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QUALITY OF MAIZE SUPPLIED UNDER SCHOOL FEEDING PROGRAM AND ASSOCIATED FINANCIAL LOSSES IN TURKANA COUNTY, KENYA

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ABSTRACT

Turkana County, being an arid and semi-arid county is one of the major beneficiaries of the homegrown school feeding program from the government of Kenya. Most of the maize consumed in Turkana county is sourced from other counties as well as neighbouring countries such as Uganda and Ethiopia. Due to the vast distance, high temperatures as well as security challenges, post-harvest losses in the county are inevitable. This study, therefore, sought to establish the losses associated with the quality and safety of maize supplied to public primary schools under the homegrown school feeding program. All suppliers, n=22, who were supplying maize to public primary schools under the homegrown school feeding program, n=128 were included in the study. Maize samples were picked from school stores and analyzed for moisture content, aflatoxin B1, total aflatoxin and fumonisin. Moisture content was determined by AOAC method number AOAC 976.08:2012 while aflatoxin and fumonisin were determined using the ELISA method. Losses were estimated based on the Kenyan standard requirements for maize where any result above the recommended limit was considered a loss. The market price of maize at the time of study, Ksh. 50 per Kg was used to estimate the associated financial losses. The quality losses were Ksh. 15,075,950/= for moisture content and Ksh. 25,805,350/= for grading and live infestation. Safety losses based on aflatoxin B, Total aflatoxin and fumonisin were Ksh. 6,726,850/=, Ksh. 4,362,500/= and Ksh. 1,356,050/=, respectively. In total, Ksh. 53 million would be lost by the county government if the Kenyan standard for maize was well enforced. This shows that the quality and safety of maize supplied to schools under the school meals program is questionable and contributes further to post-harvest losses. Therefore, there is a need for proper sensitization on post-harvest handling among the school suppliers as well as investment in testing infrastructure by the county government.

Key words: Feeding, Losses, school, safety, quality, post-harvest, maize, financial, supplied

INTRODUCTION

A third of the food produced globally is lost or wasted resulting in economic, environmental and social costs. Food supply is resource intensive because it utilizes land, water resources and energy [1]. About 940 billion USD is lost globally every year due to food losses. Sustainable Development Goal (SDG) number 12.3 aims at ensuring sustainable production and consumption patterns and reducing the global per capita food waste at retail and consumer levels as well as reducing food loss at production and along the supply chain by half come 2030.

Maize consumption in Kenya is high with a per capita of 98 kg per annum [2]. Production of the crop has been diminishing and the deficit is supplemented by imports from neighboring countries. Food safety loss as defined by Hoffman *et al*. [3] is the deterioration in the safety of food affecting its healthfulness as well as its economic value. Economic losses can occur through public regulations when food products fail to meet the set quality standards. Food safety losses can also be quantified based on the expected loss of health and life from exposure to hazards such as mycotoxins[4]. This loss is different from other food losses because there are no incentives for safe food and some measures that can help prevent it such as testing are expensive for small-scale value chain actors. Food safety threats are unobservable in most cases without the enforcement of standards in developing countries and therefore most consumers are unaware of the risks associated with unsafe food [4]. The willingness of consumers to pay for safer food is also not guaranteed because of the unseen dangers [5]. Food quality, on the other hand, is observable. For instance, quality attributes such as broken grains, rotten, diseased, discoloured or pest-damaged maize can be checked at the buying point [6]. Quality losses may include loss of nutrients as well as loss of value through downgrading the grains to grades that do not meet national standards. These losses can be quantified using financial terms, however, they may be affected by various factors including seasonal variations [7].

Mycotoxins are among the major contributors to losses along the maize value chain in most African countries including Kenya. They greatly affect the economy as well as the health of both humans and animals. They also hinder the country's goal of achieving food security by limiting food availability [8]. Aflatoxins and fumonisin are the common mycotoxins affecting maize. About 1.2 billion USD is lost due to aflatoxin contamination in the world and Africa accounts for 38% of this loss [9]. These losses are attributed to crop losses when infested with toxigenic fungi, destruction of contaminated produce or loss of value where alternative uses are available and effects on animal and human health. About 83% of freshly harvested and stored grains are lost through contamination with toxins and toxins account for 10% loss of grains annually [10]. The limit for aflatoxin is 10ppb and that for fumonisin is 2ppm.

Turkana County is one of the poorest counties in Kenya and it is arid and semi-arid [12]. Due to the low rainfall and the sandy soils, most foods are not produced in the county hence the heavy reliance on importation [13]. Being a border county, most of the maize grains are sourced from Uganda and Ethiopia. Most households in the county also relies on relief food for their survival because of drought, poverty and food insecurity[14]. The high temperatures in the county, greater than 30ºC could greatly contribute to mycotoxin contamination in stored cereals [15,16]. Studies have shown that school children are exposed to mycotoxins through school meals and therefore the safety and quality of the food supplied to schools is still questionable [17–19]. The school meals program in public schools is supported by the government and if measures are not put in place to ensure the safety and quality of the food supplied, then millions of money can be lost [8]. The aim of this study, therefore, was to determine the quality of maize supplied to schools in Turkana County and the associated economic losses.

MATERIALS AND METHODS

Study site

The study was conducted in Turkana County. The county is located in Northern Kenya, approximately 740 kilometers from Nairobi. It borders Uganda, South Sudan and Ethiopia to the west, north and northeastern respectively. The neighboring counties include Marsabit, Samburu, West-Pokot and Baringo. In the 2019 census, the county had a population of 926,976 people. The county is also arid and semi-arid with a warm and hot climate. The mean annual rainfall in the county is 200mm and temperatures range between 20ºC and 41ºC. The economic activities include pastoralism, weaving, fishing, trade and tourism.

Sampling of maize from suppliers

Purposive sampling was used to identify suppliers of maize to public primary schools in the county. All suppliers supplying maize to schools under the homegrown school feeding program were included in the study, n=22. A composite sample was then picked from each supplier, vacuum packed and transported to the laboratory for analysis.

Sample Preparation

In the laboratory, the samples were milled using a laboratory mill and stored in well-labelled airtight sample bottles.

Moisture content determination

Moisture content was determined according to AOAC method number AOAC 976.08:2012 using a hot air oven for two hours [20]. The analysis was conducted at the University of Nairobi, Department of food science, nutrition and technology laboratory. Each sample was analysed in triplicates and the results were expressed as a percentage.

Grading

Grading of the maize grains was determined by a modification of the method described by Mutungi *et al*. [21]. Briefly, a 200g sample of maize was accurately weighed using a top pan balance and passed through a 4.5mm sieve. The sieve was agitated by hand 30 times. All the broken grains that passed through the sieve were separated from the foreign matter. The grains retained on the sieve were then sorted by hand to remove any remaining foreign matter, pest-damaged grains, rotten and diseased grains and discoloured grains. Each of the separated grains was weighed and the results were expressed as a percentage. The total defects were calculated as per the East African standard for maize grains [22].

$$Total\ defects\ (\%) = \frac{sum(broken + pest\ damaged + rotten\ and\ diseased + discoloured) * 70}{100} \quad (1)$$

Mycotoxin determination

Aflatoxin and fumonisin were determined using the ELISA method. Aflatoxins were extracted from milled maize grains by adding 70% methanol to 20g of the samples and shaking for 30 minutes on an orbital shaker. The mixture was allowed to settle for 5 minutes and filtered into a clean tube. The extracts were then analyzed and quantified as described by Wanjiru *et al.* [23] . For fumonisin analysis, 20g of the milled and homogenized sample was weighed, 100ml of distilled water added and the mixture vortexed for 3 minutes. Five ml of the top layer was pipetted into a clean centrifuge tube and centrifuged at 3500 rpmfor 5 minutes. One ml of the supernatant was then transferred to a clean tube and diluted with distilled water to a ratio of 1:8. Detection and quantification of fumonisin was then done using Helica Biosystems, California USA Fumonisin Hydro kit.

Determination of the associated financial losses

The financial losses were estimated using the formula by Harris and Lindblad [24]. losses were based on different requirements of the East African standard for maize, EAS 2 [22]. The market price of the maize grains at the time of the study, 0.4 USD (Ksh.50) per kilogram, was used in the calculations.

$$Lq = Vg - Va. \quad (2)$$

Where L_q=Value of quality loss
V_g=Value of grain if it was all of a standard set
V_a=Value of the quality of the grain when in store used

Data analysis

Data on the amount of maize in kilograms supplied per school, the moisture content, grading quality as well as aflatoxin and fumonisin was collected and analyzed using Excel, 2016. Descriptive statistics were done and the results were presented in tables.

RESULTS AND DISCUSSION

Moisture and the associated financial losses

The moisture content and the associated financial losses are shown in .

Conflict of interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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Table 1. The moisture content in the maize ranged between 10.1% and 21%. The recommended moisture content for maize in Kenya is 13.5% and therefore, all the grains with moisture above this level were considered not of good quality. Maize from 6 suppliers had a moisture content of 13.5% and below. On the other hand,16 suppliers had maize with moisture contents above 13.5%. Based on the standard requirement for moisture in maize grains, 301,519Kg of maize which translates to Ksh. 15,075,950/= in monetary value would be lost by Turkana County.

Moisture content is a key quality indicator because it greatly affects the shelf life of grains [25]. The high moisture content can lead to the growth of moulds which may produce mycotoxins, make the grains not palatable, and facilitate the growth of bacteria that cause the grans to rot [26]. The moisture content levels were not met by most of the school suppliers for maize in Turkana County. The moisture results obtained in this study were slightly higher than those reported by Kortei *et al.* [27]. This can be attributed to poor postharvest handling [28,29]. Since most of the grains are sourced from other counties such as Trans Nzoia, Uasin Gishu, and Nakuru, transportation may greatly affect the moisture content, especially with unpredictable weather [30]. Storage of the grains before distribution to schools as well as storage in the schools could also contribute to the high moisture content. In their study, Mwangi *et al*.[31] attributed a loss of up to 3.4% to moisture in stored grains. This loss is however reversible. The grains can be dried further until the recommended moisture content is achieved.

Grading and the associated financial losses

Grading is the sorting of grains based on their physical characteristics. The Kenyan Standard [22] specifies three grades for maize based on the total defects in the grains. Those with defects of 5% or below are classified as grade 1,9% and below are classified as grade 2 while grade 3 are those with 14% or below defects. With grade 3 being the minimum acceptable as per the standard requirements, only 5 suppliers met this requirement. Maize grains from 19 suppliers were off-grade. Live infestation is also a grading parameter. It is one of the first quality indicators when a bag of maize is opened. 36% of the suppliers had maize without infestation.

The estimated loss due to grading by the county is indicated in Table 2. 86% of the maize supplied to schools would be rejected based on grading and therefore Ksh. 12,316,750/= would be lost. A loss of Ksh. 13,488,600/= would be encountered by the county if the maize supplied to schools were to be rejected based on live infestation, Table 2.

Grading of cereals and pulses helps remove defects as well as increase the value of the grains. There are incentives for higher grades of cereals and pulses. The price of grade 1 is higher than that of grade 3 cereal because it has fewer defects. The results indicate that suppliers and schools in the county are not conscious of the quality of maize. This also shows a lack of understanding of the requirements of the maize standard in Kenya and poor postharvest handling [32]. This could be attributed to poor storage conditions of the grains. The high temperatures in Turkana county increase the moisture content of the grains in poorly ventilated maize stores, resulting in mould growth and grain rotting. The losses due to grades are also reversible through sorting. The defects can be lowered to acceptable levels either manually where the volumes are small or mechanically using sorting equipment for the large volumes.

Weevils and the larger grain borer are the major storage pests affecting maize grains in Kenya. Degroote *et al*. [33] found that weevils cause up to 21% loss in the grain and 18% loss is caused by the larger grain borer. The presence of even a single live pest in the grains can be a sign of a bigger problem in the grains. Since most of the grains purchased are to be consumed within four months or even a year, live pests are a threat. If not controlled, they can destroy up to 85% of the stored grain [34]. They can also introduce other problems in the grain. For instance, they can increase the moisture content as they respire which may lead to the growth of moulds and eventually mycotoxin contamination can occur [35]. Insects also reduce the nutritive value of the grains. In a study conducted by Mwangi *et al*. [31] on postharvest losses in off-farm grain stores, insects were the largest contributor to the total perceived losses of the grains.

Mycotoxin content and the associated financial losses

The mycotoxin content and the associated financial losses are indicated in

Table 3. Maize samples from 46% of the suppliers were contaminated with aflatoxin B1 above the recommended limit of 5ppb in maize. The maximum allowable limit for total aflatoxin for maize in Kenya is 10 ppb and 32% of the suppliers failed to meet this requirement. Fumonisin contamination was low among the two mycotoxins tested with only 3 suppliers having maize that exceeded the standard requirement of 2 ppm maximum. About 137,900Kg of maize would be rejected based on aflatoxin B1 contamination. In monetary value, this translates to Ksh. 6,726,850/=. Based on failure to meet total aflatoxin requirements, the county could lose Ksh. 4,362,500/=. A loss of Ksh. 1,356,050/= would be incurred by the county based on the fumonisin results obtained.

Aflatoxin and fumonisin are the major mycotoxins affecting most cereals and pulses in Kenya. Aflatoxin is a secondary metabolite produced by *Aspergillus flavus* and *Aspergillus parasiticus*. Fumonisins on the other hand are produced by *Fusarium* species of fungi. The production of this mycotoxins is promoted by high moisture content and high temperatures. The fact that they affect the grains while in the farm and continue to accumulate in the other stages such as storage makes it difficult to control them [36]. The two mycotoxins have been the major contributors to losses in maize and maize products in Kenya. Different brands of maize flour have been recalled from the Kenyan market by the Kenya Bureau of Standards because of aflatoxin contamination [37]. Imports from neighbouring countries have also been stopped because of these two mycotoxins [38]. Aflatoxin B1 is the most common aflatoxin type compared to the G types. It is the most potent and the limits in Kenya are 5ppb for human food and 10ppb for most animal feeds. Grains costing up to 6.7 million Kenyan shillings were contaminated with aflatoxin B1. Most of the suppliers met the legal requirement for fumonisin in maize in Kenya which is 2ppm. Only one supplier had an extreme of 4.11ppm. Mycotoxin contamination in the maize can also be due to the high temperatures in the county, poor storage conditions and poor post-harvest handling. It has been reported that temperatures of between 22ºC and 29ºC coupled with inappropriate storage conditions promote the proliferation of fungi and production of mycotoxins [39]. Ngum *et al*. [40] identified climate change and storage techniques as some of the primary contributors to high mycotoxins in food from Africa. Jere *et al.* [41] also found that school food handlers including suppliers used poor post-harvest handling practices which can contribute to mycotoxin contamination. The results obtained by Ngure *et al.* [42] were lower than those obtained by this study for aflatoxin B1 but they reported a higher contamination of fumonisin.

In their study, Mitchell *et al*. [43] estimated the losses in the US corn industry caused by aflatoxins to be between 0.521-1.68 billion USD. The losses associated with mycotoxins are irreversible. The contaminated grains can be subjected to alternative use such as animal feed processing [32]. However, this can only be applied to grains with acceptable levels for the animal feed industry. In Kenya, most animal feeds have 20 ppb as the maximum limit for total aflatoxin. From the results, only one supplier had levels above 10 ppb for human consumption and below 20 ppb for animal feeds. This shows that the majority of the grains would still be destroyed resulting in a loss of about 3.8 million Kenyan shillings due to aflatoxins only. The grains can also be subjected to other detoxification methods such as nixtamalization and ozonation, but these are yet to be taken up on a large scale in Kenya. Additional charges may also be incurred because most destruction sites are far from the county.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The results of this study concluded that maize from most school suppliers in Turkana County did not meet legal requirements. The maize was contaminated with aflatoxin and fumonisin which may pose a great health risk to school children. The losses associated with quality parameters such as moisture, grading and mycotoxins were also high with the county losing more than Ksh.50 million. The findings of the study can be used to emphasize the importance of meeting standard requirements.

The county government should put measures in place to check the quality and safety of foods from school suppliers before procurement to prevent financial losses. This can be done through collaboration with other government institutions with testing facilities such as the Kenya Bureau of Standards, Government Chemist, National Public Health Laboratory among others.

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Conflict of interest

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Table 1:Losses due to moisture

Supplier	Maize Quantity (Kg)	Maize cost (Ksh)	Moisture (%)	>13.5 %	Loss (Ksh)
A	5450	272500	15.9	Fail	272500
B	29400	1515500	15.9	Fail	1515500
C	10900	485550	15.7	Fail	485550
D	6850	321250	14.4	Fail	321250
E	16750	763750	13.5	Pass	0
F	26100	1305000	14.9	Fail	1305000
G	29100	1600600	15.0	Fail	1600600
H	8250	398750	14.9	Fail	398750
I	12850	566300	21.0	Fail	566300
J	98700	4418750	17.9	Fail	4418750
K	13650	600600	11.5	Pass	0
L	33100	1512100	12.8	Pass	0
M	4750	237500	15.6	Fail	237500
N	1350	70200	10.1	Pass	0
O	6250	281250	13.9	Fail	281250
P	5150	242050	12.3	Pass	0
Q	22150	1025300	15.1	Fail	1025300
R	14200	670400	14.9	Fail	670400
S	18050	722000	17.3	Fail	722000
T	20750	942500	15.9	Fail	942500
U	12100	551500	13.5	Pass	0
V	5400	312800	16.2	Fail	312800
Total	**401250**	**18816150**	**328.2**		**15075950**

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Table 2:Losses due to grading

Supplier	Maize Quantity (Kg)	Maize Cost (Ksh)	Defectives (%)	Grade	Loss	Live Infestation	Loss (Ksh)
A	5450	272500	10.5	G 3	0	Absent	0
B	29400	1515500	15.7	OFF	1515500	Present	1515500
C	10900	485550	7.8	G 2	0	Present	485550
D	6850	321250	15.2	OFF	321250	Present	321250
E	16750	763750	38.5	OFF	763750	Present	763750
F	26100	1305000	30.2	OFF	1305000	Absent	0
G	29100	1600600	13.2	OFF	1600600	Present	1600600
H	8250	398750	19.2	OFF	398750	Present	398750
I	12850	566300	30.9	OFF	566300	Present	566300
J	98700	4418750	13.9	G 3	0	Present	4418750
K	13650	600600	9.3	G 3	0	Present	600600
L	33100	1512100	19.4	OFF	1512100	Absent	0
M	4750	237500	40.0	OFF	237500	Present	237500
N	1350	70200	17.8	OFF	70200	Absent	0
O	6250	281250	21.3	OFF	281250	Present	281250
P	5150	242050	19.6	OFF	242050	Absent	0
Q	22150	1025300	23.7	OFF	1025300	Present	1025300
R	14200	670400	19.1	OFF	670400	Absent	0
S	18050	722000	9.0	G 2	0	Present	722000
T	20750	942500	17.1	OFF	942500	Absent	0
U	12100	551500	28.0	OFF	551500	Present	551500
V	5400	312800	28.9	OFF	312800	Absent	0
Total	**401250**	**18816150**			**12316750**		**13488600**

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Table 3: Losses due to Safety

Supplier	Maize Quantity (Kg)	Maize Cost (Ksh)	AFB1 (ppb)	Loss (Ksh)	AFT (ppb)	Loss (Ksh)	FUM (ppm)	Loss (Ksh)
A	5450	272500	0	0	0	0	1.74	0
B	29400	1515500	0	0	0	0	0.66	0
C	10900	485550	0	0	0	0	0.4	0
D	6850	321250	0	0	0	0	4.11	321250
E	16750	763750	6.64	763750	6.64	0	1.3	0
F	26100	1305000	83.37	1305000	89.57	1305000	0.1	0
G	29100	1600600	7.89	1600600	7.89	0	0.28	0
H	8250	398750	29.05	398750	29.05	398750	0.32	0
I	12850	566300	19.44	566300	19.44	566300	1.83	0
J	98700	4418750	0	0	0	0	0.11	0
K	13650	600600	0	0	0	0	0.35	0
L	33100	1512100	2.48	0	2.48	0	1.78	0
M	4750	237500	91.06	237500	243.84	237500	0	0
N	1350	70200	0	0	0	0	0.16	0
O	6250	281250	0	0	0	0	0.15	0
P	5150	242050	41.97	242050	41.97	242050	0	0
Q	22150	1025300	0	0	0	0	0	0
R	14200	670400	179.67	670400	206.97	670400	0	0
S	18050	722000	0	0	0	0	2.22	722000
T	20750	942500	60.39	942500	66.32	942500	1.82	0
U	12100	551500	0	0	0	0	0.81	0
V	5400	312800	9.46	0	9.46	0	2.78	312800
Total	**401250**	**18816150**		**6726850**		**4362500**		**1356050**

AFB1-Aflatoxin B1, AFT-Total Aflatoxin, FUM-Fumonisin

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