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Quality of Dairy Milk Obtained from Automated Dispensing Machines in Nairobi County, Kenya

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Dairy milk is one of the most widely consumed food products. Owing to its rich nutritional value, milk acts as a good medium for microbial growth. Suppliers have been known to adulterate milk with various chemicals for preservation, increasing viscosity and whitening, among other reasons. Increasingly, residents of big cities such as Nairobi County are purchasing their milk from automated milk dispensing machines, which obtain milk from small scale dairy farmers. This study set out to determine the quality of milk purchased from automated milk dispensing machines in selected settlements in Nairobi County. Microbial quality was determined using the methylene blue reduction test while established chemical methods were employed in the tests for hydrogen peroxide and formaldehyde. Twenty one samples, representing 70% of the samples analyzed, tested positive for hydrogen peroxide while only 5 (16.7%) and 7 (23.3%) samples tested positive for formaldehyde and microbial contamination, respectively. These results indicate that there is need to improve the quality of milk dispensed in automated dispensing machines.

Keywords: Milk, adulteration, formaldehyde, hydrogen peroxide

INTRODUCTION

Dairy milk forms an important part of many diets [1]. It can be consumed as is, included in beverages or processed into a myriad of products. Milk is known to be rich in proteins, carbohydrates, fat, fat soluble vitamins and minerals [2]. Unfortunately, this dietary advantage also makes milk a good medium for microbial growth, including growth of pathogenic microbes [3]. Contamination can occur during handling, processing or storage.

Adulteration of milk, usually done for economic reasons, is a matter of global concern [4]. Milk is diluted with water to increase its volume [5] and mixed with reconstituted milk powders and starch are used to increase viscosity [6]. To increase shelf life, suppliers use carbonates, bicarbonates, antibiotics, caustic soda, hydrogen peroxide, hypochlorite, dichromate, salicylic acid, melamine, urea and formaldehyde [7–9]. In addition to deliberate adulteration, hydrogen peroxide is widely used to disinfect equipment used for mixing, transporting, bottling and packing milk [10]. Incomplete removal or decomposition of hydrogen peroxide can lead to its incorporation in dispensed milk. Adulteration of milk is hazardous to health, sometimes resulting in fatalities, and also diminishes the nutritional value of the milk [11].

In urban centers, milk is distributed for sale in shops by dairy companies in packets and containers of fixed volume (250 ml, 500 ml, 1 liters, 2 liters, 3 liters or 5 liters). In Nairobi County, milk vendors are mainly encountered in outlying estates which are next to farmlands. Instead, milk automated dispensing machines (ADMs) are becoming a common feature in many low- and middle-income residential areas in Nairobi. The machines are located in shopping centers and supermarkets. ADMS offer the advantage of flexibility by dispensing milk in variable volumes equivalent to the money presented by the buyer. In addition, since the buyer has the option of carrying their own container, milk prices at ADMs are lower than prices for similar volumes of pre-packaged milk.

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The aim of this study was to assess the microbial quality and test for the presence of formaldehyde and hydrogen peroxide in milk obtained from ADMs in selected outlets Nairobi County.

MATERIALS AND METHODS

Sampling

Purposive sampling was used to collect two milk samples from each of the following selected residential areas in Nairobi County: Umoja, Buruburu, Jericho, Maringo, Ngumo, Nyayo Highrise, Kawangware, Riruta, Ayany, Kangemi, Eastleigh, Pangani, Dandora, Pipeline and Dornholm. Thirty samples were collected in total. Samples were coded, stored at 4 °C and analyzed within 24 hours of collection.

Reagents

Potassium iodide, starch, ferric chloride, hydrochloric acid and methylene blue were analytical grade reagents.

Test for hydrogen peroxide

A 1 ml aliquot of the milk sample was transferred into a test tube and mixed with 1 ml of potassium iodide starch solution. The appearance of a blue color was indicative of the presence of hydrogen peroxide in the sample [12].

Test for formaldehyde

A 5 ml milk sample was placed in a boiling tube. Separately, 1 ml of 10% ferric chloride solution was placed in a 500 ml volumetric flask and made up to volume with concentrated HCl. A 5 ml aliquot of this solution was added to the milk sample in the boiling tube. The boiling tube was placed in a boiling water bath for 4 minutes. The appearance of a brownish pink color is indicative of the presence of formaldehyde [12].

Test for microbial contamination

To a 10 ml milk sample was in a boiling tube, 1 ml of methylene blue was added. The tube was sealed using a rubber stopper and inverted five times to allow the contents to mix adequately. The boiling tube was then placed in a water bath maintained at 37 C. After 30 minutes, color of the boiling tubes was checked. Discoloration of the blue solution to a whitish color was indicative of microbial contamination [13].

Mapping

Map coordinates for two points were randomly selected for each sampled area and plotted on mapcustomizer (www.mapcustomizer.com), using different colors for the different results obtained, to give an indication of the distribution of samples.

RESULTS AND DISCUSSION

Seven of the 30 samples (23.3%) tested negative for all three tests. The results for the remaining twenty three samples are displayed in table 1 below. The regional distribution of all samples and their test results is indicated in figure 1.

Twenty one samples, representing 70% of the samples analyzed, tested positive for hydrogen peroxide. Among the samples that tested positive for hydrogen peroxide, 12 samples tested positive for only hydrogen peroxide. while the remaining nine tested positive for microbial contamination (4 samples: JE2, NG1, NG2 and PI2), formaldehyde adulteration (4 samples: KA1, EA1, EA2 and DA1), or both microbial contamination and formaldehyde adulteration (1 sample: DA2). Only 5 (16.7%) and 7 (23.3%) samples tested positive for formaldehyde and microbial contamination, respectively. All five samples that tested positive for formaldehyde also tested positive for hydrogen peroxide. One sample, DA2, tested positive for all the three tests. Five of the seven samples that tested positive for microbial contamination also tested positive for hydrogen peroxide adulteration. Two samples, both from the same residential area (NY1 and NY2) tested positive for only microbial contamination. Assessment of the distribution of the samples did not show any particular pattern of contamination or adulteration (figure 1).

Table 1: Results for microbial contamination and chemical adulteration tests

Sample	Hydrogen peroxide	Formaldehyde	Methylene blue reduction test
UM1	+	-	-
UM2	+	-	-
JE1	+	-	-
JE2	+	-	+
MA1	+	-	-
MA2	+	-	-
NG1	+	-	+
NG2	+	-	+
NY1	-	-	+
NY2	-	-	+
KA1	+	+	-
KA2	+	-	-
KM1	+	-	-
KM2	+	-	-
EA1	+	+	-
EA2	+	+	-
PA1	+	-	-
PA2	+	-	-
DA1	+	+	-
DA2	+	+	+
PI1	+	-	-
PI2	+	-	+
DO1	+	-	-
DO2	+	-	-
TOTAL +	21	5	7

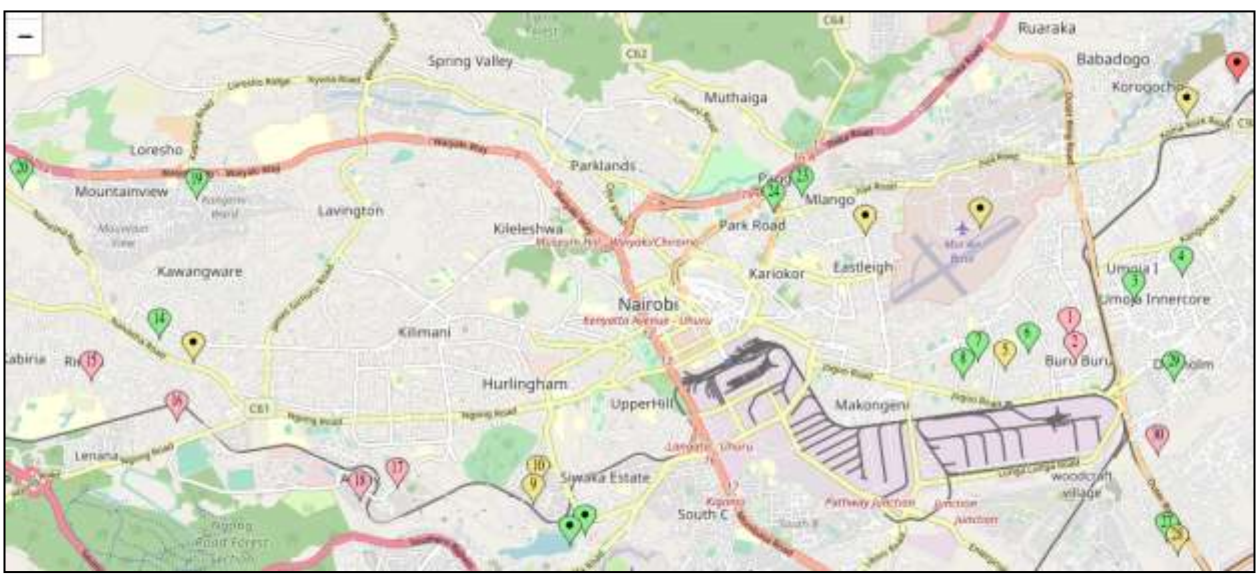

Figure 1: Estimated distribution of sampling sites (not the actual ADM locations).

Pink numbers (7) = all tests negative; Red dot (1) = all tests positive; Yellow dots (4) = hydrogen peroxide and formaldehyde positive; yellow numbers (4) = hydrogen peroxide and microbial contamination positive; green dots (2) = only microbial contamination positive; green numbers (12) = only hydrogen peroxide positive

The adulteration and contamination of milk either for financial gain or through inappropriate handling, processing or storage raises a number of concerns. On one end of the spectrum, it is a matter of fraud with relatively limited health concerns. This is true for example when the milk is diluted with water or starch to increase volume and density. Generally, these may be considered as harmless substances. However, these innocuous substances may themselves be contaminated negating this assumption. On the other end of the spectrum, the deliberate addition of chemicals like formaldehyde into milk not only interferes with its nutritional value but also can cause harm to consumers. At the global level, one of the most publicized case of adulteration is the 2008 Chinese milk scandal [https://www.theguardian.com/world/2008/dec/02/china]. Milk and infant feeds were found to be contaminated with melamine, an adulterant used to increase nitrogen levels and falsify protein content. Widespread adulteration resulted in a number of deaths, with tens of thousands of hospital admissions. Microbial contamination is also a major concern especially when pathogenic microorganisms are involved. The presence of hydrogen peroxide in milk may not be a serious cause for alarm as long as the levels are low. In fact, there have been recommendations about using low percentages of hydrogen peroxide as a preservative [14]. However, such use has not been sanctioned in marketed milk.

In the Kenyan market, there is a paucity of published studies on the quality of marketed milk. In 2005, a study on the quality of milk in Nairobi and neighboring districts [15] was not a widespread problem, and that water was the major adulterant. However, the study found that microbial contamination was widespread but attributed the finding to stringent standards borrowed from developed countries where milk is processed extensively though cold chains. Ndung'u et al. in their 2016 study found that total bacterial count and coliform count of milk marketed in Nyandarua and Nakuru counties were way above recommended levels by the Kenya Bureau of standards [16].

To improve the quality of milk in the formal sector, Kenya has in early 2019 adopted a quality based milk payment system [17]. Such a system gives farmers an incentive to be more meticulous in how they handle raw milk. The benefits of improved milk quality then trickle down all the way to the consumer. Supply of milk though ADMs can benefit by tapping into this system. At their level, small scale suppliers should invest in a small quality control system to test for common adulterants and microbial contamination.

This study had a number of limitations. The levels of adulterants should be assayed to aid in risk assessment. Secondly, for samples testing positive for microbial contamination, the type of bacteria involved was not determined. Thirdly, only two of the commonest adulterants were studied. The presence of antibiotic residues in milk, while not included in this present study, has continued to receive a lot of attention [18–20]. This is justifiable owing to the emergence of antimicrobial resistance as a global threat to modern healthcare. Another group of chemicals that requires attention is that of aflatoxins. A number of recent studies have reported high levels of aflatoxins in animal feeds and milk [21-22].

Routine and detailed surveillance of the quality of milk and other foods is recommended. Findings should be reported in both the scientific and nonscientific press.

CONCLUSION

Adulteration of milk continues to be a major challenge in the local market. In this study twenty one samples, (70% of the samples analyzed) tested positive for hydrogen peroxide, while 5 (16.7%) and 7 (23.3%) samples tested positive for formaldehyde and microbial contamination, respectively. These results indicate that there is need to adopt mechanisms for quality control to improve the quality of milk dispensed in automated dispensing machines.

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