

The Effect of Sun-Drying and Oven-Drying on the Nutritive Value of Meat Pieces in Hot Humid Environment

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Abstract: A study was conducted to investigate the effect of sun-drying and oven-drying on the nutritive value of meat strips from chicken, beef and chevon. Oven-drying was done at 60°C for 72 hrs while sun drying was done at 33°C for 120 hrs to obtain a constant weight of the meat strips. The results showed that oven-drying and sun-drying increased ($p < 0.05$) the dry matter and protein contents of the dried samples compared to the fresh samples while fat, carbohydrates and energy (Kcal/g) were significantly ($p < 0.05$) higher in the fresh meat samples than the dried samples. The sun-dried samples had higher ($p < 0.05$) functional properties, proteins, acceptability level, but lower fat than the oven-dried samples. The results were attributed to the various changes that occurred during the drying process. Sun-drying of meat samples could be adopted under the hot humid tropical environment provided it is done under hygienic conditions.

Key words: Sun-drying, oven-drying, nutritive value, meat, hot humid environment

Introduction

Meat, as used in this work is in line with the definition of Janus (1999), where meat was referred to as the flesh of the animal used as food. It is the part of the muscle of the domesticated or other designated animals that are consumed. It includes the muscles that are found in the skeleton, tongue, diaphragm, heart or oesophagus with or without the accompanying and overlying fat. Portions of bones, skin, nerve and blood vessels that normally accompany muscles are included as meat parts. Meat does not include the muscles found on the lips, snout or ears (Janus, 1999).

Meat quality is related to a number of physical properties such as the amount of intra-muscular fat and the age of the animal (Ihenkoronye and Ngoddy, 1985). The primary meat quality factors include tenderness. The surface texture of the lean may play important roles in meat quality assessment by consumers (FAO, 1991). The chemical composition of meat is also a significant factor in meat quality evaluation. The meat composition varies with the breed, species, age and the degree of fattening of the animal (Gill, 1983). The unique composition and structure of muscle gives rise to the characteristic properties of meat (Macrae *et al.*, 1997). Meat is regarded as an excellent dietary source of vitamins (Boyle, 1994), protein and energy (Lawrie, 1981).

In spite of the numerous benefits of dietary meat it is highly perishable due to its high moisture and protein contents which can be utilized by micro-organisms (Hotchkiss and Potter, 1995). This situation necessitates the extension of the shelf-life of meat, by creating an unfavorable environment for the micro-organisms to survive or grow. The principle of meat

preservation is concerned, mainly with preventing or delaying microbial spoilage, autolysis is avoidance of weight loss and any changes in taste or texture (Macrae *et al.*, 1997). Preservation methods include use of low or high temperatures, reduction of water contents (activity) or adoption of chemical preservations.

Among the many preservation methods, dehydration or drying is probably one of the earliest and most effective method developed (Hotchkiss and Potter, 1995). FAO (2001) reported that in the absence of a cold chain, meat drying remains the most practical way of preserving and storing meat in developing countries with warm climate. It however, stated that the open air sun-drying process which involves exposing pieces of meat to air and sunlight unprotected has a lot of disadvantages over oven-drying, as such meat pieces can be exposed to dust, rain, insects which contribute to general acceptability of the meat or non-acceptability of meat. Drying in the open air is a common phenomenon in developing countries and the effects need to be examined. This work was therefore designed to evaluate the effects of oven-drying and sun-drying methods on the nutritive value of three types of meat pieces (chicken, chevon and beef) after sun-drying and oven-drying and possibly recommend the better method of drying for adoption by the people in these areas.

Materials and Methods

Fresh samples of chicken meat, beef and chevon were collected from the central market in Minna, Niger state Nigeria.

Sample preparation: The meat cuts were collected, on the same days from different distribution points in the market. It was ensured that the meat samples were

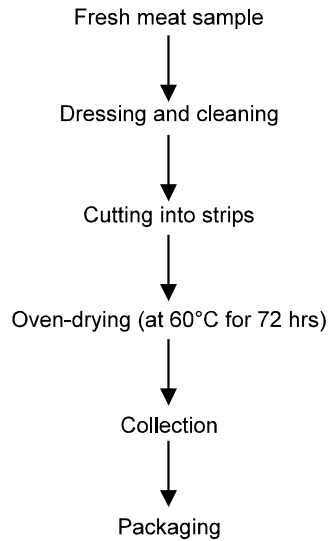


Fig. 1: Flow chart for the production of oven drying meat

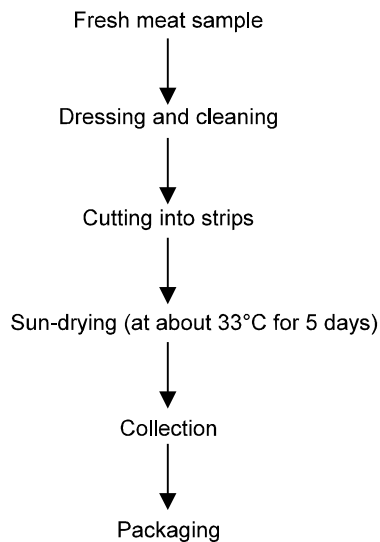


Fig. 2: Flow chart for oven-dried meat

collected from the different parts of an animal. The meat cuts from the same animals were then mixed together for proper blending. The samples were then thoroughly washed in clean cool water. They were then cut into small pieces (strips) with the following dimensions, 0.02 cm thickness, 5 cm wide and 8 cm long. These strips were weighed in bulk and dried using either of the two methods, that is, oven-drying and sun-drying to a constant weight of about 7% moisture content.

Oven-drying method: The oven-drying of the meat samples was done using an oven drier at a constant temperature of 60°C. Each sample was then ground with a mortar and a pestle after drying. Each dried

sample was then stored in an air-tight bottle for the proximate and functional analyses. Both the raw and the dried samples were analyzed. The oven drying process lasted for 72 hrs.

Sun-drying method: Sun-drying was carried out by placing the meat samples on a wire gauze and put directly in the hot humid tropical sun. The sun-drying was done between 9:00 hrs and 15:00 hrs daily. The average daily temperature during this period was 33°C and relative humidity was 67%. Sun-drying lasted for 5 days, pounding with mortar and pestle was done to increase the surface area for analytical purpose. The flow charts for the production of both oven-drying and sun-drying meat pieces are indicated in Fig. 1 and 2 respectively.

Proximate and chemical analyses: The proximate and chemical were carried out by A.O.A.C. (2000) methods.

Functional properties analyses of meat samples

Foaming capacity and stability: These were determined by the methods described by Okezie and Bello (1988).

Emulsion capacity and stability: Emulsion capacity and stability were determined using the methods of Yatsumatsu *et al.* (1972). In this method emulsion stability was calculated as the ratio of the height of the emulsified layer to the total height of the meat sample (material).

Hygroscopicity: Hygroscopicity was determined using the method described by Bhatti (1988). About 5.0 g of the meat sample was exposed to ambient conditions (temperature and humidity). Hygroscopicity was then expressed as the percentage of weight gained by the meat sample after 48 hrs of exposure.

Sensory evaluation: The fresh and dried meat samples were evaluated for colour, appearance, aroma, texture and overall acceptability using a 5-point descriptive hedonic scale (5 = excellent and 1 = poor) as described by Ihenkoronye and Ngoddy (1985). A panel of 10 untrained judges was constituted from randomly selected students of the department and used for the evaluation. The order of presenting the meat samples to the judges was randomized and the meat samples were coded to hide their identity.

Statistical analysis: The data collected were statistically analyzed using analysis of variance (ANOVA) with a Completely Randomized Design (CRD) (Snedecor and Cochran, 1973) and Duncan (1955) method for mean separation.

Results and Discussion

Table 1a, b and c show the results of the proximate analysis of fresh, oven-dried and sun-dried chicken

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Table 1a: Proximate composition of chicken meat (dry weight basis)

Parameters:	Fresh	Oven-dried	Sun-dried	
%	Chicken	Chicken	Chicken	
Dry Matter	28.33 ±0.38 ^b	92.49±0.00 ^a	92.40±0.00 ^a	*
Protein	64.38±1.20 ^b	75.53±0.44 ^a	77.99±0.09 ^a	*
Fat	29.25±1.94 ^a	21.22±0.93 ^b	18.43±0.07 ^b	*
Ash	1.30±0.13 ^a	1.01±0.13 ^a	1.04±0.09 ^a	NS
Carbohydrate	5.08±0.08 ^a	2.24±0.06 ^b	2.90±0.036 ^b	*
Energy value (kcal/g)	5.41±0.07 ^a	5.01±0.04 ^b	4.88±0.07 ^b	*

Values are means of duplicate determination. superscripts are significantly (p<0.05) different, NS = Not significantly different. *Significantly different

Table 1b: Proximate composition of chevon (dry weight basic)

Parameters	Fresh	Oven-dried	Sun-dried	
(%)	Chevon	Chevon	Chevon	
Dry matter	36.16±0.00 ^b	92.80±0.00 ^a	92.46±0.00 ^a	*
Protein	60.33±1.16 ^a	66.72±0.48 ^b	73.33±1.10 ^a	*
Fat	33.41±1.16 ^a	29.77±0.68 ^a	22.78±1.01 ^b	*
Ash	2.77±0.05 ^a	1.52±0.01 ^b	1.83±0.05 ^b	*
Carbohydrate	3.49±1.01 ^a	1.97±0.06 ^b	2.07±0.86 ^b	*
Energy value (Kcal/g)	5.54±0.08 ^a	5.43±0.04 ^a	5.06±0.03 ^a	*

Values are means of duplicate determination, Mean values in the same row with different superscripts are significantly (p<0.05) different, NS = Not significant different; *Significantly different

Table 1c: Proximate Composition of beef samples (dry weight basis)

Parameters	Fresh	Oven-dried	Sun-dried	
(%)	Chevon	Chevon	Chevon	
Dry matter	29.06±0.00 ^b	92.16±0.00 ^a	92.16±0.00 ^a	*
Protein	59.33±0.83 ^b	80.85±0.98 ^a	82.34±0.95 ^a	*
Fat	34.30±0.16 ^a	15.97±0.31 ^b	15.06±0.47 ^a	*
Ash	2.71±0.56 ^a	1.39±0.43 ^b	1.55±0.53 ^a	NS
Carbohydrate	3.69±0.28 ^a	2.30±0.13 ^b	1.06±0.11 ^c	*
Energy value (Kcal/g)	5.61±0.08	4.74±0.03	4.69±0.09	NS

Values are means of duplicate determinations, Mean values in the same row with different superscripts are significantly (p<0.05) different. NS is not significantly different. *Is significantly different

meat, chevon and beef respectively. There were no significant (p>0.05) differences in the values for protein, fat, ash carbohydrate, dry matter and energy (kcal/g) of oven-dried and sun-dried chicken meat samples. However, the values of dry matter and protein were significantly (p<0.05) lower in the fresh chicken meat than in the oven-dried and sun-dried chicken meat pieces. On the other hand, the proportion of fat, carbohydrate and energy were significantly (p<0.05) higher in the fresh chicken meat than either the oven-dried or sun-dried meat.

In Table 1b, the dry matter proportions, ash, carbohydrate and energy (kcal/g) of the oven-dried and sun-dried chevon samples are not significantly (p>0.05) different. The dry matter and protein values are significantly (p<0.05) higher than the values for the oven-dried sample.

Table 1c, indicates no significant (p>0.05) differences in the values of dry matter, protein, ash and energy (Kcal/g) for the oven-dried and sun-dried beef. But the values of dry matter and protein were reduced in the fresh beef compared to the values for either the oven-dried or the sun-dried beef.

Table 2a: Functional properties of chicken meat samples

Parameters	Fresh	Oven-dried	Sun-dried	
(%)	Chevon	Chevon	Chevon	
WAC (ml/g)	7.54±0.13 ^a	2.70±0.30 ^c	5.11±0.21 ^b	*
OAC (ml/g)	6.73±0.00 ^b	4.83±0.52 ^a	12.86±0.08 ^c	*
Emulsion Capacity	4.95±0.00 ^a	5.50±0.042 ^a	5.65±0.35 ^a	NS
Emulsion stability	4.95±0.00 ^a	4.75±0.25 ^a	4.50±0.05 ^a	NS
Foam capacity	4.25±0.25 ^b	4.75±0.25 ^b	9.50±0.05 ^a	*
Foam stability	1.25±1.00 ^c	4.25±0.25 ^b	9.00±0.25 ^a	*
Hygroscopicity	0.00±0.00 ^c	4.95±0.05 ^a	2.65±0.15 ^b	*

Values are means of duplicate determination, Mean values in the same row with different superscripts are significantly (p<0.05) different, WAC is water absorption capacity; OAC is oil absorption capacity, NS = not significantly different. *Significantly different

Table 2b: Functional properties of chicken meat samples

Parameters	Fresh	Oven-dried	Sun-dried	
(%)	Chevon	Chevon	Chevon	
WAC (ml/g)	3.4±0.66 ^b	4.40±0.20 ^b	5.22±0.38 ^a	
OAC (ml/g)	5.38±0.29 ^b	4.83±0.37 ^b	11.14±0.18 ^a	
Emulsion Capacity	4.95±0.00 ^b	4.20±0.020 ^b	7.25±0.25 ^a	
Emulsion stability	4.95±0.00 ^b	6.00±0.20 ^a	6.20±0.20 ^a	
Foam capacity	2.05±0.05 ^c	3.75±0.25 ^b	9.50±0.50 ^a	
Foam stability	0.00±0.00 ^b	0.00±0.00 ^b	1.25±0.25 ^a	
Hygroscopicity	0.00±0.00 ^c	6.55±0.30 ^a	4.75±0.15 ^b	

Values are means of duplicate determinations, Mean values in the same row with different superscripts are significantly (p<0.05) different

Table 2c: Functional properties of chicken meat samples

Parameters	Fresh	Oven-dried	Sun-dried	
(%)	beef	beef	beef	
WAC (ml/g)	5.42±0.03 ^a	1.95±0.05 ^c	4.08±0.19 ^b	
OAC (ml/g)	9.33±0.34 ^b	5.98±0.06 ^c	13.64±0.17 ^a	
Emulsion Capacity	4.95±0.00 ^b	5.40±0.40 ^b	7.15±0.15 ^a	
Emulsion stability	4.95±0.00 ^a	5.10±0.10 ^a	6.20±0.25 ^b	
Foam capacity	7.00±1.00 ^a	4.00±0.00 ^b	6.50±0.50 ^a	
Foam stability	5.50±0.50 ^a	0.00±0.00 ^b	0.00±0.00 ^b	
Hygroscopicity	0.00±0.00 ^c	5.30±0.10 ^a	3.15±0.15 ^b	

Values are means of duplicate determinations, Mean values in the same row with different superscripts are significantly (p<0.05) different

These results have clearly shown that the nutritive value of the oven-dried and sun-dried, chicken meat, chevon and beef measured in terms of dry matter, protein, fat, ash, carbohydrate and energy values are basically similar. But the proportions of dry matter and protein in the fresh meat samples are significantly (p<0.05) lower compared to dried sample.

This might be attributed to the higher moisture content of the fresh samples. This is in agreement with the findings of Ockerman (1985) who reported that as the moisture content of meat increased, protein and dry matter contents decreased. The differences observed in the nutrient value of fat, ash, carbohydrate or energy between the fresh and the dried samples could be due to losses during drying as a result of the higher drying temperature compare to the fresh samples. There could also be lipid oxidation, leaching and increased solubilization of some micro-nutrients into the evaporative water in the course of drying.

The results of the functional properties are shown in Table 2a, b and c, for chicken meat chevon and beef. In Table 2a, oven-drying reduced (p<0.05) Water Absorption Capacity (WAC) Oil Absorption Capacity

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Table 3: Mean sensory scores of chicken meat, chevon and beef samples (%)

	Appearance	Colour	Aroma	Texture	Taste	Overall acceptability
Chicken						
Fresh	3.00±0.30	2.90±0.23	3.30±0.26	3.60±0.27	3.30±0.34	3.00±0.26
Oven-dried	3.40±0.27	3.50±0.27	3.00±0.27	3.00±0.33	3.40±0.31	2.90±0.27
Sun-dried	3.60±0.31	3.70±0.34	3.60±0.34	3.00±0.26	2.90±0.23	3.60±1.10
Chevon						
Fresh	3.30±0.26	3.10±0.31	3.00±0.31	3.40 ±0.33	2.80±0.36	3.20±0.25
Oven-dried	3.40±0.27	3.50±0.26	3.10±0.18	3.00±0.26	2.60±0.34	3.10±0.18
Sun-dried	2.90±0.23	3.00±0.33	3.00±0.30	2.80±0.39	3.40±0.34	3.50±0.27
Beef						
Fresh	3.20±0.20	3.50±0.17	3.60±0.16	3.40±0.27	3.40±0.27	3.60±0.27
Oven-dried	2.90±0.28 ^a	3.00±0.30 ^a	2.70±0.26 ^b	2.60±0.27 ^b	3.40±0.27 ^a	3.00±0.26 ^{ab}
Sun-dried	2.90±0.23 ^a	2.80±0.79 ^a	2.50±0.22 ^b	2.40±0.27 ^b	2.60±0.27 ^b	2.80±0.20 ^b

Mean values in the same row with different superscripts are significantly ($p < 0.05$) different

(OAC) Foaming Capacity (FC) and Foaming Stability (FS) in the oven-dried meat compared to the sun-dried chicken meat. The fresh chicken meat had higher ($p < 0.05$) values for Water Absorption Capacity (WAC), lower foaming stability and hygroscopicity than the dried meat samples. Table 2b clearly indicates that sun-dried chevon samples had high ($p < 0.05$) values of WAC, OAC, Emulsion Capacity (EC) Foaming Capacity (FC) and Foaming Stability (FS) compared to the oven-dried chevon. The values of WAC, OAC, EC and FS were similar for both fresh and oven-dried chevon.

Table 2c, shows that there are a lot of variations in the functional properties of the beef. These variations did not give a consistent pattern as in the case of chicken meat and chevon.

The higher ($p < 0.05$) water absorption capacity of fresh samples of chicken, chevon or beef could be due to the high carbohydrate content of the fresh samples, which usually results in greater starch swelling. It could also be attributed to lesser structural change in the starch and proteins present in the meat samples. A microscopic investigation of kilish (a meat product) has shown that the size and shape of the starch granules as well as the distribution of the protein clusters had an important effect on the Water Absorption Capacity (WAC) (Muir *et al.*, 2000).

The high WAC values for the fresh samples could also be attributed to the larger pore spaces in its structure than that of the dried samples. The higher ($p < 0.05$) WAC of the sun dried samples of chevon. Than the oven-dried chevon samples could be due to the higher fat ($p < 0.05$) content of the over-dried sample or the greater structural changes in the starch and proteins present in the oven-dried samples.

The higher Oil Absorption Capacity (OAC) of the dried meat samples than the fresh and oven-dried meat samples could be due to the lower fat content of the sun-dried meat samples, resulting from lipid oxidation during drying. When this happens, the sun-dried samples would have a higher ability to absorb more oil into its structure. The higher OAC value of the sun-dried sample could also be that the hydrophobic properties or proteins

present in the sun-dried samples remained almost unchanged in nature. This agrees with the statement of Hayta *et al.* (2002) that the oil absorption capacity of any food material is dependent on the degree of hydrophobicity of the system.

The higher values for emulsion capacity in the sun-dried samples could be due to its lower fat content, higher protein content and the drying method. This could also be due to greater interactions of its protein with other components of the sample. Emulsion capacity of a product is dependent on the oil content and protein concentration of the product (Nkonge and Balance, 1984; Kato *et al.*, 1995). Similarly, Prinyawiwatkul *et al.* (1993) suggested that emulsification properties are rather more influenced by the type of protein than the quantity of protein.

The results obtained from the fresh meat samples could be due to higher moisture content which might have masked the effect of the other components in the meat thereby reducing the interaction level of the oil with the meat components.

The higher foaming capacity of the sun-dried sample is due to its higher protein content and lower fat content. This is in agreement with Iwe (2003) who reported that the foaming capacity of a substance depends on the surface active properties of the proteins involved. The higher foaming capacity of sun-dried samples could also be due to stronger forces at the interphase between the air bubbles and water, permitting hydrophobic interactions (Vojdam and Whitake, 1994). Kinsella (1979) found that some food proteins are capable of forming foams and their capacity to foam and keep stable foams depends on the type of protein, degree of denaturation, PH, temperature and processing method. The hygroscopic value of the oven-dried meat samples is higher than the sun-dried samples probably due to the higher exposure of the sun-dried samples to the atmosphere.

The sensory evaluation scores shown in Table 3, indicates that the drying methods had no significant ($p > 0.05$) effect on the organoleptic qualities of the chicken meat and chevon samples. The chicken meat

and chevon had higher ($p < 0.05$) level of acceptance by the panelists. These results could be due to unacceptable changes in the organoleptic properties of the beef compared to chevon and chicken.

Conclusion: The study showed that dry matter and protein contents are lower in the fresh meat pieces than in the dried samples while fat, carbohydrates and energy are higher in the fresh meat than the dried samples. The dried samples had higher functional properties, higher proteins and lower fat contents compared to oven-dried samples. The sun-dried samples had higher acceptability level than the oven-dried samples. Sun-drying of the meat samples is therefore recommended provided it is done under an hygienic condition.

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