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Quality Characteristics and Microbial Status of Beef Smoked with Different Plant Materials

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Target Audience: Animal Scientist, Meat Scientist, Extension Officers and Meat Processors

Abstract

A study was conducted to evaluate the effect of smoking beef using different plant materials as sources of smoke in Zaria, Kaduna State. The effect of smoke from four plant materials (*Acacia raddiana, Eucalyptus camaldutensis, Azadirachta indica* and *Cocos· nucifera*) on organoleptic, microbial and physicochemical properties of smoked beef was evaluated. There was no significant (P>0.05) difference among the sources of fuel wood tested on the overall acceptability of smoked meat. The organoleptic scores (1.40-3.50) were lowest for beef smoked with in C. *nucifera* and highest for beef smoked with A. *raddiana* (standard check). The pH values were within the accepted limit (5.5-6.5). Percentage thermal shortening was highest (7.00 %) in beef smoked with A. *raddiana*. Total viable counts/Aerobic plate count, coli-form counts were all within safe limits (i.e. <½ million/g). It was concluded that *Eucalyptus camaldutensis* (Turare), *Azadirachta indica* (Neem) and *Cocos nucifera* (coconut husk) are good sources of fuel wood and can be used as an alternative to *Acacia raddiana* for smoking beef.

Key words: Smoking, Beef, Organoleptic, Proximate, Microbial count

Description of problem

Meat being nutritious with high moisture content and nearly neutral pH is a good culture medium for many micro-organisms (bacteria, yeasts moulds) and as such, classified among perishable foods whose contamination with spoilage organisms is almost unavoidable (1). This makes meat preservation more difficult than other kinds of food as it may result in oxidative rancidity, discolouration, mouldiness, off flavour, sliminess etc. The kind and amount of spoilage in meat depends upon the availability of nutrients, presence of oxygen, temperature and pH at the storage time of the product, generation time of the spoilage microorganism under given environment (2). It is necessary to minimize deterioration in order to prolong the time during which acceptable levels of quality are maintained. This depends upon the processing and preservative method used and the inherent properties of the meat in question (2).

Meat smoking as a method of red meat preservation dates back to prehistoric time. Preservation by smoking is achieved by dehydration and antibacterial effect of the smoke. Smoked meat has good shelf life unless rehydrated. Handling and storage methods are primarily concerned with minimizing microbial contamination and retarding microbial growth and activity (3). Smoking involves the use of wood fuel which in turn affects product quality. Smoking improves flavor and appearance of meat (4), making them a delicacy in many communities. Smoking is normally used in combination with salting. The moisture content drops to 10-40 % depending on the smoking process.

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An alien tree species that has encroached the North West region of Nigeria is *Eucalyptus Camaldutensis* (Turare). It has potentials as a wood fuel though it has not been reported as a source of smoke for meat smoking in Nigeria. It also has edible component and can ease pressure on *Acacia raddiana* and Doka which are the current tree of choice for meat smoking in West Africa (5). Coconut *(Cocos nucifera)* plantations provide numerous products such as coconut meat, milk and husks. Coconut husks can be used for cooking and as the heating base for smoking meat and fish. The use of coconut husks for fish smoking was tried by (6, 7), Results showed that fish smoked using coconut husk had good sensory qualities. The main interest in using Neem (*Azadirachta indica*) in meat smoking is because of activity of its components as a deterrent for both insect activity and mould. It has multiple pesticidal and medicinal properties. Smoke from its' leaves are used as insect repellant, about 135 different compounds are found in every part of the tree and it also has antimicrobial effects (8). Studies involving use of Neem wood for meat smoking in Nigeria for control of insect infestation during storage of smoked meat are limited. Variations in the quality of the meat products produced due to the type of wood fuel used for smoking have however not been monitored closely in Nigeria and exact statistics of storage losses of smoked meat is not available but observations reveal that post processing losses of the smoked meat do occur during storage. Therefore, any reduction in processing and post processing loss by simple modifications of existing methods will benefit the meat sellers as well as introduce newer varieties of meat products. The objective of this study is to determine the effect of smoking beef with *Acacia raddiana, Eucalyptus camaldutensis* (Turare), *Azadirachta indica* (Neem) and *Cocos nucifera* (coconut husk) on the sensory properties, physicochemical composition and microbial load.

Materials and Methods:

Nine kilogram of beef round from a freshly slaughtered 3 years old bull was obtained from the Animal Product Laboratory Department of Animal Science, Ahmadu Bello University was used for the study, After excising muscle from carcass meat was trimmed of any extra muscular fat and cleaned thoroughly with water. The round was held for 24 hours at 4^0C, after which it was cut and sliced into pieces weighing 70-90 grams and 6-8 cm wide. The sliced pieces were sprinkled with tincture of salt.

Meat smoking trays were oiled with food vegetable oil prior to meat distribution to avoid sticking. A total of 1000 gram sliced beef round were placed on trays in the smoke oven, same was done for each treatment. The trays with the meat were transferred under a shade and placed at an angle to enable the meat drip dry for 20-30 minutes prior to smoking.

An upright drum smoke house with stoke holes was used for the smoking, Small logs of wood from *Eucalyptus camaldutensis* (Turare), Acacia raddiana and *Azadirachta indica* (Neem) obtained from Savanna Forestry Research Institute, Forestry Institute of Nigeria, Ahmadu Bello University, Zaria were cut into chunks using a power saw. Smaller pieces were cut using hand saws from the chunks to give smaller pieces of 50 cm length and a fairly uniform thickness of 4.0 to 7.0 cm. The coconut husks (*C.nicifera*) was utilized the way they are in nature when dried. The fire was lit 15 minutes before smoking started using dried grass and allowed to burn till the flames die off and only smoldering wood remained. The beef samples were transferred to the smoking chambers already prepared. Each set of trays with 1000 g of meat was then smoked using the four tree types in four different ovens.

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The treatments were: Meat smoked with Acacia (MA), Meat smoked with Eucalyptus (ME), Meat smoked with Neem (MN) and Meat smoked with Coconut husk (MC).

The fire from the plant materials was controlled by closing the stoke holes during smoking to allow less air. To control the excessive temperature in the ovens, the intensity of the fire was reduced by intermittent withdrawal of some of the logs from the fire point, the temperature of the oven was measured at intervals to ensure it was within the range of 50-80°C. The positions of the meat samples were changed at intervals to ensure uniform penetration of smoke. At the end of the 60 -90 minutes of smoking, meat samples were removed from the kilns and exposed to air to cool for 5-10 min in accordance with procedure of (9).

The smoked beef samples packed in labeled, clean, plastic containers were stored in the Animal Product laboratory. Proximate, organoleptic and microbial analyses were also carried out.

Determination of Physical Properties

Percentage cooking loss was determined by evaluating the differences in weight of cooked sample from initial divided by the weight before cooking multiplied by 100.

Percent cooking loss

$$= \frac{\text{initial sample wt} - \text{cooked sample wt}}{\text{initial sample wt}} \, x\, 100$$

Percentage moisture content was determined by the air oven method using 10 grams of meat samples at 80°C to a constant weight. The difference in weight before and after smoking divided by weight before smoking multiplied by 100 was recorded (10).

$$\text{MC}\ (\%) = \frac{\text{LWS}}{\text{WFS}} \times 100$$

Where MC = Moisture Content (%), LWS = Loss in Weight of Sample and WFS = Weight of Fresh Sample

Determination of thermal shortening was carried out according to the procedure described by (11). Cores taken from beef round and length measured prior to broiling in a fire stand for 10 min. After broiling, the beef cut was allowed to cool to room temperature and the length measured again with the difference in length expressed as percentage thermal shortening.

Thermal shortening (%) = (initial length – final length) × 100

Percentage water holding capacity was determined following a slightly modified method by (12). In the process, intact samples (10 x 10 x 5 mm) were weighed individually from the smoked beef samples on two filter papers each and pressed for a minute, using a weight of 10 kg. The amount of water released from the sample was measured indirectly by measuring the area of the filter paper wetted relative to the area of pressed sample. The water holding capacity (WHC) of the meat was calculated using the formulae developed by (12).

$$\text{WHC} = \frac{100 - (\text{Ar} - \text{Am}) \times 9.47}{\text{Wm} \times \text{Mo}} \times 100$$

Where

Ar= Area of water released form meat (cm^2),

Am = Area of meat sample (cm^2)

Wm= Weight of meat in mg,

Mo = Moisture content of meat %, 9.47 is a constant factor.

The pH of fresh beef and smoked products were determined according to the method

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described by (13). The pH was measured in an aqueous extract from 1g of the dried samples homogenized in 10 ml distill water. The pH was measured using a Checker pH meter.

Determination of proximate composition
Proximate analyses were carried out using 14 methods which include protein determination using Kjeldahl method, fat extraction via Soxhlet method, crude fiber determination using digestion with sulphuric acid and moisture determination by drying the sample for 16-18 hours at 100-102°C in an oven at the Animal Science Departmental Biochemical Laboratory of Ahmadu Bello University, Zaria.

Microbial Analysis
25g/225ml of 0.1% peptone water and 5g of sample were weighed out using aseptic technique, and homogenized in enrichment medium to obtain 10^{-1} dilution. 10^{-1} bacterial suspension was serially diluted to 10^{-4}. 0.5 ml of each set pipetted onto the surfaces of two plates; Mac Conkey for coliforms and Nutrient agar for Total viable count and immediately spread out with a sterile glass spreader using a standard pour plate technique. The Total viable count was calculated from the average colony count/plate after incubation. Microbial load guide in animal food product, according to (15) is shown in Table 1

Table 1: Standard Microbial load specification on animal food product.

Grades	TVC (total viable count)/g at 30°C	Description
I	<½ million	Satisfactory
II	½ million to <10 million	Passable
III	10 million and more	Unsatisfactory

(Wilson et.al., 1981)

Sensory Evaluation
Smoke-cooked beef from round was cut into bites sample sizes and served in plates to a twenty member semi-trained panelists. The organoleptic parameters that were evaluated include colour, taste, odour, texture and provision for a score on overall acceptability. A 5 point hedonic scale was used with a score of 5 indicating 'extremely acceptable', 4 'very acceptable', 3 'acceptable', 2 'fairly acceptable', 1 'not acceptable'. A score below 2 was considered not acceptable. The meat samples were coded with numbers of 2 digits indicating no information about the samples to avoid bias in preferred treatments. The panelists received each sample separately, rinsing their mouth in-between samples.

Statistical Analysis
All data obtained were subjected to analysis of variance (ANOVA), and significant means separated using the Duncan's Multiple Range (DMR) test. The SAS computer package was used for all statistical analysis (16).

Results and discussion
Percentage water holding capacity, cooking loss, thermal shortening and pH of beef smoked with *Acacia raddiana, Eucalyptus camaldutensis, Azadirachta indica* and *Cocos nucifera* husk are shown in Table 2. Water holding capacity, which is the ability of meat to retain its water during external forces such as cutting, heating, grinding and pressing, gave values that ranged between 11 – 15 % which is lower than values (59 %) reported by (17). This is important in meat processing as it influences the overall eating quality. Beef smoked with eucalyptus gave better water holding capacity (10.59 %). When meat is heated, protein denatures and coagulates causing spaces within the myofibril protein to

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decrease consequently. Thermal shortening ranged from 5.71 -7.00 % which also occurs as a result of structural changes caused by heating. There is a positive relationship between thermal shortening, Water Holding Capacity and product yield. Hence, the percentage thermal shortening, water holding capacity and cooking loss were highest in beef smoked using acacia raddiana suggesting higher temperature produced by *Acacia raddiana* wood during the smoking. Tronberg (18), reported that cooking induces structural changes and in turn decreases the water holding capacity of meat, thereby causing increase in shortening and rigidity, hence reduced moisture content. Cooking loss refers to the combination of liquid and soluble matter lost from the meat during cooking. Cooking loss percent was highest in beef smoked using *Acacia raddiana* (60 %). Heymann (19), reported that the cooking loss is mostly water and could be caused by protein denaturation which causes less water to be entrapped within the protein structures held by capillary forces. Okubanjo (20) opined that water or cooking loss is of economic concern because it affects weight loss along the distribution chain. Values obtained in this study are incomparable with those reported by (17) for oven dried beef. The pH values for fresh beef were below the maximum accepted limit of 6.0 suggested by (21) and sited by (17) for fresh meat, suggesting that the products were produced from well-nourished and rested stock. The pH of smoked beef ranged from 5.80 to 6.50.

TABLE 2: Physical Parameters of Smoked Beef

Samples	pH	Cooking loss %	Thermal shortening %	W.H.C %
MA	6.00	60.00	7.00	11.34
ME	6.10	43.15	5.71	10.5 9
MN	5.80	59.00	6.70	13.01
MC	6.50	52.00	6.19	14.75

MA: Meat smoked using *A. raddiana,* ME: Meat smoked using *E. camaldutensis* MN: Meat smoked using Neem, MC: Meat smoked using Coconut husk

The Percentage dry matter content was highest (64.04 %) in beef smoked with coconut husk followed by acacia, eucalyptus and neem, respectively (Table).There was an inverse relationship between percentage dry matter and Cooking Loss of smoked meat irrespective of the wood fuel used (Table 3). The inverse relationship observed in this experiment agrees with report by (17). The Crude Protein value ranged between 40.93 - 43.87 %, with beef smoked with Neem having a higher value of 43.87 %. The high protein content observed in beef smoked with the various wood fuel sources agrees with (22) who reported that Intermediate Moisture Meats are meats low in moisture content which have higher protein than raw protein equivalent and are less bulky. However, the production process has been reported to lead to the loss of some soluble protein (23). The ether extract value ranged between 5.89–7.98 % which is comparable to 1.5 - 13.0 % reported by (24) for smoked meat products. The higher fat content observed in beef smoked with Acacia (7.98 %) could be attributed to the low moisture and fat content relationship as suggested by (17), due to the fact that they relate inversely. Fat is very important in flavour development of meat, as meat ages the fat deteriorates through microbial attack, tissue enzyme activity and oxidation of unsaturated bonds, which results in development of bad odours and taste

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deterioration. Moisture Content of smoked beef obtained, was within 30 – 40 % range, equally reported by (22) for Kundi. The values were however higher than 8.2 - 11.1 % observed for moisture of oven dried and sun dried Kilishi reported by (18). The moisture content observed for smoked beef after processing using acacia, turare, neem wood and coconut husk, was 30 - 40%, which is quite low for microbial survival and activities in such medium. The values for percentage proximate composition of meat product from different smoke source, obtained in this study are within ranges reported by other authors.

Table 3: Proximate and mineral composition of smoked beef samples

Samples	D.M (%)	C.P (%)	CF (%)	Oil (%)	Ash (%)	NFE (%)	Moisture (%)
MA	57.15	41.87	2.72	7.22	7.03	41.13	40.35
ME	55.25	41.31	2.8	5.89	4.27	45.73	37.15
MN	50.37	43.87	2.72	6.77	6.17	40.47	39.02
MC	64.04	40.93	2.2	7.98	4.76	44.13	31.79

Results were mean of triplicate sample readings. MA: Meat smoked using *A. raddiana,* ME: Meat smoked using *E. camaldutensis* MN: Meat smoked using Neem, MC: Meat smoked using Coconut husk

Total viable counts and coli-form counts of smoked beef from all the treatments (Table 4) were within control limits (25), probably due to lower moisture contents, pH and water holding capacity of smoked samples, which might have aided in preserving the product. Aerobic plate count results are acceptable when compared to suggested range of 2.5 x 10^5 to 1.0 x 10^8 cfu/g by (21) as sited by (17). The low microbial content recorded on beef smoked with neem (MN), could be attributed to the antimicrobial compounds contained in the plant. Smoking which was done at high temperature contributed to the reduction in microbial load since most bacteria are not able to withstand the high temperatures encountered in the smoking process. When smoking is combined with curing, the shelf life of such products is increased and decreases the microbial load especially on the meat surface (26). This result can also be linked to the level of hygiene of the meat during processing as suggested by (27). Smoke constituents from acacia, eucalyptus, neem wood and coconut husk play important role in preserving the product against microbial spoilage. Thus it is possible to produce smoked beef with low microbial counts as smoking, salt (curing) and adequate hygienic conditions are maintained.

There was no significant difference (P<0.05) in the overall acceptibilty of meat smoked using Acacia, Turare, Neem and Coconut husk when compared to Acacia as shown in

Table 4: Total aerobic plate count, Total viable counts, coli-form counts (Smoked beef)

			MCA(LF)		EMB(GMS)	
Sample	*NA CFU/ml*	*Description*	*CFU/ml*	*Description*	*CFU/ml*	*Description*
MA	1.47×10^6	Passable	23×10^4	Satisfactory	8×10^4	Satisfactory
ME	19×10^4	Satisfactory	19×10^4	Satisfactory	-	Satisfactory
MN	8×10^4	Satisfactory	12×10^4	Satisfactory	-	Satisfactory
MC	29×10^4	Sa23sfactory	36×10^4	Satisfactory	9×10^4	Satisfactory

MA: Meat smoked using *A. raddiana,* ME: Meat smoked using *E. camaldutenis* MN: Meat smoked using Neem, MC: Meat smoked using Coconut husk, NA: Nutrient Agar MCA: MaConkey Agar, EMB: Eosin methylene blue.

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Table 5. For all the organoleptic parameters, beef smoked with coconut husk as fuel wood recorded the lowest values except texture, although they were all above 2. The newer trees used, scored above 2 which is the limit of acceptability and competed well with *acacia,* the conventional wood fuel. Result observed are comparable with study involving trials with *Acacia* tree species as fuel wood, good appearance and taste were recorded (7). Coconuts husks used to smoke catfish fillets in a separate study (28) gave acceptable attribute ratings comparable to what is found in this study.

Many factors influence the quality of smoked meat products including the properties of meat flesh, age, sex of animal and factors involved in the smoking procedure such as wood type, composition of smoke, temperature, humidity, velocity and density of the smoke (28). Phenolic and carbonyl compounds contribute towards taste in smoked meat (29). Specific volatile compounds in particular phenolic compounds have been related to the different smoking techniques which directly influence the sensory characteristics of smoked meat. Organoleptic properties of smoked foods are decisively influenced by composition of the smoke and nature of wood involved. There is no agreement about which wood or mixture of woods imparts the preferred sensorial properties to smoked woods. The fact that there is no significant difference in sensory attributes between the various wood types during smoking in this study suggests that Turare, Neem and coconut husk can be used in meat smoking. However, there might be a negative impression towards beef smoked using Neem as wood fuel. This could be due to the influence in culinary habits and the bitter taste experienced after consumption of its liquid extract. The slight differences in taste observed between the wood types could be due to the different compounds in the various smokes interacting differently with components of the beef. Different wood sources give wood smokes that have distinctly different sensory properties. Kjällstrand (30), reported that reactions between the carbonyl compounds and proteins are mainly responsible for colour formation on smoked surfaces suggesting that smoke from acacia and eucalyptus had higher carbonyl compounds while the absorbed phenolic compounds are related to flavor and aroma of the smoked product.

Table 5: Organoleptic properties of Smoked beef samples

Samples	Colour	Juiciness	Taste	Smoky flavor	Texture	Overall acceptability
MA	2.60^{a}	2.85^{a}	2.30^{ab}	2.85^{a}	2.85	3.30
ME	2.60^{a}	2.30^{a}	2.05^{bc}	2.35^{ab}	3.20	2.60
MN	2.35^{ab}	2.65^{a}	2.85^{a}	2.65^{ab}	2.96	3.15
MC	1.57^{b}	1.40^{b}	1.50^{c}	2.00^{b}	3.50	2.50
SEM	0.12	0.12	0.12	0.13	0.13	0.14

Means in the same Colum with different superscript are significantly (P>0.05) different. *Rated on a five-point hedonic scale. Higher value indicates higher preference. MA: Meat smoked using *A. raddiana,* ME: Meat smoked using *E. camaldutensis* MN: Meat smoked using Neem, MC: Meat smoked using Coconut husk

Conclusion and Application

Eucalyptus camludensis (Turare), *Azadirachta indica* (Neem) and *cocos nucifera* (Coconut husk) are good sources of fuel wood for meat smoking as evidenced by the low microbial count, high crude protein and organoleptic scores of meat smoked with these new sources.

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