EFFECTS OF STORAGE CONDITIONS ON THE SHELF-LIFE OF *KILISHI*

BY

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2003/14826EA

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BEING A FINAL YEAR PROJECT
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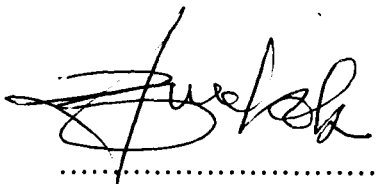
NOVEMBER, 2008

DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.



Linus Ithoitsoyah Imodiboh

(2003/14826EA)

19/11/2008

Date

CERTIFICATION

This project entitled "effects of storage conditions on the shelf-life of *Kilishi*" by Linus Ithoitsoyah Imodiboh meets the regulations governing the award of the degree of Bachelor of Engineering (B. Eng.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

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Engr. Dr. O. Chukwu
Supervisor

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Date

19/11/2008
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Engr. Dr.(Mrs) Zinash D. Osunde
Head of Department

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Date

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External Examiner

19-11-08
.....
Date

DEDICATION

This project / research work is dedicated to Almighty God, the maker of Heaven and Earth, the Author and finisher of life who has been my source of wisdom and strength since I was admitted into this citadel of learning to acquire a bachelor degree in Agricultural and Bioresources Engineering.

To my Aunt, Angela Ugiomoh who stood as an inexhaustible warehouse of the financial requirements for the actualization of my dream in this university. To my mother Mrs. Rose Imodiboh for her words of wisdom and encouragement which enabled me to have gone this far in the quest to acquire this degree. Finally, to widows all over the world especially those who have been dehumanized for the death of their husbands of which they know nothing.

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ABSTRACT

The principles of beef carcass processing and the effects of storage conditions on the shelf-life of *Kilishi*, Nigerian dried meat product were studied over a six week storage period comparing traditional production and packaging systems with a potassium sorbate treatment system and simple modern packaging. Changes in chemical composition and microbiological counts are reported. Moisture and water activity results indicated that the experimental *Kilishi* was sufficiently dried to minimize microbial growth. Fat oxidation levels measured by free fatty Acid (FFA) (%) on extracted fats were unacceptably high and may be a reflection of the quality of the groundnut and its oil in the ingredients. Processing of beef into *Kilishi* appears to lead to a decrease in mineral availability. Results suggest that treatment of *Kilishi* with 10% (w/v) potassium sorbate confers high degree to mould contamination. *Aflatoxin* levels far exceeded all established safe limits and are thought to be due to the use of pre-contaminated groundnut, as mould growth level in *Kilishi* was very low. However, it is important to note that the *Kilishi* samples used for this study were made from beef. More results can be obtained if the same experimental process is conducted using meat from a different source.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

As it is highly perishable, meat surplus over immediate requirements needs to undergo some form of preservation if it is not to be wasted. Man developed meat preservation technologies from an early period. The history of meat preservation in West Africa dates back to records of the 12th century. The main method of meat preservation transferred by the medieval Arabic sources to West Africa was that of sun drying (Alonge and Hiko,1981). Although modern methods of meat preservation might be preferred by consumers, refrigeration equipment is expensive to install and difficult to maintain in tropical developing countries, so dried meat products often maintain their importance.

There are many methods used to prepare dried meat. These include exposure of strips of lean meat to the sun, as in the manufacture of *Pemmica* by North America Indians, or a combination of salting followed by air drying , as in the preparation of *Charqui* in South American and *Biltong* in South Africa (Lawnie, 1989).

The dried meat product *Kilishi* is produced mainly by *Hausas* and *Fulanis* in the Northern parts of West Africa (Alonge and Hiko ,1981). *Kilishi* is prepared by partially drying thin sheets of quality beef in the sun followed by addition of ingredients before a second period of sun drying and briefly roasting (Igene *et al.*, 1990; Musonge and Njolai, 1994). There is little or no packaging of the product

before presentation to the consumers. This may have an effect on the quality of the final product. This study reports the findings of the evaluations conducted on the quality of traditional Nigerian *kilishi* and the effects of simple, cheap packaging and treatment with an anti-fungal agent during storage under two different conditions.

1.2 Statement of the Problem

Kilishi production and storage under conditions free of microbial activity has been seen as a process usually difficult to achieve. This is due to the oily nature of the product (*kilishi*) which attracts agents of microbiological spoilage such as insects which feed on the moisture extracted from the product. Therefore, this study is aimed at producing and storing *kilishi* with the least occurrence of the negative effects brought about as a result of microbial activities.

1. 3 Objectives of the Study

The Objectives of this Study are :

1. To determine the effects of storage conditions on the shelf life of *Kilishi*

2. To determine the effects of microbial activities on the quality of *Kilishi* under storage conditions.

1.4 Justification of the Study

Agricultural Products storage operations have been described as the only solution to the problem of products deterioration and adequate supply of highly

nutritive food for the World (FAO, 1990). Hence, there is need to determine the effects of environmental conditions on the products under storage conditions.

1.5 Scope of the Study

The Scope of this Study is limited to the effects of storage conditions on the shelf- life of *Kilishi* which include its production, packaging and storage.

CHAPTER TWO

2.0 LITERATURE REVIEW

The art of sun-drying of raw meat products has been practiced for thousands of years by pastoral and nomadic people seeking simple means to preserve meat in surplus supply (Ihekoronye and Ngoddy, 1985). A variety of traditional products have been developed that rely on the interaction of preservation techniques involving the following:

1. A restriction of water activity by drying

2. The use of salts and sugar to further control water activity and to act as selective inhibitors of microbial and enzymic action and

3. The use of spices to further limit microbial development and to impact characteristic flavour (Ihekoronye and Ngoddy , 1985).

The curing of meat is a process depending on the inhibition of microbial growth by the use of sodium chloride and control of water activity, together with optional additional use of nitrite salts to stabilize meat colour and smoking to give further microbial control and a desirable cured meat flavour . Many traditional processes have been developed to give products of distinctive character. Pre-slaughter control designed to achieve a low ultimate pH is an important aspect of all cured meat processes since a pH of 5.8 or below is required (Ihekoronye and Ngoddy, 1985).

The familiar high perish ability of meat is due to it's nutritious composition, for both men and microbes, as well as to meat's invariable surface contamination by spoilage microbes.

Low temperatures have been used throughout history to slow down the rate at which surface contaminants increase their numbers from initial level to final levels indicative of spoilage. The time taken for such microbial increase is a measure of the storage life. The term cold 'storage' generally refers to the use of low temperatures within the range of 1 to 3.5°C , temperatures well in excess of the commencement of muscles freezing, but within the temperature optimum between -2°C and 7°C for the growth of *Psychrophilic* organisms (Ihekoronye and Ngoddy, 1985). The essence of meat marketing through cold storage is thus to have as rapid turnover as possible based on a storage life of not more than 3-5 days , ensuring a maintenance of the cold condition throughout wholesale storage , distribution, retail storage and sale . This procedure is very widely used throughout Western cities , relying on a large daily kill at a city-based abattoir together with a cold-chain distribution and refrigerated storage in the consumer's home. Spoilage of locally produced and consumed meat is avoided by using the meat promptly.

2.1 Principles of Meat Drying

Drying meat under natural temperatures, humidity and circulation of air, including direct influence of sun ray, is the oldest method of meat preservation. It consists of a gradual dehydration of pieces of meat cut to a specific uniform shape that permits the equal and simultaneous drying of whole batches of meat. Warm,

dry air of low humidity of about 30% and relatively small temperature differences between day and night are optimal conditions for meat drying. However, meat drying can also be carried out with good results under less favourable circumstances when basic hygienic and technological rules are observed . Intensity and duration of the drying process depend on air temperature, humidity and air circulation. Drying will be faster under high temperatures, low humidity and intensive air circulation (FAO, 1990).

Reducing the moisture content of the meat is achieved by evaporation of water from the peripheral zone of the meat to the surrounding air and the continuous migration of water out of the deeper meat layers to the peripheral zone. There is a relatively high evaporation of water out of the meat during the first day of drying, after which it decreases continuously. After drying the meat for three or four days, weight losses of up to 60 - 70% can be observed, equivalent to the amount of water evaporated. Consequently, moisture losses can be monitored by controlling the weight of a batch during drying. Continuous evaporation and weight losses cause changes in the shape of the meat through shrinkage of the muscle and connective tissues. The meat pieces become smaller, thinner and to some degree wrinkled. The consistency also changes from soft to firm to hard. In addition to these changes which are physical, there are also certain specific biochemical reactions with a strong impact on the organoleptic properties of the product.

Meat used for drying in developing countries is usually derived from unchilled carcasses and rapid ripening processes occur during the first stage of drying as the meat temperature continues to remain relatively high. For that reason

the specific flavor of dried meat is completely different from the characteristic flavour of fresh meat. Slight oxidation of the meat fats contributes to the typical flavour of dried meat. Undesirable alteration may occur in dried meat when there is a high percentage of fatty tissue in the raw meat. The rather high temperature during meat drying and storage causes intensive oxidation (rancidity) of the fats and unpleasant rancid flavour which strongly influences the palatability of the product.

Meat drying is a complex process with many important steps, starting from slaughtering of the animal, carcass trimming, selection of the raw material, proper cutting and pre - treatment of the pieces to be dried and proper arrangement of drying facilities. In addition, the influence of unfavourable weather conditions must also be considered to avoid quality problems or production losses. The secret of correct meat drying lies in maintaining a balance between water evaporation on the meat surface and the migration of water from the deeper layers. In other words, care must be taken that meat surfaces do not become too dry while there is still a high moisture content inside the meat pieces.

Dry surfaces inhibit further evaporation of moisture, which may result in products not uniformly dried and microbiological spoilage starting from the area where the moisture content remain too high. Strict adherence to meat drying techniques should avoid failure in the production of dried meat and ensure obtaining product of good quality with a long shelf life. The basic technology of meat drying is the salting of the meat before drying. Pre-salting is not absolutely necessary but has certain advantages, particularly for the drying of meat strips and

large flat meat pieces and is therefore strongly recommended for this type of product (dried meat) (FAO, 1990).

2.2 Selection of Meat for Drying

As a general rule, only lean meat is suitable for drying. Visible fatty tissues adhering to muscle tissue have a detrimental effect on the quality of the final product . During processing and storage of dry meat, rancidity quickly develops, result in flavour deterioration.

Dry meat is generally manufactured from bovine meat although meat from cameloids, sheep, goat and venison (e. g antelope and deer) is also used. The meat best suited for drying is the meat of a medium-aged animal, in good condition but not fat. Meat from animals in less good nutritional conditions can also be used for drying, but the higher amount of connective tissue is likely to increase toughness (Discovery Channel Television, 2005). It is very important that the raw material for the manufacture of dry meat is examined carefully for undesirable alteration such as discolouration, haemorrhagic spots, off-odours and manifestation of parasites . Such defects must be trimmed off. Carcasses have to be properly cut to obtain meat suitable for drying. Owing to their sizes, beef carcasses are more difficult to handle under rural conditions than carcasses of goat, sheep or game. In the absence of chilling facilities, beef carcasses must be cut and deboned immediately after slaughter.

2.3 Beef Carcass Cutting, Trimming and Deboning

It is important that in order to obtain quality beef, certain basic unit operations must be carried out so as to ensure good quality product which the beef may be converted to as the final product.

1. Carcass Cutting

The carcass is first split into two sides along the spinal column and then cut into quarters. Fore-and hind-quarters are separated after the last rib, thus leaving no ribs in the hindquarter.

2. Trimming

After the quarters are suspended so that they do not touch the floor or anything around them, they are trimmed. Careful trimming is very important for quality and shelf life of the final product. The first step is to remove with a knife all visible contamination and dirty spots. Washing these areas will spread bacterial contamination to other parts of the meat surface without cleaning the meat. After completing the necessary cleaning of the meat surface, knives and hands of personnel must be washed thoroughly. Using a sharpened knife, the covering fat from external and internal sides of the carcass and the visible connective tissues, such as the big tendons and superficial faciae, are carefully trimmed off.

3. Deboning

It is recommended that this operation should start with the hindquarters and follow with the fore quarters. The aim is to remove the bones with least possible

damage to the muscles. Incisions into the muscles are inevitable but only at spots where the bones adhere and have to be cut off. Deboning of the suspended hindquarters should start from the leg and proceed to the rump and muscles along the vertebral column. Deboning of the forequarters must start with cutting and deboning the shoulder separately, followed by cutting off the rib set, together with the inter-costal muscles. Deboning of the forequarter is completed by removing the meat from the neck and the breast region of the spinal column.

2.4 Technique of cutting Meat pieces for Drying

Anatomic cuts, which were separated from the carcass, are suspended again and the big individual muscles are carefully cut out, while the smaller muscles are left together. The next step consist s in cutting the muscles into thin strips. This operation is crucial for the appearance and quality of the final product. All strips to be dried in one batch must be cut to an identical shape. Care must also be taken to obtain rather long strips of meat.

There are two ways of cutting muscles or smaller muscles groups into strips;

1. Cutting the meat after placing it on an appropriate clean chopping board

2. Cutting the muscles in the hanging position (Discovery Channel Television, 2005).

In both cases the muscles have to be split exactly along the muscles fibres. The strips must be cut as uniformly and as smoothly as possible and the diameter of

the strip must remain the same throughout the length. The length of the strips may differ, though it should not be less than 20cm and not more than 70cm. Meat cut into shorter strips requires considerably more time for hooking than the same quantity cut into longer strips.

However, strips which are too long may break because of their weight. Beef muscles suitable for drying are usually no longer than 50cm (except the sirloin strips attached to the spinal column). However, strips longer than 50cm can be produced by cutting the muscles along the fibre in one direction, without cutting through the end of the muscle. Using this technique, longer strips can be obtained, but their length should not exceed 70cm for reasons of stability. The thickness of the strips determines the duration of the drying process. Since thick strips takes considerably more time to dry than thin ones, it is important that strips to be placed in the same batch are of the same cross-section, with only the length differing. Insufficiently dried or over dried pieces will be the result if this rule is not followed. Cutting muscles into long, thin and uniformly shaped strips requires experience and skill. Knives with broad blades are best suited for this purpose. Under dry climatic conditions two basic shapes of meat pieces proved to be the most suitable for natural drying;

1. Strips with a rectangular cross-section of 1cm by 1cm

2. Flat or leaf-shaped pieces with cross-section of maximum 0.5cm by approximately 3, 4 or 5cm.

2.5 Recommended Treatment before Drying

Because meat is always consumed slightly salted, the raw material may be pre-salted before drying. This procedure not only contributes to a tastier product, but it is also desirable from the technological and hygienic standpoint. Pure common salt is used for this purpose, either dry or dissolved in water. In the case of meat for drying cut into strips or flat pieces, the use of a 14% salt solution is preferred. Dipping the meat into the salt solution serves first of all to inhibit microbiological growth on the meat surfaces (FAO, 1990). For that reason salting has to be carried out within five hours after slaughter, as after that period massive microbiological growth occurs which cannot be reduced by salt treatment.

Secondly, pre-salting is a protection against insects during drying. The freshly cut meat surfaces are very attractive to various insects, in particular domestic flies, which feed on the moisture excreted from muscles fibres . These insects cause considerable contamination of the meat and may also deposit eggs into it. Meat is no longer such an attractive environment for insects after it has been dipped into the salt solution. The salt concentration on the meat surface keeps them away. Furthermore, a thin layer of crystalline salt is formed on the surface of the meat during drying. The crystals are hygroscopic and absorb part of the water excreted from the meat , thus preserving the meat surfaces by keeping them dry. Dry meat surfaces inhibits the growth of bacteria and moulds which is one reason for the preservability of pre-salted and dried meat (FAO, 1990). The salt is prepared by adding the necessary amount of edible common salt to water and dissolving it by intensive stirring. To obtain the recommended salt concentration of

Table 2.1: Recommended Salt/Water Concentration for Meat Processing

Water (litres)	*Salt(g)*
1	810
2	975
3	1140
4	1300
5	14601
6	1630

Source: FAO, (1990).

As soon as the salt is dissolved in the water . the meat strips are dipped into the solution, soaked for five minutes and then drained. Draining should be done by placing the strips into a plastic sieve in order to allow the brine to drop off for collection and re- use. The handling of the meat strips before drying has to be carried out under strict hygienic conditions in order to avoid contamination and ensure a long shelf-life of the product. However, if accidental contamination of certain pieces occurs, further processing can only be undertaken with certain precautions. A special bucket with salt solution should be available in order to soak the contaminated pieces of meat, after having rinsed them previously in clean water. However, it must be born in mind that the original quality of the contaminated pieces cannot be restored (FAO, 1990). For that reason such pieces should always be dried separately, and not stored for a long period, but should be used as soon as possible in the preparation of meals.

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2.6 Quality of the Finished Product

Drying of meat of the shape described above takes four to five days. After this period the dried meat is ready for consumption and can be packaged, stored or transported. At this stage the product should meet the following quality criteria. The appearance of the dried meat should be as uniform as possible. The absence of large wrinkles and notches indicates the desired steady and uniform dehydration of meat. The colour of the surfaces, as well as of the cross-cut, should be uniform and dark red. A darker peripheral layer and bright red colour in the centre indicates incorrect, too fast drying, with the formation of hard rings which hinders evaporation from the deeper layers of the product. In this case the central parts have a brighter colour and softer consistency and are, because of the higher water content, more susceptible to microbiological spoilage when packaged or otherwise stored. A softer consistency can also be recognized by pressing the meat with the fingers. These pieces should be kept for one more day in the dryer for finishing. The consistency of properly dried meat must be hard and similar to frozen meat (FAO, 1990).

Taste and flavour are very important criteria for the acceptance of dried meat by the consumers. Dried meat should posses a mild salty taste which is a characteristic of naturally-dried meat with no added spices. Off-odours must not

occur. However, a slightly rancid flavour which occurs because of chemical changes during storage is commonly found in dried meat. Dried meat with a high fat content should not be stored for a long period but used as soon as possible in order to avoid intensive rancidity. Dried meat must be continuously examined for spoilage-related off-flavour, which is the result of incorrect preparation and / or drying of the meat. Meat with signs of deterioration must be rigorously sorted out.

2 .7 Packaging and Storage

After taking the dried meat strips out of the dryer, a selection of the pieces based on length can be undertaken. Packaging serves to protect the product from contamination to which the meat might be exposed on its way from the producers to the consumers. Numerous materials are used for packaging dried meat, such as paper, plastic foils, aluminum foils, cellophane and textiles. The longest shelf-life is obtained using vacuum-packaging (FAO, 1990). Transparent plastic materials and cellophane are more appealing to the consumers. Packaging is employed for both the retail and wholesale trades. The weight per package of dry meat for retail sale usually does not exceed 1kg, whereas those for the wholesale trade 5, 10, 25, or 50kg (Discovery Channel Television, 2005). If plastic bags are used for packaging, the pieces of dry meat should be cut to a certain length so that they can be best arranged in the bags. Cardboard boxes are very useful for additional packaging. During storage, special care has to be taken to prevent dried meat, which is not packaged in water-proof containers, from becoming wet, resulting in rapid growth of bacteria and moulds. For this reason the environment for storing dry meat have to be rain-proof. It is further advisable to cover the piles of packaged dry meat with

plastic sheet, as additional protection against moisture for meat to be stored more than six months . During storage, individual packages must be opened at least once a month and the organoleptic quality of the product is examined. These controls enable the person responsible to evaluate storage conditions and to assess the shelf-life of the dry meat. For controlling temperature and air humidity, it is useful to have a thermometer and hydrometer installed on the premises. A maximum and minimum thermometer is recommended to obtain the highest and lowest temperatures recorded between two readings (FAO, 1990). The temperature and relative air humidity should be carefully registered bearing in mind that dry meat is extremely sensitive to changes in environmental conditions, especially of the ambient temperature and relative humidity.

2.9 Preparation of Dried Meat for Consumption

Dried meat manufactured as described above has to be rehydrated to resemble fresh meat again. Rehydrated dried meat has almost the same nutritive value as fresh meat(Discovery Channel Television, 2005). Rehydration is in most cases combined with cooking. The procedure usually starts by putting the dried meat which may be cut into smaller pieces, into a pot. The meat in the pot is then covered with water and boiled. The rehydrated and cooked meat and the broth are used together with other additives which may vary according to local consumption habits, for the preparation, of tasty dishes.

2.9 Meat Drying in Combination with Additional Treatment

Meat drying after pre-salting, as described above, is the simplest and most efficient method of meat dehydration. Additional treatments used for some special dried meat products are curing, smoking and the utilization of spices and food additives. Specific anti-microbial agents in smoke or spices or the anti-microbial properties of the curing substance, nitrite, may allow a less intensive dehydration of the meat. The resulting semi-dry products are in most cases consumed without rehydration , whereas rehydration is indispensable for common dried meat.

In many countries, including developed countries and developing nations, semi-dry products such as unsmoked raw hams and sausages are not only popular because of the products' durability but particularly because they are delicious, high-quality meat specialties. In developing nations like Nigeria, where the preservation aspect is even more important because of the lack of cold chain, treatment carried out in addition to drying of meat will be some what different and in some cases (e.g intensive smoking over fire) the product quality is lowered rather than improved.

There are also of course other reasons for additional treatment, such as special flavours or special mixtures with non-meat ingredients, which may be preferred locally. Curing is the operation carried out on dried meat to inhibit microbiological activity on the product. It is the impact of nitrite on meat, in particular on the muscle pigment, *myoglobin*, which results in the formation of the pigment *myochromogen* and gives a stable red colour to muscle tissue. In addition,

nitrite inhibits to some extent microbiological growth in the meat, but does so efficiently only in combination with low temperature and/ or low water activity. These effects are of particular importance for the shelf-life of raw hams and dry sausages. Apart from occasional use in biltong (the South African dried meat), it can be concluded that curing is not important in the manufacture of traditional dried meat products. The reasons are that a bright-red colour is not desirable in meat (because it will be rehydrated and used for cooking meals) and drying is generally so intensive that the inhibiting effects on microbiological growth is unnecessary. Curing substances must be handled very carefully as they are toxic even in low concentrations. Very small dosages are sufficient for the curing effects, about 2g or less in 10kg meat (Discovery Channel Television, 2005).

CHAPTER THREE

3.0 MATERIALS AND METHODS

This Study was conducted in Kaduna State in the months of May and June 2008 at two environmental conditions (day and night).

3.1 Materials for *Kilishi* Production

1. Meat (Beef)
2. Knives
3. Papyrus mats
4. Wire net
5. Groundnut paste
6. Ginger
7. Onion
8. Dried pepper (ground)
9. Seasoning cubes
10. Water
11. Bowl.

3.2 Methods, Analysis and Storage of *Kilishi*

3.2.1 Preparation of Samples

Kilishi is a product obtained from sliced lean muscles of beef, goat meat or lamb and is made on a large scale under the hot and dry weather conditions prevailing from February to May in the Northern part of Nigeria by the *Hausas* and

Fulanis. It is produced by sun-drying thin slices of meat cut into dimensions of about 1-2mm thick. However, recent experience indicates that the product *(Kilishi)* can also be produced industrially using tray drying in a warm air oven. Connective tissues and adhering fatty material are trimmed off the meat which is cut with a curved knife into thin slices of about 1-2mm thickness, 15mm length and as much as 6mm width. The trimming of the fatty material from the meat is one of the basic unit operations performed on the raw meat to avoid the oxidation of fat (rancidity) which leads to rapid deterioration of the product during storage.

Traditionally, the slices of meat are spread on papyrus mats on elevated platforms or tables in the sun for drying. However, these papyrus mats may lead to hygienic problems, especially after repeated use. Therefore, easily washable corrosion free wire nets or plastic nets are recommended for horizontal drying. The vertical drying method is also recommended in this case.

Sum drying of *Kilishi* could also be improved by the use of solar dryers. These devices will increase the rate of drying of the product and keep insects and dust free from the product. In the first stage of drying, which takes two to four hours, the moisture content of the meat slices has to be reduced to about 40% - 50%. The slices are then put into an infusion containing wet groundnut cake paste as the main component (about 50%) and are further composed of water (30%), onion (10%), seasoning cubes (5%), salt (2%) and spices such as pepper and ginger. The "dried" slices of meat should absorb the infusion up to almost three times their weight. After infusion, the wet product is again exposed to the sun to dry. Drying at this stage is much faster than at the first stage. When the moisture

content of the slices has been reduced to 20% - 30%, a process which takes two to three hours depending on weather conditions and the dimensions of the product, the slices are finally roasted over a glowing fire for about five minutes. The roasting process helps to enhance desirable flavour development and to inactivate contaminating microorganisms. Roasted *kilishi* is therefore superior in flavour to the unroasted version. After roasting, the final moisture content ranges between 10% - 12%. It decreases during storage at room temperature to as low a level as 7%. When packaged in hermetically sealed, low density plastic bags, the product remain remarkably stable at room temperature for a period of about one year.

3.2.2 Experimental Procedure

Trial 1: Quality characteristics of traditional *kilishi* two days after production.

Representative samples of *kilishi* (approximately 2.3kg) were obtained two days after production from four different producers in Kaduna, Nigeria. The samples were weighed and finely ground in a pre-sterilized and chilled blender. The ground *kilishi* was then subjected to a range of analyses and results obtained.

Trial 2: Effects of storage conditions on *kilishi* during short term storage using potassium sorbate as an anti-fungal agent.

Representative samples of *kilishi* (approximately 9kg) were obtained from a *kilishi* producer immediately after production. The samples were subjected to a range of analyses after storage under ambient conditions of temperature and relative humidity. Approximately half the samples were stored wrapped in

traditional brown paper (control). The other half was heated to 100°C for 8 minutes and then lightly sprayed with 10% (w/v) solution of potassium sorbate in sterilized water, onto the surface of the product before being packaged in polythene bags and stapled (treatment). The heat from the product aided evaporation of the water, leaving the sorbate as an inhibitor. Sample were prepared for analysis as in trial 1 and then analyzed each week for three weeks and results obtained.

Trial 3: Effects of storage conditions on *kilishi* during long term storage using potassium sorbate as an anti-fungal agent.

Representative samples of *kilishi* (approximately 10kg) were obtained from a producer immediately after production. Approximately one third of samples were stored wrapped in traditional brown paper (control), one third treated with 10% (w/v) potassium sorbate (as in trial 2) before being packaged in sealed polythene bags (treatment1) and one third packaged in sealed polythene bags (treatment 2) without potassium sorbate treatment. Samples were prepared and subjected to a range of analyses after 6 weeks storage under ambient conditions and results obtained.

3.2.3 Storage of *Kilishi*

The products *(Kilishi)* is stored in an environment free of moisture, this is because most Agricultural products are hygroscopic. The presence of moisture in a *kilishi* stored environment results in rapid growth of bacteria and moulds. For this reason the environment for storing *kilishi* have to be rain-proof. It is also important to cover the piles of packaged *kilishi* with plastic sheets, as additional protection against moisture and dust.

3.2.4 Materials for Packaging *Kilishi*

Numerous materials are used for packaging *Kilishi,* such as plastic foils, Aluminum foils, paper, cellophane and textile. To obtain a longer shelf-life, vacuum-packaging is made used. Transparent plastic material and cellophane are more appealing to consumers but for the purpose of this study, paper and polythene bags were used as the packaging materials.

Kilishi production is not standardized and there are many variations of the method described earlier. Ingredient formulations, infusion time and duration of the solar drying stages vary depending on the required taste and environmental conditions (Igene, 1988). There are also variations in drying methods and some producers do not employ the final roasting stage.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Results

The environmental conditions in Kaduna during the months of May and June, 2008 are presented in Table 4.1

Table 4.1: Environmental Conditions in Kaduna During the Months of May and June, 2008.

Environmental conditions	Day	Night
Temperature (°C)	37.0 ± 0.1	24.2 ± 0.3
Relative humidity (%)	24.8 ± 1.2	82.6 ± 1.9

Mean ± S.E: n = 42.

Source: NIMET, (2008)

The quality characteristics of traditional *kilishi* two days after production are Presented in Table 4.2.

Parameters	Mean ± S.E.
Moisture content (%)	5.99 ± 0.54
Water activity (%) *	0.59 ± 0.02
Ash (%)	5.71 ± 0.12
Protein (%)	61.95 ± 1.85
pH	5.71 ± 0.06
Fat (%)	24.28 ± 1.65
Free Fatty Acid (%) of extracted fat*	4.34 ± 0.43
Calcium (mg / 100g)*	54.69 ± 7.23
Magnesium (mg / 100 g)*	114.97 ±13.92
Phosphorus (mg / 100g)*	-392.42 ± 57.88
Calcium: phosphorus (Ca: P) ratio	-0.14 ± 0.02
Aerobic plate count (cfu/g)*	$7.4 \times 10^4 \pm 9.3 \times 10^3$
Moulds and yeast (cfu/g)*	$6.1 \times 10^2 \pm 3.0 \times 10^2$
Xerophilic moulds (cfu/g)*	$2.4 \times 10^3 \pm 7.3 \times 10^2$

For mean, n = 8

S.E.= Standard Error

* = Analyses on wet weight basis (WWB); all others on dry weight basis (DWB).

The effects of storage conditions on *kilishi* during short-term storage using potassium sorbate as an anti-fungal agent are shown in Table 4. 3

Parameters		Elapsed time (weeks)			
		0	1	2	3
Moisture	(c)	7.81	9. 12	7.31	7
Content	(t)	7.81	8.00	7.06	5
(%)					
Water activity	(c)	0.80	0.71	0.68	0
(%)	(t)	0.80	0.65	0.65	0
pH	(c)	5.55	5.62	5.87	5
	(t)	5.55	6.02	6.09	6
FFA of extracted	(c)	2.43	3.78	4.84	5
Fat	(t)	2.43	3.66	3.71	4
(%)					
Aerobic plate	(c)	7.0×10^4	1.0×10^6	1.2×10^6	1.8×10^3
Count	(t)	7.0×10^4	6.4×10^5	8.2×10^5	1.2×10^4
Moulds and yeast	(c)	$<1.0 \times 10^2$	1.7×10^2	1.1×10^2	2.7×10^3
	(t)	$< 1.0 \times 10^2$	$<1.0 \times 10^2$	$< 1.0 \times 10^2$	$<1.0 \times 10^4$
Xerophilic	(c)	$< 1.0 \times 10^2$	1.3×10^2	1.2×10^2	2.8×10^3
Mould	(t)	$< 1.0 \times 10^2$	$<1.0 \times 10^2$	$<1.0 \times 10^2$	$<1.0 \times 10^3$

Mean, n = 2; (C) = control' (t) = Treatment.

All analysis on wet weight basis (WWB).

The effects of storage conditions on *kilishi* during long term storage using potassium sorbate as an anti-fungal agent are shown in table 4.4

Parameters	Control	Treatment 1	Treatment 2
Aerobic plate count (cfu / g)	$1.2x10^5$	$2.5x10^3$	$7.6x10^3$
Moulds and yeast (cfu / g)	$1.3x10^3$	$<1.0x10^2$	$2.0x10^3$
Xerophilic Moulds (cfu/g)	$4.4x10^3$	$<1.0x10^2$	$<3.0x10^4$
Clostridium Prefringens (cfu/g)	$6.6x10^2$	$<1.0x10^2$	$<1.0x10^2$
Water activity (%)	0.45	0.39	0.33
pH	6.4	6.2	6.30
Aflatoxin B_1 (mg/kg)	112.10	1.40.65	130.0
Aflatoxin B_2 (mg/kg)	Nd	Nd	Nd
Aflatoxin G_1 (mg/kg)	81.10	72.55	87.94
Aflatoxin G_2 (mg/kg)	Nd	Nd	Nd
Total Aflatoxin (mg/kg)	193.20	217.94	217.94

Mean, n = 2

Nd = Not detected

All analyses on wet weight basis (WWB)

4.2 Discussions

The Association of Official Analytical Chemists (AOAC) 1984 nutritional guidelines Appendix (A) were used for the determination of moisture, ash, fat and mineral elements (Ca, Mg and P).

The products *(Kilishi)* was stored in an environment free of moisture, this is because most Agricultural products are hygroscopic. The presence of moisture in a *kilishi* stored environment results in rapid growth of bacteria and moulds. For this reason the environment for storing *kilishi* have to be rain-proof. It is also important to cover the piles of packaged *kilishi* with plastic sheets, as additional protection against moisture and dust.

Kilishi production is not standardized and there are many variations of the method described earlier. Ingredient formulations, infusion time and duration of the solar drying stages vary depending on the required taste and environmental conditions (Igene, 1988). There are also variations in drying methods and some producers do not employ the final roasting stage.

Results for Trial 1 are presented in Table 4.2. Moisture and water activity result indicates that *kilishi* is sufficiently dried to minimize microbial growth.

Ash content levels were high when compared to (fresh meat which usually contains around 3.5% mineral components when expressed on dry weight basis, and 1% minerals on wet weight basis. High ash levels suggest the presence of sand or dirt and also reflect the condiments in the ingredients.

Protein content results demonstrate the value and potential of *kilishi* as a high protein food product; however the production process has been reported to lead to the loss of some soluble protein (Mbofung, 1993).

The pH values for *kilishi* were below the maximum accepted limit of 6.0 suggested by Pearson (1968c) for fresh meat which suggests that the meat was produced from well nourished and rested stock.

Fat is extremely important in flavour development of meat. As meat ages the fat deteriorates through microbial attacked and tissues enzyme activity which causes the development of free acidity and oxidation of unsaturated bonds. This results in the development of bad odours and deterioration of taste. Pearson (1968b) reported that unpleasant flavours in cooked beef were first noticeable at a level of 2-3% (as oleic acid) in extracted fat.

Free Fatty Acid values in meat progressively increased with storage time and Pearson (1968b) stated that for odour to be acceptable the free fatty acid (FFA), should not exceed 1.2%; FFA levels for *kilishi* exceeded these limits. The presence of groundnut oil may add to the flavour of the product, but its high fat content may have had a negative effect on the quality of the product as it is suspected that poor quality oil was used in the preparation of the meat product. However, it is thought that unpleasant flavours and odours would be difficult for consumers to detect due to the spicy nature of *kilishi.*

Calcium and Magnesium results levels were similar to those obtained by Mbofung (1993) who demonstrated that the mineral content of *kilishi* was higher than that of fresh beef (Ca 50.47 and Mg 68. 12mgl 100g).The results for

Phosphorus were also higher than levels typically found in fresh beef (276.00mg/100g)(Lawnie, 1979). This increase is reflected by an increase in ash content and is mainly due to moisture loss. Mbofung (1993) found that although relative amounts of minerals were higher in *kilishi* than in fresh beef, their relative solubility was lower in *kilishi.*

Processing of beef into *kilishi* appears to lead to a decrease in the availability of it calcium and magnesium. Mbofung (1993) demonstrates the negative effects of seasoning, sun drying and roasting on the availability of calcium (approximately 60% reduction) and magnesium (approximately 40% reduction).

The calcium phosphorus ratio for *kilishi* falls below the accepted range 0.5-2.0 (Recommended dietary allowances, 1980). However, *kilishi* is generally seen as a snack food rather than as an essential part of the diet and the impact of reduction in mineral availability will be minimal but may require further investigation. No significant changes were observed for the two environmental conditions under which this study was experimented. This is because the results for moisture and water activity indicated that the experimental *kilishi* was sufficiently dried to reduce the negative effects as a result of environmental interaction with the product under storage.

No significant growth of E. coil; *Staphylococcus aureus* or *Clostridium perfringens* was observed. Aerobic plate count results were acceptable when compared to suggested limits of 2.5×10^5 to 1.0 x 108 cfu/g (Pearson 1968a). The results for moulds, yeast and *xerophilic* moulds are significant but low levels of growth.

Results for Trial 2 are presented in table 4.3. The reduction in moisture content and water activity between treated and control samples of *kilishi* after 3 weeks storage is thought to be due to the heat processing stage of the potassium sorbate treatment system. General reduction in moisture content and water activity (control and treatment) is not necessarily conducive to the quality or organoleptic acceptability of *kilishi*. The initial moisture content and water activity was not as low as those observed in trial 1 indicating variation in production standards, the increase in pH levels for *kilishi* (treatment) observed during the storage period is thought to be influenced by the potassium sorbate treatment. The reduction in the rising FFA levels for *kilishi* (treatment) over the storage period indicates a higher degree of oxidative stability. Nigerian *kilishi* analyzed by Igene (1988) reached unacceptable levels of fat spoilage after approximately 3 weeks, according to limits (Tiobarituric acid number (TBA) = 1.8 suggested by Pearson (1968b). A TBA number of 1.8 would correspond to a FFA value of 1.2-2.1%. Results here suggest a higher degree of fat rancidity in the sample used for this study than the sample used by Igene (1988). However, the *kilishi* examined by Igene (1988) was made using defatted groundnut.

No significant growth was observed for E. Coil, *Staphylococcus aureus* or *Clostridium perfringens* over the storage period. Aerobic plate count results fall within accepted limits (Pearson, 1968a) throughout the storage period, with lower levels of growth in the treated *kilishi* than in the control. There were significant levels of growth of moulds, yeasts and *xerophilic* moulds in the control *Kilishi* and an absence of growth in the treated *Kilishi*. These results generally suggest that

treatment of *Kilishi* with potassium sorbate and polythene packaging will confer a degree of product protection from mould contamination. Potassium sorbate is known to be more effective against moulds than bacteria and at pH values of 6.5 or less (Banwart, 1989) and is confirmed by these results. These properties make it suitable for use on dried meat products such as *Kilishi.*

Results for Trial 3 are presented in Table 4.4. Aerobic plate count results for the control were similar to those observed for *Kilishi* in week 0 (Table 4.3) demonstrating product stability. Aerobic plate count results were markedly lower in both treatments, especially treatment 1. Growth levels of moulds in the control were similar to those observed in week 0 (Table 4.3). However, similar growth levels were also observed in treatment 2 indicating that simple polythene packaging does not inhibit mould growth. No significant mould growth was observed in treatment 1, suggesting that the potassium sorbate treatment system was responsible for the complete inhibition of mould growth in *Kilishi.* After 6 weeks storage the first significant *Clostridium perfringens* growth was observed in the control, however no significant growth was observed in either treatment. The pH levels for the control had continued to rise from levels observed in trials 1 and 2. However, pH levels in treatments 1 and 2 were similar to those observed in trial 2 suggesting a degree of stability. *Aflatoxin* results were much higher than any recommended maximum levels. In the USA, the recommended maximum level of *aflatoxins* in foods is currently 20 mg/kg, whereas in the UK 4mg/kg is the accepted maximum level (Anon, 1993). However, much of Africa, parts of the

middle east, south America and Asia do not have legislation for *aflatoxins* in foods (Van Edmond, 1995).

Low and stable levels of mould growth throughout the storage period indicate that *Kilishi* is not susceptible to excessive mould contamination. It is thought that high *aflatoxin* levels arose from the groundnut which accounts for about 50% of the ingredients and that any mycotoxigenic moulds which may have been present in the infusion would have been killed or inhibited by the *Kilishi* production process. The production process is thought to have no marked effect on existing levels of *aflatoxins* and poor quality groundnut is probably the cause of *aflatoxin* contamination.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the findings of this Study, it can be concluded that processing of beef into *Kilishi* does not leads to significant reduction in the available mineral contents of the raw product (fresh beef) and that most of the microbiological counts detected during the analysis of the *Kilishi* samples were due to the use of pre-contaminated groundnut which constitutes about 50% of the ingredients used for the production process.

The use of potassium sorbate in the storage of *Kilishi* proved to be effective against microbiological spoilage and maintain the organoleptic properties of the product under storage conditions. Also, the use of polythene bags and the traditional brown paper as packaging materials confers certain degree of protection against mould and bacteria activity on the shelf-life of the product during storage.

5.2 Recommendations

This study was carried out using traditional method of dry meat production in Nigeria. The meat sample used for the production of *kilishi* was that of beef. It is therefore recommended that in subsequent studies,

1. Meat from other animals such as goat, deer, sheep and antelope should be used for the same experimental processes to check for any variations.

2. Different packaging materials should be employed for the packaging operation.

3. Funding this research work was one of the most militating factors towards the success of this study. It is recommended that funds should be made available for subsequent studies of this nature to aid the researcher in the procurement of the materials considered necessary for the studies.

REFERENCES

Alonge D. O. and Hiko, A. A. (1981): Traditional methods of meat preservation and preparation in Nigeria. West African Farming, March/ April, pp 19-20

Anon (1993) : Aflatoxin legislation: What is the current status? The Network 6: 8-9

Anderson M. (1980): Recommended Dietary Allowances 9th Ed., National Academy of Sciences, Washington, DC.

AOAC (1984): Official methods of analysis. Association of Official Analytical Chemists, Washington, DC.

Banwart, G. J. (1989): Basic Food Microbiology. 2nd Ed., 605-606, Van Nostrand Reinhold Publishing.

Bradburn N. and Cohern R.D. (1995): A comparative study of solvent extraction efficiency and the performance of immunoaffinity and solid phase columns on the determination of aflatoxin B1. Food Chem. 56: 179-185.

Discovery Channel Television (2005): A film documentary on beef processing. David Foster Incorporated, Texas, USA.

FAO(1990): Meat and Meat Nutrition in developing countries. Official document. The United Nation Food and Agricultural Organization, Rome.

Igene J. O. (1988): Lipid, fatty acid composition and storage stability of *kilishi*, a sun-

dried meat product.3. Trop. Sci. 28: 153-161.

Igene J.O., Farouk M.M. and Akanbi C.T. (1990): Preliminary studies on the traditional processing of *kilishi*. Sci. Food Agric. 50: 89-98.

Ihekoronye P. and Ngoddy N. (1985): Integrated Food Science for the tropic. Macmillan Publishers, London. pp 335-338.

Lawne R. A.(1989): Meat Science. Pergamon Press, London 3rd Ed., pp 241-299.

Mbofung C.M.F. (1993): The effects of traditional African method of meat processing on the availability of iron and other minerals from the finished product (*kilishi*) following in vitro enzymolysis. In: SCHLEMER U. (ed), Bioavailability 93, Nutritional, Chemical and Food Processing implications of nutrient availability, Proceedings part 2, pp 169-174.

Musonge P. and Njolai E. N. (1994): Drying and infusion during the traditional processing of *kilishi*. Food Eng. 23:159-168

NIMET (2008): Nigerian Meteorological Agency, Kaduna International Airport weather data collection centre, Kaduna State, Nigeria.

Pearson D. (1968a): Application of chemical methods for the assessment of beef quality. Part I-General considerations, sampling and the determination of

basic components. J. Sci. Food Agric. 19:364-366.

Pearson D. (1968b): Application of chemical methods for the assessment of beef quality. Part II-Methods related to fat spoilage. J. Sci. Food Agric. 19:553-556.

Pearson D (1968c): Application of chemical methods for assessment of beef quality. Part III - Physiochemical and miscellaneous methods. J.Sci. Food Agric. 19:556-559. Slack P.T. (1987). Analytical methods manual, 2nd Ed., Leather head Food.

Van Edmond D. (1995): Regulations, quality assurance and reference materials. Food Additives and Contaminants, 12:321-330.

APPENDICES

The Association of Official Analytical Chemists Methods. (AOAC, 1984) Appendix (A) were employed for the determination of moisture, ash, fat and mineral elements (calcium, magnesium and phosphorus).

Water activity was determined using a luff water activity analyzer (Model 5803, Herzger Inc Germany). A quantity of ground *kilishi* was mixed with the same weight of distilled or deionzed water and pH measured with a pH meter (jenway model 3020). Free Fatty Acids (FFA) were extracted from *kilishi* using the leather head food R.A. room temperature. Bligh and Dyer extraction method No 5 for fat and FFA determined by method N0. 2 for fat extracted from food (Slack, 1987). Protein was determined by the distillation using the atomic absorption method (AOAC 1984) and phosphorus (P) was assayed calorimetrically as the phosphomolybdovanadate complex at 400mm.

Aflatoxines were determined by hi-directional technique after extraction in acetone and phenyl bonded phase catridge clean-up (Bradburn and Cohern, 1995). Aerobic plate count (plate count agar standard, oxide CM 463), moulds and yeasts (Dichloran Rose Bengal chloramphenicol (DRBC), oxide CM727), xerophilic moulds (Dichloran-Glycerol 18 (DG18), oxide CM729), *Clostridium perfringens* (shahdi-ferguson perfringens (SFP) Agar, oxide CM587) and staphylococcus aureus (Baird parker Agar Base (BP), oxide CM275) were determined by the spread plate method. Suspected *staphyloocossus aureus* colonies were subjected to the coagulase test (staphylase test, oxide DR595) and API staph test (Biomerieus

20500) to confirm identification. Escherichia coli was determined by the pour plate method (using violet Red Bile Agar (VRBA, Oxide CM107).