2004 Reduction of Post-Slaughter Losses in the Meat Value Chain through Value Addition and Innovative Processing Technologies

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Abstract
Growing populations, urbanization and economic growth in developing countries are contributing to growing demand for livestock and livestock products. However, post-slaughter losses (50%) in the meat value chain remain a challenge for pastoral communities in Kenya. The study aimed to use simple low-cost and innovative meat processing technologies to produce meat products based on indigenous knowledge of the pastoral communities. A multi-method research approach was used to collect data using structured questionnaires in exploratory surveys, and Focus Group Discussions among pastoralist. Laboratory simulations for the new products and process development were done in the University of Nairobi laboratories. The effect of size of meat chunks, oil types, oven-drying time and deep-frying time on the physical, chemical and sensory attributes of deep-fried products was determined. The products were processed using a previously documented process flow analysis for Nyirinyiri, Enyas, Ng'amorumoru and Olpurda. The developed meat products had high proteins (52.10% to 66.48%), energy (329.69 Kcal/100g to 404.20 Kcal/100g); fats (10.78% to 15.40%) and moisture (14.05% to 19.35%) content were considerably low. No pathogenic microorganisms were present. Deep-frying and cooling products in the frying media were seen to increase the fat content (40-48%), carbohydrates (80-91%) and caloric value (54-61%) of the products. The sensory evaluation showed that Nyirinyiri was most preferred (5.34 ± 0.337) followed by Ng'amorumoru (5.23 ± 0.00) ($p<0.05$). The products had high shelf stability (6 months) and were low-cost (KES 200-250/kg). This showed that simple meat processing technologies like deep frying can be used in preservation of meat products hence loss reduction.

Keywords:
Meat value chain, post-slaughter losses, processing technology, value addition

Introduction
Post-slaughter losses in the meat value chain in most developing countries have been attributed to inappropriate post-slaughter handling, under-utilization of edible by-products and lack of appropriate processing technologies (Cederberg et al., 2011). Post-slaughter losses contribute up-to a third of total losses along meat value chains. Pre-slaughter losses include weight loss or even death during loading, transportation and marketing or quality deterioration during handling, slaughter and storage (Cassens, 2008; Parfitt et al., 2010; Cederberg et al., 2011). This is despite the fact that Kenya has an estimated livestock resource of 14.1 million indigenous cattle and 3.4 million exotic cattle. Red meat from food animals has been reported to be a major source of proteins, carbohydrates and bioactive compounds such as zinc, iron, conjugated linoleic acid and B vitamins. Despite its great nutritional benefits, about 20 per cent of meat is lost post-slaughter in the Sub-Saharan region (Parfitt et al., 2010). This has necessitated the pastoral communities to use a number of techniques and technologies for post-slaughter handling, processing and preservation to prolong its shelf-life to minimize losses (Cassens, 2008; Parfitt et al., 2010; Cederberg et al., 2011). This study presents scientific evidence on how value addition and innovative processing technology can be leveraged to address these challenges and opportunities for commercial exploitation to reduce post-slaughter losses along the meat value chain. The study also assessed the physico-chemical and sensory attributes of selected indigenous pastoral meat products with potential for commercial up-scaling in Kenya. The developed deep fried products included Nyirinyiri which is prepared and consumed in North-Eastern Kenya mostly by the Somali and Borana communities in Garissa County, Enyas and Ng'amorumoru commonly produced in Turkana County in Northern Kenya by the Turkana community and Olpurda prepared in Kajiado County by the Maasai community were based on four indigenous products which were found to be the most competitive products based on both quality cues and measures of competitiveness. The process technology was based on indigenous knowledge and techniques used by pastoral communities in Kenya.

Materials and Methods
A multi-method research approach was used to collect data using structured questionnaires in exploratory surveys, and Focus Group Discussions among pastoralist communities in Turkana, Garissa, Kajiado and Isiolo Counties. Laboratory simulations for the new products and process development were done in the pilot plant, Department of Food Science, Nutrition and Technology using 60 kg lean steak from hind leg of mature goat obtained from Dagoretti slaughterhouse. Central composite design was used to bring out different potential factors which contribute to quality of the deep-fried products. The effect of size of meat chunks, oven-drying time and deep-frying time on the physical, chemical and sensory attributes of deep-fried products was also determined. Standard analytical methods were used to assess the microbial profile (Listeria spps evaluated using ISO 11290-1:2004; E. coli evaluated using ISO 16649-3:2001; Staphylococcus evaluated using ISO 6888-1:1999; Salmonella evaluated using ISO 6579 and Total Plate Count evaluated using ISO 4833-2:2013. Sensory analysis methods were based on ISO 8587:2006 while chemical analysis (moisture content, carbohydrates, protein, fat, fiber and peroxide values) were analyzed according to the standard methods of AOAC standard methods (AOAC, 2008) and stability tests using accelerated shelf life analysis at 54 0C for 6 days. Physical properties like color were assessed using a colorimeter, texture profile analysis using a texture analyzer machine and fatty acids profile was done using gas chromatography. Sensory evaluation was used to analyze color, appearance, ease of scooping, preference based on size of meat chunks, preference based on oiliness, odor, taste and chewiness using 11 trained panelists. Statistical package data SPSS 18.0 (SPSS Inc., Chicago, IL) was used for statistical analysis and to bring out comparisons among means.

Table 1: Chemical composition and peroxide values of pre-dried and deep-fried beef chunks

Size of chunks (mm)	Drying time (minutes)	Moisture (%)	Lipids (%)	Proteins (%)	Fiber (%)	Total ash (%)	Soluble carbohydrates (%)	Energy (Kcal/100g)	Peroxide value (mEq/kg)
10	0	15.7±1.7	15.4±1.9	65.4±5.2	0.1±0.1	3.9±0.1	1.0±0.4	404.2±20.4	2.5±0.1
10	60	14.9±3.6	14.0±2.1	65.1±6.4	0.1±0.1	3.8±0.6	1.0±0.2	394.9±36.2	1.3±0.7
10	120	14.2±2.3	11.8±1.2	63.7±5.7	0.2±0.1	3.8±1.2	4.9±1.5	380.8±18.5	1.2±0.2
15	0	17.1±3.0	15.0±2.1	64.0±6.7	0.1±0.1	3.9±0.9	2.9±1.1	375.7±40.3	1.3±0.7
15	60	16.0±2.4	10.8±1.7	65.3±6.0	0.1±0.1	3.9±1.0	2.2±0.3	396.1±15.1	0.8±0.7
15	120	14.1±3.6	12.0±1.5	66.5±9.3	0.2±0.1	3.9±1.4	0.4±0.1	402.1±29.6	0.5±0.1
20	0	19.4±5.5	12.6±3.9	52.1±6.5	0.1±0.1	3.8±2.0	2.0±0.6	329.7±22.9	3.7±1.8
20	60	18.8±3.7	13.1±2.0	60.2±4.2	0.1±0.1	3.8±1.0	2.0±0.8	367.9±15.2	2.6±0.5
20	120	14.6±3.1	14.1±2.0	62.7±7.7	0.1±0.1	3.7±0.4	0.5±0.6	379.9±43.8	3.4±2.8

Results and Discussion

Results showed that there is a technological base for production of high quality, shelf stable and low-cost commercial meat products. Raw meat had approximately 78% moisture, 18% proteins, 2 % lipids, 2% carbohydrates and 2% ash content (Table 1). Nyirinyiri was pre-dried by sun-drying in the sun for about two hours while Enyas, Ng'amorumoru and Olpurda were pre-dried under shade for about two hours, followed by boiling and evaporating excess water. Boiling and evaporating excess were more effective in moisture reduction than sun-drying. The developed meat products have high proteins (52.10% to 66.48%), energy (329.69 Kcal/100g to 404.20 Kcal/100g); fats (10.78% to 15.40%) and moisture (14.05% to 19.35%) content were considerably low (Table 1). No pathogenic microorganisms were present. Deep-frying and cooling products in the frying media were seen to increase the fat content (40-48%), carbohydrates (80-91%) and caloric value (54-61%) of the products. The smaller the meat chunks, the higher the fat content mainly because of increased surface area to volume ratio of the meat chunks. The products were cooled in the deep-frying media to create anaerobic environment for storage (Figure 1).

Figure 1: Deep frying technology for beef processing

The sensory evaluation showed that Nyirinyiri was most preferred (5.34±0.337) followed by Ng'amorumoru (5.23±0.00) ($p<0.05$). It was reported that smoking, addition of spices and herbs, and incorporation of ghee and rendered fat in the formulations improved sensory attributes tested particularly appearance and color (Figure 2). Taste, overall acceptability, convenience and color were the most preferred attributes while texture, size, odor and oiliness were scored least mean values ($p<0.05$) (Table 2). The products had high shelf stability (6 months) and were low-cost (KES 200-250/kg). Pastoral products were cooled in the deep-frying oil so as to create anaerobic condition as the chunks are encapsulated in the solidified fat. Studies have found out that products tend to take up oil during post-frying cooling; this explains the high lipids content of deep-fried products cooled with deep-frying media.

In case animal fat was the deep-frying media, the solidified fat will form a network that is tough and products have to be reheated before consumption. It has also been reported that the oil used for deep-frying was found to influence the nutritional qualities of meat chunks; deep-frying in animal fat results in lower moisture contents and higher proteins, fats and carbohydrates contents. This translated into lower score on convenience as observed for Olpurda. Ghee and vegetable oils were semi-liquid during storage; hence the chunks could be easily scooped. Palm oil was used since it was cheaper than sunflower or corn oil (Scollan et al., 2006; Mohamed et al., 2008). All the products were within acceptable ranges with regards to chemical quality. However with storage, only the cured and smoked batches maintained their stability within the acceptable limits. With regards to microbial quality, the beef chunks were in line with the Kenya bureau of standards requirement (KEBS) legal limits (KS 2455:2013, KS59-2:2013) with regards to total variable counts, catalase positive Staphylococcus, Salmonella, E. coli and Listeria.

Figure 2: Final finished deep fried product

However, the products became unacceptable during storage at accelerated temperature with the smoked samples being most stable against microbial deterioration. Packaging in airtight plastic and glass jars was seen to increase stability of the products with regards to chemical and microbial spoilage. Vacuum packaging in polythene sheet was not effective in improving stability as it failed to maintain its integrity during storage. In case animal fat was the deep-frying media, the solidified fat will form a network that is tough and products have to be reheated before consumption. It has also been reported that the oil used for deep-frying was found to influence the nutritional qualities of meat chunks; deep-frying in animal fat results in lower moisture contents and higher proteins, fats and carbohydrates contents. This translated into lower score on convenience as observed for Olpurda. Ghee and vegetable oils were semi-liquid during storage; hence the chunks could be easily scooped. Palm oil was used since it was cheaper than sunflower or corn oil (Scollan et al., 2006; Mohamed et al., 2008). All the products were within acceptable ranges with regards to chemical quality. However with storage, only the cured and smoked batches maintained their stability within the acceptable limits. With regards to microbial quality, the beef chunks were in line with the Kenya bureau of standards requirement (KEBS) legal limits (KS 2455:2013, KS59-2:2013) with regards to total variable counts, catalase positive Staphylococcus, Salmonella, E. coli and Listeria. However, the products became unacceptable during storage at accelerated temperature with the smoked samples being most

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Table 2: Mean score of the sensory attributes of the products

Size of cut (mm)	Drying period (mins)	Color	Appearance	Ease of scooping	Oiliness	Size of cut	Odor	Taste	Chewiness	Overall acceptability	Mean score
10	0	4.5 a	4.5 a	5.9 a	5.8 a	5.3 ab	4.9 a	4.9 a	3.3 a	4.6 a	4.9
10	60	4.3 a	4.3 a	5.9 a	5.7 a	5.1 ab	4.8 a	4.9 a	3.8 ab	4.6 a	4.8
10	120	4.3 a	3.9 a	5.5 a	5.5 a	4.7 a	4.7 a	4.9 a	3.9 ab	4.7 a	4.7
15	0	4.9 a	4.7 ab	5.3 a	5.2 a	5.0 ab	5.0 a	5.2 a	4.4 b	4.9 a	5.0
15	60	4.9 a	4.5 a	5.4 a	5.3 a	5.6 ab	5.1 a	5.2 a	4.2 ab	4.9 a	5.0
15	120	4.8 a	4.5 a	5.7 a	5.3 a	5.8 ab	5.1 a	5.0 a	3.7 ab	4.8 a	5.0
20	0	6.1 b	5.8 b	5.5 a	5.7 a	6.3 b	5.0 a	4.9 a	3.5 a	4.6 a	5.3
20	60	5.1 ab	5.7 b	5.3 a	5.4 a	5.6 ab	5.4 a	4.7 a	4.3 b	4.7 a	5.1
20	120	5.1 ab	5.1 ab	5.3 a	5.1 a	5.4 ab	5.6 a	4.6 a	4.6 b	4.8 a	5.1
Mean		4.9	4.8	5.5	5.4	5.4	5.1	4.9	4.0	4.7	

Mean ± standard deviation (N= at least three determinations); Means followed by the same letter are not significantly different from each other ($p < 0.05$)

Conclusions and Recommendations

The study concluded that post-slaughter losses can be reduced by value addition and upgrading of indigenous process techniques with great potential for commercialization in Kenya. Further research is needed to up-scale this technologies for integration into the formal meat sector for income generation and creation of employment for the pastoral communities. Post-harvest losses can be reduced by increasing efficiency along the chains, value addition and by- products utilization. In addition, the research recommends use of locally available meat processing and packaging technology and use of non- meat functional ingredients utilization to minimize losses, increase shelf-life and improve utilization of slaughter by-products. In addition, there is need to increase extension services for improving hygiene and safety especially at the low market ends.

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