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NUTRITIONAL AND MICROBIAL QUALITY OF SHADE-DRIED MEAT "SUMUNGAYA"

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ABSTRACT
Shade dried meat bearing fat (Summungaya) is a popular food product in the western State of Sudan (Darfur). Meat bearing fat was cut into slices and it was hung on a rope inside a storeroom. Meat slices were left for 9 days to undergo fermentation and drying. At the end of the drying process some of the dried strips were stored hung on the rope and the others were ground, kept in sterilized glass and metal container and stored at room and refrigerator temperature. Samples were subjected to microbiological analysis, which were carried at 3 days intervals for 9 days and monthly for three months. The chemical evaluation was determined after a month and 3 months. Drying of the fresh slices revealed a drastic drop in total viable bacterial count (TVBC), coliform, *E. coli*, and moisture content, while Staphylococci sp. and *Salmonella* were not detected. After 3 months drying, the TVBC of the hung strips increased from $5.75x10^4$ to $4.25x10^5$cfu/g and moulds from $1.53x10^3$ to $7.20x10^4$cfu/g as moisture decreased from 8.7% to 4%, however yeasts almost remained constant. The TVBC ($5.75x10^4$cfu/g), yeasts ($2.00x10^3$cfu/g) and moulds ($1.53x10^3$cfu/g) for glass container samples remained constant at both storage temperatures. With respect to metal container samples the TVBC increased from $5.75x10^4$cfu/g to $6.20x10^5$cfu/g, yeasts and moulds remained constant at level of $2.50x10^3$ and $2.20x10^3$cfu/g respectively. After one month drying protein, ash and fat content increased. After 3 months drying the product showed slight changes in protein, fat and ash content. The dominant bacteria were identified as *Bacillus* sp., yeasts as *Candida edax* and *Candida graminis* and moulds as *Rhizopus nigricans* and *Apergillus niger*. Mycotoxin B2 content (5.8ppb) found in hung strips was less than the permissible level of SSMO. This findings revealed that the production of Sumungaya should be under more hygienic condition. The presence of metabolic compounds from these moulds and their interaction with pathogenic bacteria may lead to the outbreak of food-borne illness.

KEYWORDS: Shade-dried meat, Sumungaya, Sermoud, Storage stability, Nutritional value.

INTRODUCTION
Fermentation as a method of food preservation, it is an ancient technology widely world used. It extends the shelf life, enhances the nutritional value and ensures the microbiological safety of some foods and makes them palatable and more digestible. Most of the food in Sudan are preserved by double method of fermentation and sun-drying.[1] As recorded by[2] about 90 fermented products are made in the Sudan today.

There are different protocols which can be used to preserve meat in Sudan. These protocols include: light fermentation during sun drying as thin Sermoud and kaido-digla, fermentation during drying as thick Sermoud (Sumungaya) and skin, wet fermentation in a container, then consume or store wet as miriss, doddery, bierta, jerbi-jerbi and lahmat nimir. The fermentation process seems to be the desire for strong (almost putrid) flavor rather than preservation alone.[2] Dried meat products in Sudan are common diet among pilgrims, travelers, hunters and tribes. Sermoud (shermout) of Sudan is a fermented dried meat product. It is an ancient food referred to king Aezanes's inscription.[3] described Sermoud of the Sudan as a wholesome and more palatable product.

Thick Sermoud or slow shade-dried sermoud (Sumungaya) is popular and widely distributed product in Western Sudan (Darfur State) like other surrounding countries as Chad and Nigeria.[4;5] To produce this

product, meat containing fat is intentionally chosen as it is believed that fat enhances the development of a proteolytic flavor. During the slow drying the meat develops a strong flavor and even maggots may appear on it.[2] Similar product was made by the Betra tribe of the southern Blue Nile State. The product usually stored in skin bags for one or two months, during which it developed a rotten flavor.[6] The proteolytic flavor of the shade-dried Sermoud is mixed with a rancid flavor. Rancidity which is an oxidative spoilage of lipid[7] is usually not accepted in food but in case of Sermoud, it appears to be almost desired as it indicates that the dry meat contain fat.

Food products may be stored at ambient temperature, where the prevention of spoilage depends on other parameters or under refrigeration where temperature is expected to play a preservative role. Dried foods spoilage is due to normal range of moulds which are capable to grow above $0.77a_w$ and Slow at $0.75a_w$. [8] Moulds genera which are associated with dried meat are *Aspergillus*, *Rihzopus*, *Penicillum*, *Alternaria* and *Mucor*.[9, 10]

It is difficult to specify maximum permissible limits of moisture content for dried foods because deterioration of these products (change of flavor, texture and color) occur in a manner that does not allow the definition of critical moisture content.[11] Dried meat and salted meat products were not change during storage.[12]

Mycotoxins consumption may cause foodborne diseases. They are a secondary metabolite compounds that produced by moulds. The main genera which produced these toxins are *Asperigillus*, *Penicillium* and *Fusarium*.[13] These products particularly aflatoxins are carcinogenic and hazardous for human health. They are responsible for thousands death of humans when they are associated with hepatitis B mostly in non-industrial tropical countries.[14] These toxins are capable to cause acute and chronic effects in man and animals from death to disorder of central nervous, cardiovascular, pulmonary system and intestinal tract.[15]

Dried meat products are not regulated in developing countries and are produced in small ethnic markets. The microbiological, physical and chemical properties as well as eating quality of processed meat are becoming increasingly important to provide the consumer with high quality meat and meat products. The main objectives of this study is to isolate and identify Microorganisms associated with shade-dried beef, the effect of drying on shade-dried beef quality, storage stability and detection of aflatoxins were detected.

MATERIAL AND METHODS

Laboratory preparation of Sumungaya (shade-dried beef)

The traditional technique practiced by inhabitants in western Sudan (Darfur State) was followed. Meat containing fat is intentionally chosen (Plate 1). Meat sample was obtained from a butcher at Khartoum North market. The sample was immediately transferred in iced cooled thermo-flask to inhibit the microbial growth.[16] The microbiological and chemical analyses were carried out on arrival the laboratory.

The meat samples were placed in a sterile stainless steel tray. The meat was then cut using sterile knife into slices of about an inch thickness and 12 inch length (Plate 2). The slices were then hung on a rope inside a storeroom (Plate 3) for 9 days to undergo fermentation and to dry well. Complete drying was achieved after one month. At the end of the drying process some of the dried strips were stored hung on the rope and the others were ground, kept in sterilized glass and metal containers and stored at room and refrigerator temperatures for 3 months.

Plate 1. Meat containing fats.

Plate 2. Sliced meat.

Plate 3. Sliced meat hung on a rope inside a storeroom.

The microbiological parameters investigated

The microbial investigation was carried out every 3 days during 9 days drying (slices taken randomly), after one month and then monthly during the storage period (3 months). For the fresh meat slices samples were minced, while for other samples (semi dry and dry samples) were ground into a powdered form using sterile grinder and then ten-fold serial dilutions were carried out.[17, 18] Ready-made media (Oxoid) were used to assess the microbiological quality. The parameters investigated were total viable count (TVBC), *Staphylococcus* count, *Salmonella* detection, yeasts and moulds count. For the enumeration of total coliforms and faecal coliforms the Most Probable Number (MPN) technique was used.[19] Extra confirmatory test were conducted onto Eosin Methylene Blue agar medium (EMB) and then by the IMVEC test.[18]

Identification of the isolates

Pure bacterial isolates (from fresh sample, during drying and the storage process) were identified using the conventional methods based on cultural, morphological, and biochemical tests.[20, 21, 18] Yeasts isolates were identified by the methods of[22, 23, 24] The methods of[25, 8, 26, 27] was used to identify mould isolates.

Chemical analysis

The method of[28] was used to measure the pH of the fresh sample and 'Sumungya' samples. The moisture content, protein, fat and ash content were determined according to the method described by.[29]

Aflatoxin analysis

The strips of the hung dried meat slices were analyzed for aflatoxins presence at the Sudanese Standard Metrology Organization (SSMO) using thin layer chromatograph an extraction procedure based on[29] by Romer method.

RESULTS AND DISCUSSION

Fig. 1 shows the variation of pH during the drying process. Drying revealed that the pH was decreased from an initial value of 5.6 to 5 within 6 days drying and remained constant thereafter. Similar result was obtained by[30] They found that the pH value of seasoned 'kundi' beef was 5.43 at zero time, 3 and 6 months drying, while for unseasoned one was 5.32 at zero time and 5.33 after 3 and 6 month drying. The decrease in pH reported in this study may be referred to the fermentation by lactic acid bacteria.[31] reported that fermentation can be carried out by "cultured" or "wild" microorganisms that lower the pH. The pH of different food products determine the number and types of spoilage and pathogenic microorganisms. The pH in the range of 6.8 and 8.0 is ideal for most pathogenic microorganisms growth including *E. coli, Salmonella, S. aureus* and *Shigella* isolated from dried meat (suya) in Nigeria.[5] Fig.1 also reveals that the moisture content decreased from 72% to 30% at the first nine days drying and then to 8.7% after one month drying.[32] found that the moisture content of dried sliced beef samples (kilishi) varied (19-26%). As it can be observed the TVBC decreased from initial count of log7 to about log 5 within 9 days and to about log 4 within one month drying. In Chad,[33] recorded that the aerobic plate count of fresh beef meat was log 5.68 and then decreased to log 4.32 after sun drying for 2 days. The lowering of a_w will lower the available amount of water for microorganisms and retarded their growth. However, the amount of required moisture content of different food products will affect the microbial growth.[34]

Coliforms MPN/g were reduced from17 to 14 within 3 days drying and from 14 to zero within 6 days drying. *E. coli* MPN/g was reduced from 2 to zero within 3 days drying (not plotted). This results is lower than $3.8x10^1$cfu/g which obtained by[32] and $0.53x10^5$ which recorded by.[33] claimed that the total coliforms and faecal coliform decreased from log 3.0 /g to log 1.39 /g for sun-dried cow meat and were not detected in samples treated with NaCl before drying. The decrease in total coliforms and *E. coli* may be attributed to the lowering of pH and the decrease of moisture content.[36] confirmed that fermentation and drying were sufficient to reduce the level of *E. coli* in peproni sticks by < log 2.0.[37] revealed that *E. coli* decline during fermentation and subsequence drying.

With regards to *Salmonella* sp. and *Staphylococcus* sp. presence, results showed that these pathogenic bacteria were not detected in fresh meat, during drying and after drying. These results are in accordance with that recoded by[33] They found that *Staphylococcus aureus* was not investigated in any sample dried by oven or solar-drying The microbial analysis of Suya spicy, smoked or roasted street meat in Northern Nigeria claimed that the Staphylococcal count was highest at log 6 and *Salmonella* species count was highest at log 5.70.[5]. [38] found that the Staphylococcal count was log 3.96 in

Nigerian spicy sun dried and grilled meat product (Kilishi). Another study of Kilishi explained that the Staphylococcal count of this product was $1.73x10^7$cfu/g.[39] The absence of *Salmonella* sp. and *Staphylococcus* sp. in this study may be due to the use of high quality meat used, clean environment of preparation, proper handling during processing and drying. Yeasts count of fresh meat was log 2 and then increased significantly to log 4 with decrease in moisture content within 3, 6 and 9 days drying and then

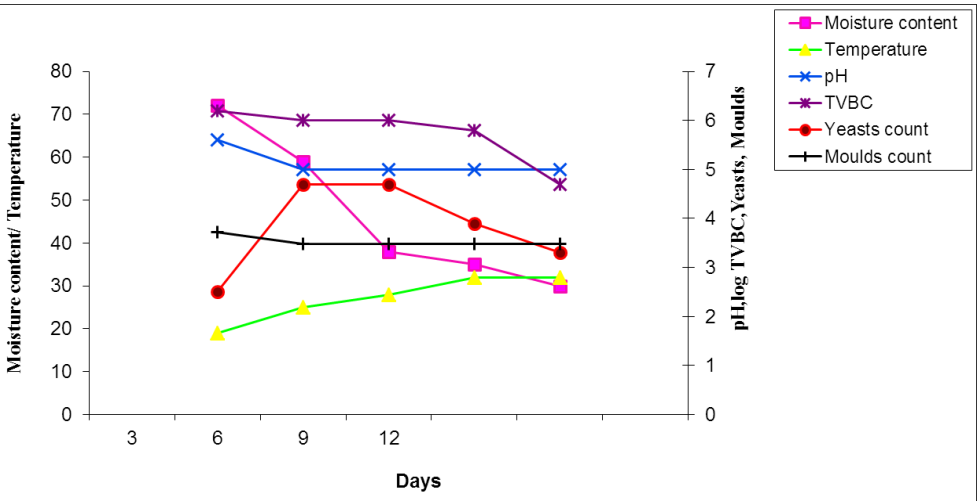

Fig. 1 . Microbail count of shade-dried beef "Sumungaya" during drying process.

decreased by 10-fold and then remained constant in the range of log 3, which is higher than log 1.27 /g that reported by[33] The increase of yeasts during the first days of drying (3-9 days) may be referred to the available and suitable conditions for their growth during fermentation and ripening.[40] reported that yeasts were found in high numbers (log 4–5) of traditional fermented sausages (Croatian) during ripening process which is probably due to the fat content of beef and pork. Yeasts were considered as an important agent in the production of sensory and palatable properties of fermented sausages and other meat products due to lipolytic and proteolytic activity.[41]

With respect to the moulds presence, results showed that there was no change in moulds count with reduction of moisture content.[5] found that yeasts and moulds count ranged between log 3.64 and log 5.36 for suya spicy, smoked, or roasted street meat in Nigeria. The presence of moulds in this study at this level may be attributed to the ability of moulds to grow at low level of a_w.[8]

Table 1 also presents the microbial load of the dried meat samples stored hung on a rope. Results showed that the samples had an increase of TVBC and moulds count with decrease in moisture content within two and three month storage. The TVBC increased from $6.2x10^4$ to $4.25x10^5$cfu/g, moulds count increased from $6x10^3$ to 7.210^4cfu/g, while yeasts remained constant.[6] reported that the sun dried Sermoud kept its quality without change in odor or microbial counts for as long as six month.[12] studied the storage stability of dried salted mutton. They found that aerobes, anaerobes, coliform, yeasts and moulds were not detected when analyzed after 60 days storage.

With regards to the samples stored in glass containers at room and refrigerator temperature, data presented that there was no change in TVBC, yeasts and moulds during storage for 3 month (Table 2). The bacterial count of the samples stored at room temperature almost remained constant, while for the samples stored in metal container at refrigerator temperature increased from $6.25x10^4$ to $6.2x10^5$cfu/g with an increase in moisture content from 8.9% to 10% after three month storage (Table 3). This indicated that these samples might have picked some moisture from the surrounding environment and attained a high a_w value which enhanced microorganisms growth.[34] If dried foods are incorrectly packaged or are stored under moist conditions, sufficient water may be reabsorbed thus enabling surviving organisms to multiply again and bring spoilage of food when these become wet.[42] There is no change in yeasts and moulds count.

The predominant bacteria isolated from fresh meat, during drying, and during storage were identified tentatively as *Bacillus* (Table 4).[6] found that the most microorganisms isolated from dried meat belonged to *Bacillus* sp. and *Staphylococcus* sp. Although drying destroys some microorganisms, bacterial endospores survive as do yeasts moulds and many gram-positive and gram-negative bacteria.[43][44] mentioned that the remaining flora after drying are spore formers (*Bacillus* sp.) enterococci and different types of moulds (e.g. *Asperigillus* sp., *Penicillium*, *Alternaria* and *Cladosporium* sp.). The presence of spore forming bacteria viz *Bacillus* and fungi will cause many problems such as food poisoning thus affecting human health.

Generally, yeasts are ubiquitous in agricultural environments; different types of yeasts were expected and found in Sumungaya. All yeasts isolates were non-glucose fermenter and did not form spores, some developed pseudohyphae and multiply by budding. These yeasts isolates were identified as *Candida edax* and *Candida graminis* (Table 5).[45] found that *Debaryomyces hansenii* was the most predominant yeast isolated from intermediate moisture meat. The other species encountered, were *Cryptococcus laurentii*, *Cryptococcus hungaricus*, *Torulaspora delbrueckii*, *Rhodotorula mucilaginosa*, *Sporobolomyces roseus*, *Debaryomyces vanriji*, *Trichosporon beigelii*, *Yarrowia lipolytica*, *Saccharomyces cerevisiae* and *Candida zeylanoides*. Yeasts occur naturally or added as starter culture during meat processing and they contribute to the aroma of the fermented meat product (*i.e.* sausages) by breaking down of lipids and proteins and forming specific metabolic products.[46] Moulds isolated from fresh meat, during drying, samples hung on a rope after one month drying and samples stored in different containers at different temperatures were identified as: *Rhizopus nigricans* and *Asperigillus niger*.

However *Asperigillus niger* was isolated from the sample stored hung on a rope after one, two and three months. *Aspreigullus* sp. are aerial contaminant. The air in Shambat area where the experiment was conducted at Khartoum State was found to be highly contaminated with moulds spores.[47] *Asperigillus* sp. have the ability to grow over the normal range of food storage at quite low a_w.

The incidence of moulds in different types of meat has been reported by.[48] They isolated 8 different genera included *Aspergillus*, *Alternaria*, *Fusarium*, *Cladosporium*, *Penicillium*, *Neurospora and Rhizopus* from sundried meat in Nigeria. The presence of metabolic compounds from these moulds and their interaction with pathogenic bacteria may lead to the outbreak of food-borne illness.[49]

Table 1. Microbial load of shade dried beef "Sumungaya" stored on a rope at room temperature.

Storage time	Storage temperature	pH	Moisture content%	TVBC count/g cfu/g	Yeasts count/g cfu/g	Moulds count/ g cfu/g
Zero time	*Room temperature	5.00	8.7	$5.70x10^4$	$2.25x10^2$	$1.53x10^3$
One month	*Room temperature	5.00	8.2	$6.20x10^4$	$2.25x10^3$	$6.00x10^3$
Two months	*Room temperature	5.00	4.0	$4.25x10^5$	$1.05x10^3$	$7.20x10^4$
Three months	*Room temperature	5.00	4.0	$4.25x10^5$	$1.05x10^3$	$7.20x10^4$

***Room temperature= 25-35°C**

Table 2. Microbial load of shade dried beef "Sumungaya" stored in glass container at room and refrigerator temperature.

Storage time	Storage temperature	pH	Moisture content%	TVBC count/g	Yeasts count/g cfu/g	Moulds count/ g
Zero time	*Room temperature	5.00	8.7	$5.70x10^4$	$2.25x10^3$	$1.53x10^3$
One month	*Room temperature	5.00	8.0	$5.60x10^4$	$2.20x10^3$	$1.53x10^3$
Two months	*Room temperature	5.00	8.0	$5.60x10^4$	$2.20x10^3$	$1.53x10^3$
Three months	*Room temperature	5.00	8.0	$5.60x10^4$	$2.20x10^3$	$1.53x10^3$
One month	4.0°C	5.00	8.6.5	$6.75x10^4$	$2.25x10^3$	$1.53x10^3$
Two months	4.0°C	5.00	8.6.5	$6.75x10^4$	$2.00x10^3$	$1.53x10^3$
Three months	4.0°C	5.00	8.6.5	$5.75x10^4$	$2.00x10^3$	$1.53x10^3$

***Room temperature= 25-35°C**

Table 3. Microbial load of shade dried beef "Sumungaya" stored in metal container at room and refrigerator temperature.

Storage time	Storage temperature	pH	Moisture content%	TVBC count/g cfu/g	Yeasts count/g cfu/g	Moulds count/ g
Zero time	*Room temperature	5.00	8.7	$5.70x10^4$	$2.25x10^3$	$1.53x10^3$
One month	*Room temperature	5.00	8.0	$5.60x10^4$	$2.25x10^3$	$1.53x10^3$
Two months	*Room temperature	5.00	8.0	$5.00x10^4$	$2.20x10^3$	$1.53x10^3$
Three months	*Room temperature	5.00	8.0	$5.00x10^4$	$2.20x10^3$	$1.53x10^3$
One month	4.0°C	5.00	8.9	$6.25x10^4$	$2.35x10^3$	$1.53x10^3$
Two months	4.0°C	5.00	8.9	$6.25x10^4$	$2.35x10^3$	$1.53x10^3$
Three months	4.0°C	5.00	10.0	$6.20x10^5$	$2.50x10^3$	$2.20x10^3$

***Room temperature= 25-35°**

Table 6 presents the chemical composition of the fresh meat samples and Sumungaya samples after one and three months storage.

There was a decrease in moisture content and increase in protein, fat, and ash contents of the samples after one month and during storage period.[30] found that the moisture, protein, fat and ash content for commercial kundi was 23.29, 66.79, 5.43 and 4.82% respectively, while for laboratory prepared beef kundi was 35.09, 58.10, 4.41 and 2.40% respectively. For laboratory prepared camel kundi the moisture was 30.21, protein 63.67, fat 4.86 and ash 1.86%. Drying, food losses its moisture content, which results in increasing the concentration of nutrients in the remaining mass. Proteins, fats and carbohydrates are present in a large amount per unit weight in dried foods than in their fresh counterparts. Due to fermentation during drying process the meat like other fermented foods has an enhanced nutritional value especially in digestibility.[2,50]

There was a decrease in moisture content of the sample stored hung on a rope, and an increase from 8.7 to 10.2% for the sample stored in a can at refrigerator temperature, while the moisture content of the other samples remained constant during storage. As it can be seen from the results, there was slight increase in protein content (54%) with decrease in moisture content (4%) for the sample stored hung on a rope. Results also showed that there was no change in protein, fat and ash content.

Table 4. Types of bacterial genera isolated from fresh meat, during drying and storage periods.

Isolates No	Gram stain	Shape	Growth in air	Oxidase test	Catalase test	O/F test	Motility	Spore forming	Genus
1	+	Rod	+	-	+	-	+	+	*Bacillus*
2	+	Rod	+	-	+	F	+	+	*Bacillus*
3	+	Rod	+	-	-	-	+	+	*Bacillus*
4	+	Rod	+	-	-	F	+	+	*Bacillus*
5	+	Rod	+	-	-	F	+	+	*Bacillus*
6	+	Rod	+	-	-	-	-	-	*Bacillus*
7	+	Rod	+	-	-	-	-	-	*Bacillus*
8	+	Rod	+	-	-	-	-	-	*Bacillus*

Table 5. Biochemical and physiological status of yeasts from fresh meat during drying and storage period.

Tests	Isolates	
	A	B
1- Fermentation	-	-
2- Utilization of carbohydrate aerobically		
Glucose	+	+
Galactose	+	+
Maltose	+	+
Sucrose	+	+
Starch	+	+
Lactose	+	+
3- Starch formation	-	-
4- Starch hydrolysis	-	+
5- Growth on		
Na-Nitrate	+	+
K-Nitrate	+	+
6- Growth in liquid media	Pellicle and sediment	Sediment
7- Pseudomycelium	-	-
8- Vegetative cell	Budding	Budding
9- Ascospore	-	-

Table 6. Chemical composition of fresh sample and dried samples after one and three month storage.

Items	Storage conditions	Moisture%	protein%	Fat%	Ash%
Fresh	-	72.90	19.0	8.31	0.5
Dried samples after one month	*Room temperature	8.7	50.0	40.0	1.8
Hung on a rope for three months	*Room temperature	4.0	54.0	40.0	2.0
metal for three months	*Room temperature	8.0	51.0	40.0	1.0
Glass for three months	*Room temperature	8.0	51.0	40.0	1.0
metal for three months	5^{o}C	10.2	50.2	38.2	1.4
Glass for three months	5^{o}C	8.65	50.0	38.85	1.5

***Room temperature= 25-35^{o}C**

For the samples stored at different environmental conditions. This indicated that the final product kept its chemical quality for three months without off-odor observed during storage process.

Results showed that the level of aflatoxin B2 in the sample hung on the robe was 5.8 ppb was less than the permissible level of[51,52] which was 15 ppb and the sample moisture content was 4%. As reported by[48] Aflatoxins were commonly found in animal tissue (AFB1, AFB2, AFG1, and AFG2) in all investigated samples of sun-dried meat. The moisture content of the sample hung on the robe was found to decrease with the increase of storage duration. Despite the drop in moisture content with prolonged storage the *Asperigullus niger* as judged by colony count showed slight increase. This little increase in *Asperigullus niger* did not result in any change in aflatoxin level. Aflatoxins are realized to be potentially hazards to humans and animal animal, and regarded as potent toxins, mutagens, teratogens and carcinogens.[53]

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