EFFECT OF DRYING ON NUTRITIONAL QUALITY OF DRIED MEAT (KILISHI)

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ABSTRACT

Kilishi is a dried meat product obtained from beef, goat meat, or lamb under hot and dry weather condition. 70g of fresh meat each from three different sources (cow meat, goat meat and sheep meat) was sun dried for complete twelve hours and their respective weight was obtained with electronic weighing balance at the interval of one hour. The amount of moisture in wet base was 69.29%, 74.02% and 66.71% while the amount of moisture in dry base was 2.26%, 2.86% and 2.00% for cow meat, goat meat, and sheep meat respectively. More also, the test analysis were carried out on both fresh meat and dried meat product (Kilishi) of the samples by using the standard procedure (AOAC). The results of the test analysis obtained on fresh and dried meat gotten from beef, goat, and sheep meats respectively are as follows: the percentage moisture was 69.00% and 11.00%, 74.00 and 11.83, 65.00% and 9.33%. The percentage ash was 1.00% and 9.50%, 0.50% and 5.17%, 0.67% and 16.00%.The percentage lipid (fat) was 10.50% and 19.67, 10.33% and 17.00%, 16.00% and 22.00%. The percentage crude protein was 19.00% and 38.99%, 15.05% and 37.22%, 18.06% and 38.68%.The percentage crude fibre was 4.17% and 4.83%, 2.33% and 2.83%, 2.67% and 2.83%.The percentage carbohydrate was -0.50% and 20.85%, 0.36% and 28.78%, -0.27% and 23.82%. From the results obtained it was observed that, drying prolongs the self-life of the meat by reducing its moisture content. However, the nutritional quality of the dried meat product (Kilishi) was increased due to various ingredients added to it.

KEYWORDS: Kilishi, Drying Rate, Nutritional Quality, Fresh Meat and Effect of Drying

1. INTRODUCTION

Meat is highly perishable which has to undergo some form of preservation to avoid deterioration. The main method of meat preservation transferred by the medieval Arabic sources to West Africa was that of sun drying (Alonge et al, 1981). There are many methods used to prepare dried meat. These include the exposure of strips of lean meat to the sun, as in the manufacture of pemmican by North American Indians, or a combination of salting followed by air drying, as in the preparation of chargui in South American and Bilton in South African (Lawrie, 1979). There are other methods of meat preservation which are: drying, freezing, curing and smoking, cold storage and chilling etc.

Meat is an excellent source of high quality B-complex vitamins and certain minerals especially iron. It digests easily when cooked and supplies nutrients which contribute significantly to the dietary balance of meal. Meat is the flesh of animals consumed for food. In the tropics the bulk of meat consumed is mostly derived from sheep, goat, pig, bush meat, poultry, bird, domesticated animals or wild animal, reptile animal and other sea foods (Hendrickson, 1978).

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. The meat best for drying is the meat of medium aged animal in a good condition (www.fao.org). However, the techniques of meat preservation can either be done by drying alone or in combination with other methods such as salting, curing or smoking. Meat drying techniques have been used for centuries and are considered as the oldest method of meat preservations (FAO, 1990; FAO, 1993).

Most processed and preserved meat by drying are usually more readily available in the market than any other preserved form such as freezing and irradiation. (Gerrard, 1971)

Meat drying is simply the exposure of strips or flat pieces of fresh meat to the sun or open air, this treatment reduces the meat water content rapidly that no bacterial spoilage can take place, even though the temperature remain high. However in order to avoid meat product contamination by insect, dust and other environmental impact during drying, cabinet solar dryers have been developed where warm air is conducted through hermetically closed

chamber. So far no source of energy other than sun has been used in solar drying method (FAO, 1993; FAO, 1994d)

The factors affecting the rate of drying includes; the physical and chemical properties of the product (such as shape, size, composition and moisture content), the geometrical arrangement of the product in relation to the heat transfer surface or medium, the characteristics of the drying equipment and the physical properties of the drying environment (such as air, temperature, humidity and velocity).The fig. 1 below shows the step by step approach to kilishi (dried meat) processing.

Fresh meat	Meat from any part of healthy cattle can be used
↓	
Trimming	Cutting off the fat using a sharp knife
↓	
Cutting	Cutting the meat into thin slices
↓	
Washing	Washing the meat in a clean water
↓	
Sun drying	put the meat under the sun for drying
↓	
Mixing	Mixing with ingredients
↓	
Sundry	put the meat under the sun for drying
↓	
Roasting	Roast the meat briefly over fire
↓	
Kilishi	Final product
↓	
Packaging	Store in a jute bag or paper

Fig. 1: the stages involved in the production of kilishi from raw meat sample. Source: (CTA, 1997)

To ensure good quality of kilishi (dried meat) product for human consumption, packaging, storage or transportation should meet the standardization criteria which include;

- The appearance of the dried meat should be as uniform as possible. The absence of large wrinkles and notches indicate the desired steady and uniform dehydration of meat
- The colour of the surface as well as the cross cut should be uniform and dark red.
- Taste and flavor are very important for the acceptance of dried meat by the consumers.

Packaging is a means of protecting the product from contamination to which the meat might be exposed on its way from producer to consumers. Numerous materials are used to package dry meat, such as paper, plastic foils, aluminum foils, cello phone and textiles. It is good to cover the piles of the packaged dried meat with plastic sheet, as additional protection against moisture and dust.The composition of lean muscle contained 74.0% moisture, 2.0% ash, 2.0% fat, 20.0% protein and 2.0% carbohydrate (Norman, 2004).

Kilishi is considered as a source of protein in human nutrition, therefore it is very essential to know the effect of drying and drying rate on nutritional drying of kilishi (dry meat). All these amongst other factors justify this research work.

The main objective of this study is to determine the effect of drying on the nutritional quality of kilishi meat with the view of establishing the moisture loss of kilishi during drying and its proximate composition.

2.0 MATERIALS AND METHODS

2.1 Raw Materials and Their Sources

Two hundred grams (200g) each of raw meat from three different sources, cow meat (beef), goat meat, and sheep meat were bought at Bosso Market Minna, Niger state. Each of raw meat was kept inside the polyethylene bags labeled I, II and III respectively under ambient temperature. These samples were taking to the Federal University of Technology Bosso Campus Minna. 60g each of the raw meat samples which was cut and put inside the polyethylene bags labeled A, B and C were taken to Biochemistry laboratory FUT, Minna for nutritional test and analysis. The remaining 140g each of the samples was processed into kilishi (see figure 1) and

their respective drying rate was determined by checking their weight using an electronic weighing balance at an interval of one hour during drying. The final products 'kilishi' were allowed to cool before packaging into another three set of polyethylene bags labeled D, E and F respectively, and were taken to Biochemistry laboratory FUT, Minna for nutritional test analysis.

2.2 Reagents and Instruments Used

2.2.1 Reagents

Tetraoxosulphate (vi) acid (H_2SO_4), sodium hydroxide(NaOH), calcium chloride ($CaCl_2$), calcium hydroxide($Ca(OH)_2$), methyl orange indicator, ammonium chloride solution (NH_4CL), petroleum ether, copper sulphate ($CuSO_4$).

The proximate compositions of these samples were determined using the method as given by Association of Analytical Chemist Standard procedure (A.O.A.C, 1980) and micro kjeldahl method.

2.3 Determination of Moisture Content (%)

A metallic dish was dried in an oven at 80^oC for 20 minutes, it was cooled in a desiccator and weighed (W_1) g. 2g of sample A was put into the dish and weighed (W_2) g, the dish with the sample A was dried in an oven for 80^0C for 24 hours until a constant weight was reached, it was then quickly transferred into a desiccator to cool. It was weighed quickly with minimum exposure to atmosphere (W_3) g. The loss in weight of the sample A during drying is moisture content. This procedure was repeated for sample B, C, D, E and F, respectively. The percentage moisture content was calculated using equation 1.

$$(\%)\ \text{Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad (1)$$

Where:

W_1 =Weight of empty metallic dish (g)

W_2 = Weight of metallic dish + fresh sample (g)

W_3 =Weight of metallic dish + dry sample (g)

W_2-W_1 =Weight of the fresh sample (g)

W_3-W_1 =Weight of dry sample (g)

2.4 Determination of Ash Content (%).

The ash of a biology material is analytical term for inorganic residue that remains after organic matter has been burnt away.

A clean flat bottomed silica dish of about 7cm diameter was hold in a hot bunsen-burner flame for one minute, it was then transferred into a desiccator to cool and weighted (W_1). A 2g of sample A was put into the dish and weighed (W_2). The silica dish containing the sample A was heated gently on a bunsen-burner in a fume cupboard until smoking ceased, it was then transfer to a muffle furnace heated to about 500c. The heating continued until all carbon burnt away for about 24 hours. The furnace was switched off; however, the silica dish was taking out and covered immediately. It was placed inside a desiccators to cool and weighed (W_3), this procedure was repeated for sample B, .C, D, E, and F respectively. The percentage ash content were calculated using equation 2.

$$\%\,\text{Ash Content} = \left(\frac{W_3 - W_1}{W_2 - W_1} \right) \times 100 \qquad (2)$$

Where:

W_1 = Weight of flat bottomed silica dish (g)

W_2 = Weight of flat bottomed silica + sample ‘A’ before burning (g)

W_3 = Weight of flat bottomed silica + sample ‘A’ after burning (g)

The portion of the sample which burnt off was the organic matter. It was calculated using equation 3.

(%.) Organic matter = $\left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times 100$ (3)

2.5 Determination of Lipid Content (%)

The lipid content of a biological material can be estimated by direct extraction of the dry material exhaustively using a suitable lipid solvent e.g. petroleum, (40c-60c) diethyl ether etc. in a convenient continuous extractor, such as soxhlet, Bolton or Bailey Walker type, Direct extraction gives the proportion of free fat.

A 2g of the sample 'A' in powdered form was taken into a thimble of a known weight (W_1). Both the sample A and thimble was weighted (W_2), the thimble with sample A was placed inside a soxhlet extractor. A 30cm of acetone-ethanol mixture of (1:1) was put into a 500ml round bottom joint flask which was silted in electrically connected heating mantle and was switched on. The heat increased carefully and slowly until the solvent boiled. Condensed solvent with dissolved lipid was continuously rush back into the flask and the heating and the extraction process was continue for about 24 hours, then cooled in a desiccators and weighed (W_3) .This procedure was repeated for sample B,C,D,E, and F respectively.

The solvent was distilled off to about 20ml, the lipid in solvent solution was quantitatively transferred on to an evaporating dish, cooled, dried in desiccators the lipid thus recovered may be weighed and (%) lipid calculated using equation 4 below:

(%) lipid content = $\left(\frac{W_2 - W_3}{W_2 - W_1}\right) \times 100$ (4)

2.6 Crude Protein Determination

Protein is the major compound containing Nitrogen in any food sample, so Nitrogen is used as an index of protein term "crude protein". The Kjeldahl method as described by Onwuka (2005) was used to determine the crude protein on samples. A factor of 6.25 was used in converting

nitrogen to protein. This was done by accurately weighing 2g of sample into a standard 250ml Kjeldahl flask containing 1.5g $CuSO_4$ and 1.5g Na_2SO_4 as catalyst and 5ml concentrated H_2SO_4. The Kjeldahl flask (digestion) was placed on a heating mantle and was heated gentle to prevent frothing for some hours until a clear bluish solution was obtained. The digested solution was allowed to cool and this was quantitatively transferred to 100ml standard flask and make up to the mark with distilled water. 20ml portion of the digest was pipette into a semi-micro Kjeldahl distillation apparatus and treated with equal volume of 40% NaOH solution. The ammonia evolved was steam distilled into a 100ml conical flask containing 10ml solution of saturated boric acid to which 2 drops indicator (double indicator) had been added.

The tip of the condenser was immersed into the boric acid double indicator solution and then the distillation continued until about 2/3 of the original volume obtained. It was then titrated with 0.2NHCl until a purple-pink end point was observed. A blank determination was also carried out in the similar manner as described above except for the omission of the sample. The crude protein was obtained by multiplying the percentage of Nitrogen content by a factor (6.25).

Crude Protein = % Nitrogen x factor

The basis for Kjeldahl is as shown in equation 5 below:

Crude protein = %Nx6.25= $\frac{(sampletitre - Blank\ titre)0.1\ X\ 0.04}{weight\ of\ sample} X \frac{100}{1} X \frac{100}{20} X \frac{weight\ of\ sample}{1}$ (5)

2.7 Determination of Crude Fibre (%)

The crude fibre was determined in accordance with the method described by (A.O.A.C, 1980). A 2g of sample A was taken and defatted with petroleum ether for 8hrs. It was boiled under reflux for exactly 30 minutes with 200cm^3 of 1.25% H_2SO_4. It was filtered and washed with boiled water until the washing were no longer acidic. The residue was boiled in a round bottom flask with 200cm^3 of 1.25% NaOH for another 30 minutes and the crucible with sample (residue) was dried in the oven at 100^oC. It was left in a desiccators to cool and weighed (C_2). It was then incinerated in a muffle furnace at about 600^oC for 3hrs. This was then put in a desiccator to cool and weighed (C_3). This procedure was repeated for sample B, C, D, E, and F respectively. The percentage fiber content was calculated using equation 6 below

Weight of fibre = $C_2 - C_3$

$$(\%)\ \text{fibre} = \frac{C_2 - C_3}{\textit{weight of original sample}} \times 100 \qquad (6)$$

Where:

C_2 = weight of sample residue on oven dry

C_3 = weight of sample residue incinerated in a muffle furnace

2.8 Determination of Carbohydrate (%)

The values of carbohydrate (%) were obtained by subtracting the total percentage water, mineral, protein, and fat from hundred. This is known as carbohydrate by difference and is used because no satisfactory method exists for determining carbohydrate by direct analysis (Helen, 1979).

This method was used to determine the percentage carbohydrate of sample A, B, C, D, E, and F respectively. The percentage carbohydrate was calculated using equation 7 below.

(%) carbohydrate = 100 – (P+L+M+MC) % (7)

P = (%) protein

L = (%) Lipid (fat)

M = (%) Mineral

MC = (%) Moisture Content

2.9 Statistical Analysis

All data obtained were subjected to Analysis of Variance (ANOVA) at 95%confidence level using Statistical Package SPSS (20.0) software.

3.0 RESULTS AND DISCUSSION

Drying rate: At the initial dryingstage, the rate of water evaporation from the meat was very high but later decreased continuously until the constant weight was obtained (table 1a). There was loss in weight of about 69.29%, 74.02%, and 66.71% for cow, goat and sheep meat respectively;this is equivalent to the amount of water evaporated. The moisture content(wet base) was found to be the same as the percentage weight loss above, while the moisture content(dry base) was found to be 2.29%, 2.86% and 2.00% for the product of cow, goat and sheep meat respectively. However, it was generally observed that many food products such as meat undergo an initial rapid constant rate of drying period follow by a slower, decreasing drying rate period (Ihekoronye and Ngoddy, 1985). As the drying period increases, the weight of the sample decreases (table 1a).

Moisture Content:

it was observed that there was reduction in moisture content of fresh meat to dried meat product (kilishi) from 69.00% to 11.00%, 74.00% to 11.83%, 65.00% to 9.35% for cow, goat and sheep meat respectively (table 2a). However, the obtained values of moisture content for beef and goat meat were lower compared to value reported by Norman et al., 2004. Therefore, the reduction in moisture content of both fresh meat and the dried meat product (kilishi) is not only prolonging the shelf-life but also increases the concentration of nutritional values of dried meat product (kilishi) due to the ingredients that were added to it.

Ash Content: The ash contents of the meat increased from 1.00%, 9.5%, 0.50% to 5.17%, 0.67% and 6.17% for cow goat and sheep meat respectively. The obtained value of ash content for cow is in line with the reported value in the cited reference while that of goat and sheep meat were reduced by 0.03% when compared to the valued obtained by (Sawyer, 1975). The reduction in the ash content of the meat samples may be due to the feed taken by the animal,the age of and environmental control where it grown. The ash content of kilishi increased due to the ingredients added to it.

Lipid Content: It was also observed that there was an increase in lipid (fat) content from fresh meat to dried meat product (kilishi) from 11.00% to 19.67%, 10.33% to 17.00%, 16.00% to 22.00% for cow, goat and sheep meat respectively. The amount of lipid (fat) content of cow

(beef) and sheep meat or lamb and goat meat were higher than the values in the cited reference. However, percentage increase in lipid (fat) content of the dried meat product makes it to have high energy values in human nutrition and also increase its flavour.

Crude Protein: It could also be observed that there was an increase in percentage crude protein of dried meat product compared to fresh meat from 19.00% to 38.99%, 15.05% to 37.22, 18.06% to 38.68% for cow meat, goat meat and sheep meat respectively. The obtained values of crude protein for beef sheep meat and goat in this study were closer to the value obtained by (Norman, 2004). Likewise, the protein requirement of an individual is defined as the lowest level of protein intake that will balance the loss of nitrogen from the body of a person maintaining energy balance at modest level of physical activities (FAD/WHO, 1985).

Crude Fibre: More also, table 2a shows that, there was slight increase in percentage crude fibre of dried meat product compared to fresh meat from 4.1% to 4.83%, 2.33% to 2.83%, 2.67% to 2.83% for cow meat (beef), goat meat and sheep meat respectively. The slight increase in percentage of crude fiber of dried meat product indicated the quantity of indigestible matter in the dried meat product (kilishi) is not much due to the high digestibility of protein by reducing the moisture content of the meat and subjecting it to a moderate roasting on a glowing fire after drying.

Carbohydrate: From the result obtained in table 2a and b, it was observed that, the amount of carbohydrate of dried meat product (kilishi) compared to fresh meat increased from 0.5% to 20.85%, 0.36% to 28.78%, 0.28 to 23.82% for cow meat (beef), goat meat and sheep meat respectively. However, increase in amount of carbohydrate of dried meat product was due to various ingredients such as pepper, ginger, groundnut, onion, garlic, magi salt etc. added to it which also makes it to have high energy value in human nutrition and also increase the palatability of the dried meat product (kilishi).

Table 1(a): Average Values of the Drying Rate for the Three Different Meat Samples.

Time (h)	**Weight of Sample A (g)**	**Drying Rate of Sample A (Kg/h)**	**Weight of Sample B (g)**	**Drying Rateof Sample B (Kg/h)**	**Weight of Sample C (g)**	**Rate Drying of Sample C (Kg/h)**
0	70.00	-	70.00	-	70.00	-
1	61.88	0.062	49.63	0.050	63.77	0.064
2	53.89	0.027	43.09	0.022	56.63	0.028
3	49.85	0.017	39.39	0.013	51.97	0.017
4	43.81	0.011	36.24	0.009	47.08	0.012
5	40.09	0.008	34.27	0.007	43.49	0.009
6	37.09	0.006	33.38	0.006	40.49	0.007
7	36.67	0.005	33.10	0.005	40.12	0.006
8	35.48	0.004	32.72	0.004	39.73	0.005

9	34.07	0.004	31.24	0.003	37.41	0.004
10	30.26	0.003	30.84	0.003	33.90	0.003
11	28.04	0.003	29.56	0.003	29.95	0.003
12	21.45	0.002	18.15	0.002	23.30	0.002

Where

Sample A isCow meat

Sample B isGoat meat and

Sample C is Sheepmeat

Table 1(b): ANOVA for Drying rate of the Three Different Meat Samples (cow, goat, and sheep meat)

			Sum of Squares	df	Mean Square	F	Sig.
meat source * Drying Time	Between samples	(Combined)	0.000	12	0.000	0.000	**1.000**
	Within samples		26.000	26	1.000		
	Total		26.000	38			
average weight of sample * Drying Time	Between samples	(Combined)	6073.859	12	506.155	24.661	**0.000**
	Within samples		533.638	26	20.525		
	Total		6607.497	38			
rate of drying * Drying Time	Between samples	(Combined)	0.009	12	0.001	125.510	**0.000**
	Within samples		0.000	26	0.000		
	Total		0.009	38			

Table 2(a)**:** The Average Values of Nutritional Content of Fresh Meat (Cow Meat, Goat Meat and Sheep Meat) and Their Respective Dried Meat Products (Kilishi).

Meat source	**Moisture Content (%)**		**Ash Content (%)**		**Lipid Content (%)**		**Crude Protein (%)**		**Crude Fibre (%)**		**Carbohydrate (%)**	
	FM	K	FM	K	FM	K	FM	K	FM	K	FM	K
Cow meat	69.00	11.00	1.00	9.50	10.50	19.67	19.00	38.99	4.17	4.83	0.50	20.85
Goat meat	74.00	11.83	0.50	5.17	10.33	17.00	15.05	37.22	2.33	2.83	0.36	28.78
Sheep meat	65.00	9.33	0.67	16.00	16.00	22.00	18.06	38.68	2.67	2.83	0.27	23.82

Where

FM = Fresh meat

K = Kilishi

Table 2 (b):ANOVA Table for proximate analysis of Fresh Meat (Cow Meat, Goat Meat and Sheep Meat) and Their Respective Dried Meat Products (Kilishi)

		Sum of Squares	df	Mean Square	F	Sig.
moisture content (%) * meat treatment	Between samples (combined)	5153.284	1	5153.284	469.448	**0.000**
	Within samples	43.909	4	10.977		
	Total	5197.194	5			
ash content (%) * meat treatment	Between samples (combined)	135.375	1	135.375	9.092	**0.039**
	Within samples	59.559	4	14.890		
	Total	194.934	5			
lipid content (%)* meat treatment	Between samples (combined)	79.498	1	79.498	9.541	**0.037**
	Within samples	33.329	4	8.332		
	Total	112.826	5			
crude protein (%) * meat treatment	Between samples (combined)	656.888	1	656.888	255.046	**0.000**
	Within samples	10.302	4	2.576		
	Total	667.190	5			

crude fibre (%) * meat treatment	Between samples (combined)	290	1	0.290	0.253	**0.641**
	Within Groups	4.584	4	1.146		
	Total	4.874	5			
carbohydrate content (%) * meat treatment	Between samples (combined)	871.697	1	871.697	108.524	**0.000**
	Within samples	32.129	4	8.032		
	Total	903.826	5			

3.2

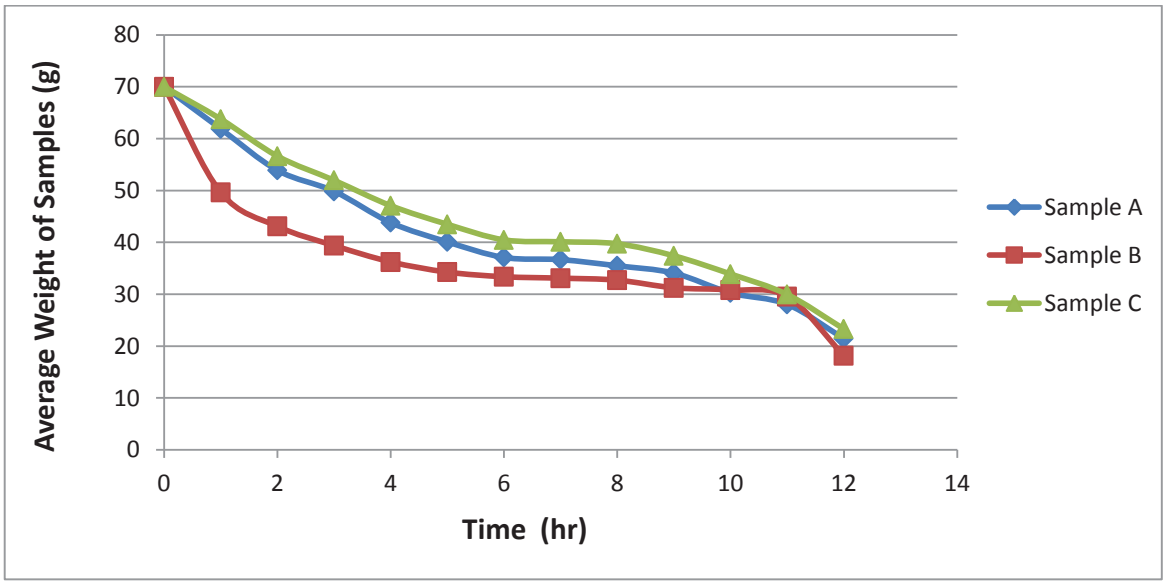

Figure 2: *A Graph of Average Weight of Samples Against the Drying Period (Time)*

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

From the results obtained in this study, It could be seen that as the drying period increases the weight of the samples decreases. This decrease in weight leads to some physical changes such as shape, colour, size and the texture of the meat. However, continuous drying process makes the meat to become smaller, thinner and to some extent hard. Therefore, the rate of drying is dependents on the drying period, the temperature, and the air circulation.

It is obvious from the study that the drying method used to process the fresh meat to dried meat product (kilishi) helps in prolonging self- life of the meat and also stop the microbiological activities that can takes place at high moisture content by reducing the moisture content of the meat. All the spices and ingredients added to it such as ginger, groundnut, pepper, magi, onion, salt, etc. increase the palatability, mineral content, protein content, fat content, amount of carbohydrate and also stabilized the colour of the dried meat product (kilishi).

However, it can be seen from the results that fresh meat is not a good source of carbohydrate. There are some variations in the nutritional contents of each of the meat sample (cow meat, goat meat, and sheep meat), these variations may be due to feeds intake by the animals, the breed, age, sex, and environmental location where these animals are grown up.

4.2 Recommendations

Drying the meat under the sun may either be over or under dried due to inability to control the intensity of the sun. Therefore, modern method of drying such as oven drying method which

will save more time and also provide the access to regulate the temperature through temperature regulator of oven machine should be adopted.

It is not only in the dry season period that, the maximum production of dried meat product could be obtained. However, continuous production of dried meat product (kilishi) can also be obtained throughout the year by adopting the advance method of drying such as tray drying.

Roasting of the dried meat product (kilishi) should be done under low and moderate heat because over heating may affect the amino acid which in turn affect the content of the dried meat product (kilishi).

REFERENCES

Alonge, D. O. and Hiko A. A. (1981). Traditional Method of Meat Preservation and Preparation in Nigeria. West African Farming, March/April, Pp 19-20

AOAC, (1980). Official Methods of Analysis. Association of Official Analytical Chemist, Washington, DC.

CTA's Publication (1997). Traditional foods processing for profit edited by Peter Fellows. Intermediate Technology Publications Ltd, 103-105 Southamptom Row, London WC1B 4HH, UK.

Denis, P. O., Blanch, J. R. and Ward, A. G. (1998). Food control in action. pp.44

FAO. (1990). Manual of simple methods of meat preservation. FAO animal production and Health Paper No. 79 Rome, FAO.

FAO. (1990C). Manual on simple method of meat preservation. Health paper. No. 79, FAO, Rome.

FAO. (1993). Report on FAO seminar on meat drying and other Low Cost Meat Preservation

Method in Africa 16-19 March, Accra, Ghana. Rome, FAO.

FAO. (1994). Manual on meat inspection for developing Countries. FAO, Animal and Health paper. No. 119, Rome, FAO production.

FAO. (1994d). Integrated grading and solar drying of meat. Project document.

FAD/WHO. (1985). Energy and protein requirement. Technical Report series 724 WHO, Geneva

FAD/WHO. (1991). Protein Quantity Evaluation Report of Joint FAD/WHO Expert Consultation, FAO Food and Nutrition paper 51, Rome.

Gerrard, F. (1971). Meat technology. Leonard Hill Press, 4th edition.

Helen, A. G. (1979). Introductory Nutrition. 4th edition Hill publisher. pp.55-87

Henrickson, R. L. (1978). Meat, poultry and Sea Food Technology. Prentico-Hall Inc. New Tersey. Pp 61-67

Ihenkoroye, A. I and Ngoddy, P. O. (1985). Integrated Food Science and Technology for the Tropics.pp.115.

Lawne R. A. (1979). Meat Science. Pergamon press, London 3rd edition. Pp. 241-229.

Lawne, R. A (1991). Meat Science. 5th edition Pergamon press, Oxford. PP. 89-109.

Norman, W. D and James, N. D. (2004). The Technology of Food Preservation.4th edition. Pp 4-5

Onwuka G.I. (2005). Foodanalysis and instrumentation theory and practice.Napthali prints Lagos

Peter, F. (1997). Traditional Food Processing for profit

Sawyer, R. (1975). The Composition of Meat. Analytical aspect in meat. Pp 287-301.

www.FAO. Org // docrep/003/X6932e/x69321;02htm//Retrieved on 13/12/2007