (Reddy *et al.*, 2017).

Hydrogen Peroxide is added to milk to prolong its freshness, but peroxides damages the gastro intestinal cells which can lead to gastritis and inflammation of the intestine. Hydrogen peroxide (H2O2) disturbs the antioxidants in the body disturbing the natural immunity hence increasing aging. (Reddy *et al.*, 2017).

Chapter Two

Materials and methods

2.1. Study area

Khartoum State is one of the most populous (5,274,321 in 2008 census). It contains largest cities and these are Omdurman, Bahri and Khartoum. Khartoum cities the capital of the state as well as the national capital of Sudan.

The city is located in the heart of Sudan at the confluence of the White Nile and the Blue Nile, where the two rivers united to form the River Nile. The state lies between longitudes 31.5 to 34 °E and latitudes 15 to 16 °N. It is surrounded by River Nile State in the north-east, in the north-west by the Northern State, in the east and southeast by the states of Kassala, Gadarif, Gezira and White Nile State, and in the west by North Kurdufan.

The northern region of the state is mostly desert because it receives barely any rainfall, whereas the other regions have semi-desert climates. The temperature in summer ranges from 25 to 40 C°, In winter, the temperature declines gradually from 25 to 15 C°. (wikipedia.org/wiki/Khartoum -state)

2.2. Milk samples

Raw cow milk samples were collected from Omdurman, Bahri and Khartoum, cities. A total of 36 samples were randomly collected from

Omdurman (12 samples), Bahri (12 samples and Khartoum (12 samples) Samples were collected from traditional farms, pick-up trucks and venders on donkey cars. The samples were collected in dry clean glass bottles (25 ml), preserved in ice box at ≤4°C and transported to the laboratory for chemical analysis.

2.3. Physicochemical analyses of milk

There are many methods for detection of adulteration in milk. These methods compiled below in this study are not only simple and rapid but also very sensitive to detect milk adulteration. These tests can be carried out easily by consumers for identifying the most common adulterants in milk, using simple laboratory apparatus, common chemicals and the milk adulteration test.

Chemical analyses of milk density, acidity, starch, formalin and neutralization of milk samples were determined by Sharma *et al*. (2012) method.

2.3.1. Detection of water in milk

To demonstrate the density of milk, the lactometer instrument was used in this test. Some milk was put in the test-tube and then the meter bulb was dip in it, the bulb going in first. The meter bulb was noted floating. The reading on the meter indicated pure or impure of milk is. The deeper

the bulb sinks, the more dilute/impure the milk. If the reading was at the red mark, it showed that the milk was rich and pure (Sharma *et al*., 2012).

2.3.2. Detection of acidity in milk

Nine ml of milk was put in the flask, Phenopthalein (one ml) was added to the milk in the flask, then sodium hydroxide (0.1) was added under continuous mixing from the beret until development of faint pink color. Amount of sodium hydroxide solution in ml was remarked then divided by 10 to expresses the percentage of lactic acid (Chaudhry and Rabbani 2018).

2.3.3. Detection of starch in milk

Five ml of milk was put in a test tube and then was bring to boiling condition and allowed the test tube to cool at room temperature. Two drops of iodine solution was added. Appearance of blue color indicates the presence of starch in the milk samples (Sharma *et al*., 2012).

2.3.4. Detection of formalin in milk

Two mL milk sample was taken in a test tube and then 2 ml of 90% sulfuric acid was added with a little amount of ferric chloride without

shaking. Appearance of violet or blue color at the junction of two liquid layers indicates the presence of formalin (Sharma *et al*., 2012).

2.3.5. Detection of Neutralizers in Milk

Reagent(s) preparation:

Rosalic acid solution (0.1%, w/v):

Hundred mg of rosalic acid powder was weighed and dissolved it in the 30 ml ethyl alcohol and make up the volume with distilled water to obtain final volume of 100 ml of the mixture.

Ethyl alcohol (95%):

Ninety five ml of ethyl alcohol was taken in a 100 ml volumetric flask and make the volume up to the mark with distilled water and mixed well.

About 5 ml milk was taken in a test tube and added 5 ml ethanol and mixed well. Two to three drops of Rosalic acid solution were added. Formation of rose red color indicates the presence of neutralizers in milk samples (Sharma *et al*., 2012).

2.4 Statistical analysis

The statistical analysis was performed using Statistical Analysis Systems (SAS, ver. 9). Data were analyzed by One-way ANOVA using statistical software package (SPSS, version 21).

Chapter Three

Results

The present study revealed that the mean values of density of milk collected from Omdurman (1.03± 0.001 g/cm^3)**.** Acidity in milk samples was 0.17±.026%, Starch, Formalin and: Neutralization percentages 0% as observed in Table 1

Table 1: Chemical analysis of the cow milk samples (n: 12) collected form Omdurman town – Khartoum state

Number of Sample	D. g/cm3	A. %	S.	F.	N.
1	1.026	0.16	-ve	-ve	-ve
2	1.026	0.23	-ve	-ve	-ve
3	1.023	0.15	-ve	-ve	-ve
4	1.024	0.17	-ve	-ve	-ve
5	1.024	0.14	-ve	-ve	-ve
6	1.024	0.14	-ve	-ve	-ve
7	1.026	0.15	-ve	-ve	-ve
8	1.027	0.16	-ve	-ve	-ve
9	1.024	0.18	-ve	-ve	-ve
10	1.025	0.19	-ve	-ve	-ve
11	1.027	0.19	-ve	-ve	-ve
12	1.027	0.15	-ve	-ve	-ve

D: Density, A: Acidity, S: Starch, F: Formalin, N: Neutralization, -ve: Negative.

The mean values of density of milk collected from Bahri was 1.02±0.002g/cm^3, Acidity was 0.15± .027%, Starch, Formalin and Neutralization percentages were zero as observed in Table 2

Table 2: Chemical analysis of the cow milk samples (n:12) collected from Bahri town - Khartoum state

Number of Sample	D. g/cm3	A. %	S.	F.	N.
1	1.023	0.145	-ve	-ve	-ve
2	1.026	0.21	-ve	-ve	-ve
3	1.025	0.14	-ve	-ve	-ve
4	1.022	0.10	-ve	-ve	-ve
5	1.027	0.144	-ve	-ve	-ve
6	1.024	0.15	-ve	-ve	-ve
7	1.025	0.14	-ve	-ve	-ve
8	1.025	0.145	-ve	-ve	-ve
9	1.026	0.175	-ve	-ve	-ve
10	1.024	0.16	-ve	-ve	-ve
11	1.025	0.17	-ve	-ve	-ve
12	1.027	0.18	-ve	-ve	-ve

D: Density, A: Acidity, S: Starch, F: Formalin, N: Neutralization, -ve: Negative.

The mean values of density of milk collected from Khartoum was 1.03±0.001g/cm^3. Acidity was 0.17± .019%, Starch and Formalin percentages were zero as observed in Table 2, but adulteration of milk by addition of neutralizer was observed in Table 3

Table 3: Chemical analysis of the cow milk samples (n:12) collected form Khartoum town - Khartoum state.

Number of Sample	D. g/cm^3	A. %	S.	F.	N.
1	1.027	0.17	-ve	-ve	-ve
2	1.026	0.14	-ve	-ve	-ve
3	1.025	0.185	-ve	-ve	-ve
4	1.026	0.16	-ve	-ve	-ve
5	1.025	0.18	-ve	-ve	-ve
6	1.027	0.185	-ve	-ve	-ve
7	1.026	0.185	-ve	-ve	-ve
8	1.026	0.19	-ve	-ve	-ve
9	1.024	0.14	-ve	-ve	-ve
10	1.025	0.15	-ve	-ve	-ve
11	1.027	0.16	-ve	-ve	-ve
12	1.026	0.15	-ve	-ve	+ve

D: Density, A: Acidity, S: Starch, F: Formalin, N: Neutralization, -ve: Negative.

Table 4: Density (mean±SD) and acidity (mean±SD) of cow milk in Khartoum State.

Region	Parameters	
	Density (g/cm^3)	**Acidity**
Omdurman	1.03± 0.001	0.17±.026
Bahri	1.02±0.002	0.15± .027
Khartoum	1.03±0.001	0.17± .019
P value	0.24	0.39

N= 12

Physicochemical properties of cow milk samples collected from Omdurman, Bahri and Khartoum towns.

3.1. Density

The mean values of density of milk collected from Omdurman (1.03± 0.001 g/cm^3), Bahri (1.02±0.002g/cm^3) and Khartoum (1.03±0.001g/cm^3) and there was no significant difference (P>0.05) between the three locations.

3.2. Acidity

Acidity in milk samples collected from Omdurman, Bahri and Khartoum was 0.17±.026%, 0.15± .027% and 0.17± .019% respectively. Also there was no significant difference (P>0.05) between the three locations.

3.3. Starch

Starch percentages 0% observed in the results (Table 1, 2 and 3).

3.4. Formalin

Formalin percentages 0% observed in the results (Table 1, 2 and 3)

3.5. Neutralizers

The three tables of the results show that the total number of samples was negative to neutralization except there is adulteration of milk by addition of neutrolizer (one sample) mainly at Khartoum.

Chapter Four

Discussion

The density of milk collected from Omdurman, Bahri and Khartoum had no significant variations (P>0.05) were obtained between the three locations. These results are in line with Elsheikh *et al*. (2014) who compared density of milk between Khartoum North and Omdurman. Also these result are similar to that stated by Tasci (2011) in Burdur (Turky). In Sudan, Adam (2009) reported that adulteration of milk by addition of water mainly at the peripheral districts of Khartoum state. The latter author added that water was used without any consideration to its health whether contamination or not and this may lead to stoma ices to the consumers. Also some seller used to sell their milk as cold milk by adding ice which may presser the milk for a long time. Sebho and Meskel (2018) stated that the water found to be higher in some areas in Hossana (Ethiopia).

The acidity of milk samples collected from Omdurman (0.17±.026), Bahri (0.15± .027) and Khartoum (0.17± .019) showed no significant variations (P>0.05) between the three locations. Similar findings are reported by Mohamed and Elzubier (2007) who found that the mean titratable acidity in Khartoum North and Omdurman was 0.18±0.03% and 0.17±0.03%, respectively. These results are also similar to the findings of

Shojaei and Yadollahi (2008) in Shahrekord (Iran). These results are lower than the findings of Elsheikh *et al*. (2014) who reported that the acidity of milk samples collected from Khartoum North (0.23±0.03%) was higher than that collected from Omdurman (0.21±0.03%), and these values showed higher significant variation (P<0.001) between the two locations. Mohamed and Elzubier (2007) added that the high acidity in milk might be due to the high temperature and growth and multiplication of bacteria.

In this study, starch percentage was zero, observed. This result is in line with Adam (2009). Our results were unconfirmed with the findings of Shehzadi *et al*. (2016) who reported that starch provide ten percent. Starch is another common carbohydrate adulterant that has been reported in milk samples from different places (Ahmed, 2009 and Barham, 2014).

In this study, formalin percentage was zero. The present result is not in agreement with the findings of Shehzadi *et al*. (2016) in Pakistan who stated that formalin provide fifty percent calories of total caloric value obtained from milk. Also Mabood *et al*. (2017) who reported the presence of formalin adulteration in milk and the lowest level less than 2%.

In our study it is evident that the milk samples collected from different areas of Khartoum state were found to be adulterated with addition of neutralizers in Khartoum city. Pouranik *et al*. (2017) who reported that most milk samples were found to be alkaline and tested

positive for neutralizers. Swetha *et al.* (2014) revealed that milk was adulterated with neutralizers to an extent of 8.7%, which are almost similar to the results of Ramya *et al.* (2015) (6%) and nearer to the results reported by Singuluri *et al.* (2014) (26%) and Chanda *et al.* 2012 (20%). Presence of this neutralizers may causes disruption of hormones which are important for development and reproduction (Rideout *et al*., 2008).

Conclusion

There was no significant difference (P>0.05) between the Omdurman, Bahri and Khartoum in density, acidity, starch and formalin. But all samples were negative to neutralization except there is adulteration of milk by addition of neutralizer (one sample) mainly at Khartoum. This is due to presence of critical control points in the phases of production, storage and sale during this period of this study.

Recommendations

I. Raw milk may cause a potential risk to the public and therefore hygienic precautions should be taken by determining critical control points in the phases of production, storage and sale and regular check-ups of milk should be performed at various critical control points according to food regulations.

II. The consumer to be aware about the kind of milk he consumes, and the authorities should realize the importance of frequent inspection of the market to check whether this milk meets the minimum legal standards.

III. The research recommended to control the marketing of milk by regulation and rules which include the standards of the sold milk. Distribution, nominations of the producer and the distributors, good labs and Skilled technician in order to control the quality then to save consumer health and economy.

IV. We recommended that it is important to have an efficient and reliable quality control system that will regularly monitor, combined efforts from scientific communities and the regulatory authorities. The human and technology interface,

awareness and access to information can play vital role in irradication of the milk adulteration.

V. Therefore it could be recommended reviewing the standard specifications and some clauses should be changed to achieve minimal nutritional and healthy value requested in the dairy products.

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