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Microbiology and Water Activity Relationship in the Processing and Storage of Sudanese Dry Meat (Sharmoot)

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ABSTRACT

The Sudanese dry meat SHARMOOT is a major food product in East Africa. No information is available on microbial profiles or improved methods of processing the product. We have developed a pre-cooking and grinding procedure that produces the meat efficiently. The product is chemically and microbiologically stable for at least 4 months without refrigeration.

While staphylococci and *Enterobacteriaceae* were the most common major bacterial groups isolated from dried meat samples at the beginning, micrococci and bacilli predominated during the last stages of storage.

Microbiological data (total, spore, yeast and mold, and *Staphylococcus aureus* counts and *Clostridium perfringens* detection) indicated that the product made by us is microbiologically more acceptable than a comparable product made traditionally in Sudan. The potential exists for large-scale production of SHARMOOT.

A powdered dried meat product known as Sharmoot is a major ingredient in the popular Sudanese Asida meal. Asida is prepared by rehydrating the dried meat (Sharmoot) and cooking it together with powdered, dried okra to form a thick, sticky sauce (mulah) that is served on top of a jellied substance made from boiled, fermented sorghum meal (asida). The production of Sharmoot and its traditional use with other food ingredients (and the proposed improvement in the method of its preparation) are shown in Fig.1.

The product is prepared by cutting the meat into thin strips, hanging it in the sun for 3 to 5 days until it is dry, then grinding it into a fine powder. In addition to being slow, this method subjects the meat to contamination by microorganisms and dirt particles from the atmosphere. So far, no work has been done to improve the drying process or determine the safety and storage stability of the dried meat.

The purposes of this study were to: 1) define a procedure for efficient production of a wholesome dried meat product, 2) determine the chemical and microbial stability of the dried meat during storage, 3) compare the chemical composition and microbial loads on dried meat samples prepared under controlled conditions in the laboratory with those of dried meat samples prepared in Sudan by the traditional method, and 4) identify the major microbial groups associated with dried meat (Sharmoot).

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MATERIALS AND METHODS

Drying of meat

Meat samples

Outside-round cuts of beef weighing between 2-3.5 kg each and selected from different carcasses were obtained from the Department of Animal Sciences and Industry, Kansas State University, Manhattan, Kansas. Every 3 cuts were combined, trimmed of visible fat and used as one sample.

Strips versus ground

Each of five samples was divided into 2 portions. One portion was cut parallel to the muscle grain into strips 1 cm^2 in diameter and 15-20 cm in length. The strips were hung by stainless steel bacon hangers and placed in a smoke house (Vortron model TR-2, Beloit, Wisconsin). The other portion was coarsely ground first, then finely ground, mixed thoroughly by hand, spread (1 kg/0.1 m^2) over pieces of cheesecloth placed on ham screens, and put in the smoke house. Both portions were then dried at 37.7°C (100°F) at slow air speed for 12 h. Samples of about 100 g of the ground meat and of 3 meat strips were taken every 2 h, pulverized in a Waring Blender to a powdery consistency (ca 2-3 min), and used for moisture and water activity determination.

Raw ground versus precooked ground

Each of five meat samples was ground, mixed thoroughly, and divided into 2 portions. One portion was spread (1 kg/0.1 m^2) over cheesecloth placed on ham screens for drying. After the addition of 100 ml water per kg to prevent sticking, the other portion was cooked for 15 min in a pressure cooker. The meat was then cooled, drained from cooking juices, and spread over cheesecloth on ham screens as described above. The cooking juices were concentrated by boiling for 30 min and distributed evenly over the meat. Ham screens containing the raw and precooked meat portions were placed in the smoke house and dried for 12 h at 65.5°C (150°F) at high air speed. Samples of

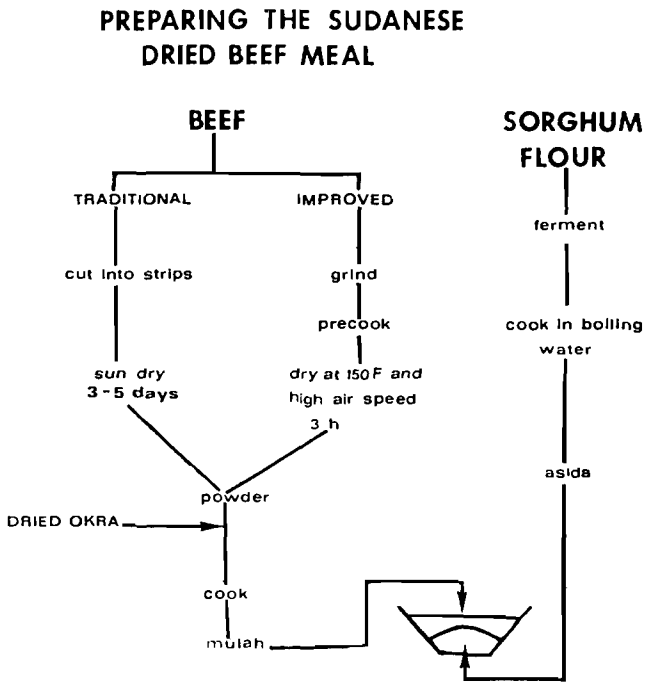

Figure 1. *The production of "Sharmoot" and its traditional use with other food ingredients (and the proposed method of its improvement).*

100 g were taken at 2 h intervals from each portion. These were finely ground in a Waring Blender and used for moisture and water activity determination.

Dried meat samples from Sudan

A permit was obtained from the United States Department of Agriculture to import from Sudan 12 dried meat samples, which were prepared according to the traditional procedure. Meat from beef round was bought from the market, cut into strips of about 1 cm^2 diameter and 15-20 cm length, and hung to dry in the sun for 3-5 days. The dried meat strips were then collected, finely ground in a wooden mortar, and packaged in polyethylene bags. After arrival in the United States, these samples were stored at 25°C until a period of 4 months had passed since their preparation. They were then analyzed for moisture, protein, fat, Aw, pH, and microbial counts.

Storage studies

Six raw and 6 precooked meat samples were prepared as described above. The raw samples were dried for 9 h and the precooked samples for 3 h in the smoke house at 65.5°C (150°F) and high air speed. Each sample was then collected separately, pulverized in a Waring Blender to a powdery consistency (ca 2-3 min), and distributed into 100 g lots in sterile Stomacher bags. A set of the bag from each sample was stored at 25°C and the other set at 37°C.

Analysis of samples

Duplicate samples of 100 g each were used for determining moisture, protein, fat, Aw, pH, and microbial counts from the fresh and precooked meat before drying, and from the dried meat samples after 0, 1, 3, and 4 months of storage at both 25 or 37°C.

Physical and chemical analyses

Analysis of moisture and protein contents of the meat samples was done in triplicate by AOAC methods *(2)*. A Beckman pH meter, model 43, Beckman Instrument Inc., Fullerton, CA was used to measure the pH of meat samples. Dried powdered samples were prepared for pH measurement by suspending 10 g into 200 ml water and allowing to stand for 30 min. Water activity was measured by a Kaymont Rotronic Mygroscop, Kaymont Instrument Inc., Huntington Station, NY.

Mesophilic, mold and yeast, aerobic spore (bacilli), Staphylococcus aureus *MPN counts and detection of* Clostridium perfringens

A 1:10 dilution from each sample was obtained by aseptically weighing 25 g into a sterile Stomacher bag, adding 225 ml sterile phosphate buffered diluent *(11)* and stomaching for 1 min in a Stomacher Lab-Blender model 400, Dynatech Laboratories, Inc., Alexandria, VA. Appropriate amounts were then pipetted into dilution bottles to give the required decimal dilutions. For mesophilic counts, duplicate pour plates of standard plate count agar (Difco) were prepared from decimal dilutions of each sample and incubated at 37°C for 48 h *(11)*. Antibiotic-containing (chlortetracycline HCl and chloramphenicol) standard plate count agar (Difco) incubated at 25°C for 5 d was used to enumerate mold and yeast *(16)*. For aerobic spore counts, tubes containing suitable decimal dilutions of each sample were heated for 1 min in a water bath set at 80°C. After rapid cooling to 10°C in ice water, samples of 1 ml from each tube were pour plated in standard plate count agar (Difco) and incubated at 37°C for 48 h *(20)*.

A modification of the method described by Ordal et al. *(22)* was used for the isolation and enumeration of *Staphylococcus aureus* from meat samples. Meat samples were placed in 3 decimal MPN tubes with 10% NaCl in trypticase soy broth (Difco) and incubated at 37°C for 24 h. After that, a 3 mm loopful from each tube was streaked on the surface of a staphylococcal #110 medium (Difco). Typical golden colonies similar to those produced by a *Staphylococcus aureus* control culture were counted and recorded. A coagulase test by the tube method was run from representative colonies *(5)*.

For *Clostridium perfringens* detection, samples of 1 ml portions from 1:10 dilution of each sample were pipetted into sets of 3 screw-cap test tubes each containing 9 ml fluid thioglycolate (BBL). The tubes were incubated at 45°C for 4 h, then at 37°C for 24 h. One ml from each tube that showed turbidity or gas production was pour plated in sulfitepolymyxin-sulfadiazine (SPS, Difco) agar and incubated in a BBL anaerobic jar at 37°C for 18 h. Typical black colonies similar to those produced by a control culture of *Clostridium perfringens* were further tested for motility, gelatin liquefaction, and nitrate reduction. Results for meat samples were recorded as positive or negative, depending on whether they contained detectable levels of *Clostridium perfringens* or not *(8)*.

Isolation and characterization of bacteria from dried meat

Five colonies (one from the center and one from each quarter) were isolated at random for one of the mesophilic count plates that were prepared from each sample prepared in the laboratory after 0, 1, 2, 3, and 4 months of storage. Ten colonies were isolated after 4 months of storage from each of the samples obtained from Sudan. A total of 480 cultures were isolated from dried meat samples prepared in the laboratory and 120 cultures from samples obtained from Sudan. The cultures were purified,

Gram-stained, and stored at 4°C until needed. Cultures isolated from dried meat samples prepared in the laboratory included 342 Gram-positive and 138 Gram-negative bacteria, whereas cultures isolated from meat obtained from Sudan included 74 Gram-positive and 46 Gram-negative bacteria. Conventional microbiological methods were used to identify the isolates at the genus level *(3)*. Further identification of the enteric bacteria to species was accomplished by using the Micro I.D. diagnostic kit (General Diagnostics, Morris Plains, NJ).

Analysis of variance at 0.05 significance level of data was performed with the aid of SAS program at the statistics department at Kansas State University.

RESULTS AND DISCUSSION

Drying of meat

Grinding versus stripping

Fig. 2 shows the drying rates of ground meat and meat strips. Ground meat had a faster drying rate and lower ultimate moisture content than meat strips. This is because ground meat has more total surface area and shorter distances for water travel from the center to the surface than meat strips. More cell disruption in ground meat results in greater moisture loss (faster drying rate) as well. The drying curves for both ground meat and meat strips followed a sigmoidal pattern (Fig. 2).

Raw versus precooked meat

Fig. 3 shows the drying curves of raw and precooked ground meat. The raw meat had an initial moisture content of 70%, whereas the precooked meat, because of the moisture loss during cooking, had an initial moisture content of 62%.

The precooked meat lost almost 50% of its moisture during the first 2 h and only 10% of the remaining moisture during the next 7 h.

The 10% final moisture content usually desirable in dried meat was reached after 3 h in precooked meat and after more than 8 h in raw meat.

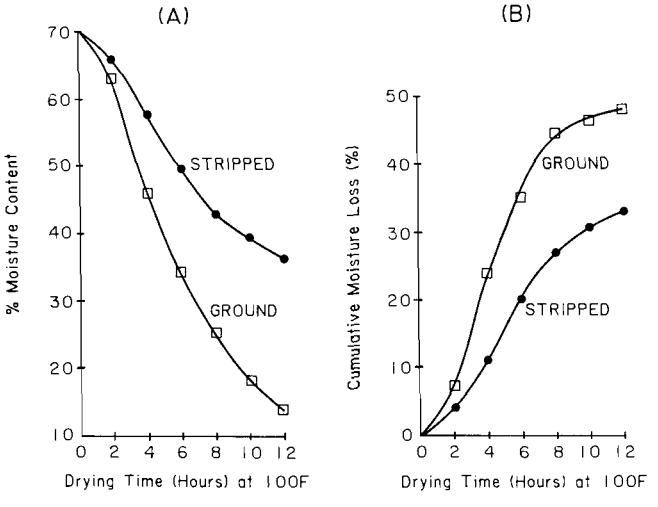

Figure 2. *Dehydration curves for ground meat and meat strips (A). Moisture content versus time. (B). Cumulative moisture loss versus time (average values from 5 samples).*

Fig. 4 shows moisture sorption isotherms for the raw and precooked meats. At similar moisture contents, precooked meat had higher Aw values than raw meat. This is probably because precooking had destroyed some the water-absorbing sites of the meat. Also, addition of concentrated juice back to meat samples might have influenced the Aw. At 10% moisture, the Aw of raw meat was .350 and that of precooked meat was .450. Both Aw values are far below the levels that allow microbial growth.

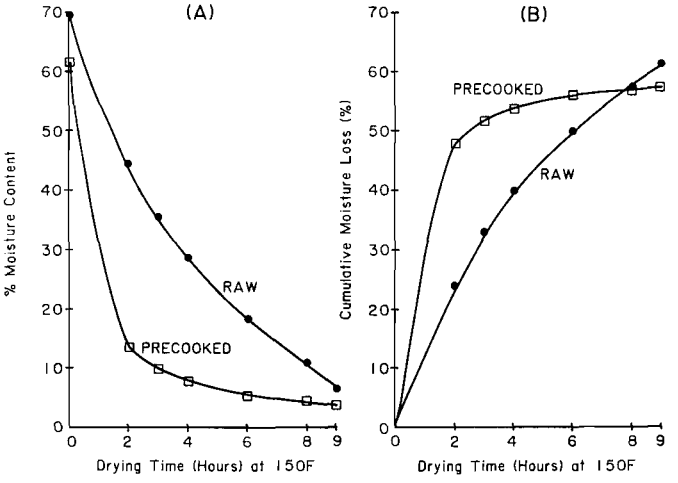

Figure 3. *Dehydration curves for raw and precooked ground beef (A). Moisture content versus time. (B). Cumulative moisture loss versus time (average values from 5 samples).*

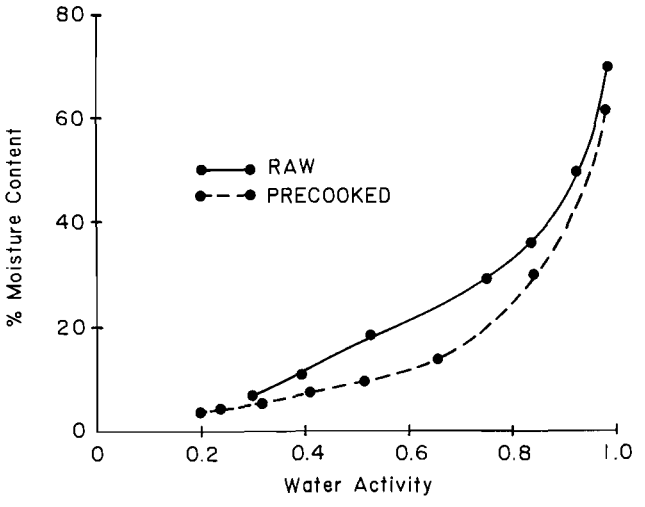

Figure 4. *Moisture sorption isotherms for raw and precooked ground beef (average values from 5 samples).*

Storage studies

Tables 1-4 show mean values from the chemical and microbiological analysis of ground dried raw meat (GDR meat) and ground dried precooked meat (GDP meat) samples stored for 4 months at either 25 or 37°C.

Chemical analysis

Moisture content and Aw

The mean initial moisture content was 8.1% for the GDR and 10.2% for the GDP samples. It continued to increase for samples stored at 25°C and decrease for samples

TABLE 1. *Analysis of ground dried raw meat stored at 25°C*[1].

	Attribute[2] tested	Fresh ground meat	Ground dried raw meat 0 Time	1 Month	2 Months	3 Months	4 Months
Chemical	% Moisture	68.2	8.1[a]	8.5[ab]	9.1[b]	9.4[bc]	10.1[c]
	% Protein	20.1	61.3[a]	61.0[a]	60.8[ab]	60.4[b]	60.2[b]
	% Fat	9.7	27.1[a]	27.3[a]	27.0[a]	27.0[a]	26.3[a]
	pH	5.69	5.66[a]	5.64[a]	5.63[a]	5.61[a]	5.58[a]
	Aw	.993	.407[a]	.418[a]	.466[b]	.466[b]	.518[c]
Microbiological	Mesophiles/g	$1.3x10^6$	$7.4x10^{2a}$	$6.4x10^{2a}$	$5.4x10^{2a}$	$2.5x10^{2b}$	$1.5x10^{2b}$
	Aerobic spores/g	3.5x10	$1.1x10^{2a}$	$5.2x10^b$	$1.4x10^{2a}$	$9.2x10^b$	$9.5x10^b$
	Staphylococcus aureus						
	MPN/g	9	.7[a]	3.6[b]	.3[a]	ND	ND
	Clostridium perfringens						
	Detection	ND[3]	ND	ND	ND	ND	ND
	Molds and yeast/g	$6.8x10^2$	$7.3x10^a$	$3.7x10^a$	$1.1x10^{2b}$	$1.8x10^{2b}$	$5.5x10^a$

[1]Mean values from 6 samples (arithmetic).
[2]For each attribute tested, means with similar letters are not different (P>.05).
[3]ND = Non detectable.

TABLE 2. *Analysis of ground dried raw meat stored at 37°C*[1].

	Attribute[2] tested	Fresh ground meat	Ground dried raw meat 0 Time	1 Month	2 Months	3 Months	4 Months
Chemical	% Moisture	68.2	8.1[a]	7.8[ab]	7.5[b]	7.4[b]	7.3[b]
	% Protein	20.1	61.3[a]	62.0[ab]	61.7[ab]	62.3[b]	62.4[b]
	% Fat	9.7	27.1[a]	27.2[a]	26.7[a]	27.3[a]	27.0[a]
	pH	5.69	5.66[a]	5.64[a]	5.60[a]	5.58[ab]	5.55[b]
	Aw	.993	.450[a]	.457[a]	.453[a]	.422[b]	.415[b]
Microbiological	Mesophiles/g	$1.3x10^6$	$7.4x10^{2a}$	$1.5x10^{2b}$	$2.2x10^{2b}$	$8.8x10^c$	$2.3x10^c$
	Aerobic spores/g	3.5x10	$1.1x10^2$	6.0x10	8.2x10	7.2x10	4.5x10
	Staphylococcus aureus						
	MPN/g	9	.8[a]	5.0[b]	.3[a]	ND	ND
	Clostridium perfringens						
	Detection	ND[3]	ND	ND	ND	ND	ND
	Molds and yeast/g	$6.8x10^2$	$7.3x10^a$	$8.5x10^a$	$3.8x10^{2bc}$	$3.8x10^{2bc}$	$1.2x10^c$

[1]Mean values from 6 samples (arithmetic).
[2]For each attribute tested, means with similar letters are not different (P>.05).
[3]ND = Non detectable.

TABLE 3. *Analysis of ground dried precooked meat stored at 25°C*[1].

	Attribute[2] tested	Fresh ground meat	Ground dried raw meat 0 Time	1 Month	2 Months	3 Months	4 Months
Chemical	% Moisture	68.2	10.2[a]	9.7[a]	10.1[a]	10.3[b]	10.7[b]
	% Protein	20.1	61.1[a]	61.2[a]	61.0[a]	60.8[a]	60.2[a]
	% Fat	9.7	25.8[a]	25.7[a]	25.7[a]	25.4[a]	25.2[b]
	pH	5.69	5.99[a]	5.92[a]	5.84[ab]	5.76[b]	5.74[b]
	Aw	.993	.517[ab]	.496[b]	.550[a]	.555[a]	.565[a]
Microbiological	Mesophiles/g	$1.3x10^6$	$6.4x10^a$	$1.4x10^{2b}$	$8.7x10^{2ab}$	$6.0x10^a$	$3.8x10^a$
	Aerobic spores/g	3.5x10	5.2x10	5.8x10	5.9x10	4.5x10	4.8x10
	Staphylococcus aureus						
	MPN/g	9	3.7[a]	13.7[b]	5.0[a]	ND	ND
	Clostridium perfringens						
	Detection	ND[3]	ND	ND	ND	ND	ND
	Molds and yeast/g	$6.8x10^2$	ND	ND	ND	ND	ND

[1]Mean values from 6 samples (arithmetic).
[2]For each attribute tested, means with similar letters are not different (P>.05).
[3]ND = Non detectable.

TABLE 4. *Analysis of ground dried precooked meat stored at 37°C*[1].

	Attribute[2] tested	Fresh ground meat	Ground dried raw meat 0 Time	1 Month	2 Months	3 Months	4 Months
Chemical	% Moisture	68.2	10.2[a]	8.9[b]	8.5[b]	8.1[bc]	7.6[c]
	% Protein	20.1	61.1[a]	62.0[b]	62.0[b]	62.4[b]	62.4[b]
	% Fat	9.7	25.8[ac]	25.6[ac]	23.0[b]	26.1[ac]	26.3[c]
	pH	5.69	5.99[a]	5.90[a]	5.84[ab]	5.78[b]	5.73[c]
	Aw	.993	.570[a]	.542[ab]	.519[b]	.514[b]	.406[c]
Microbiological	Mesophiles/g	$1.3x10^6$	$6.4x10^{ac}$	$4.9x10^{3b}$	$2.2x10^{2c}$	$7.0x10^a$	$1.8x10^c$
	Aerobic spores/g	3.5x10	$5.2x10^a$	$3.0x10^b$	$4.1x10^b$	$3.2x10^b$	$1.1x10^c$
	Staphylococcus aureus MPN/g	9	3.7[a]	36.0[b]	17.3[c]	3[a]	1.7[a]
	Clostridium perfringens Detection	ND[3]	ND	ND	ND	ND	ND
	Molds and yeast/g	$6.8x10^2$	ND	ND	ND	ND	ND

[1]Mean values from 6 samples (arithmetic).
[2]For each attribute tested, means with similar letters are not different (P>.05).
[3]ND = Non detectable.

stored at 37°C. After 4 months of storage 25°C, the mean moisture content reached 10.1% for GDR and 10.7% for the GDP meat samples, whereas at 37°C, it reached 7.3% for the GDR and 7.6% for the GDP meat samples.

Because of the effect of temperature on the Aw values, the mean initial Aw values for both GDR and GDP samples were lower at 25°C than at 37°C. At 25°C, the mean initial Aw values were .407 for the GDR and .517 for GDP samples, whereas at 37°C, the mean initial Aw values were .450 for the GDR and .570 for the GDP samples.

After 4 months of storage, the Aw values were .518 for the GDR and .565 for the GDP samples stored at 25°C, and .415 for the GDR and .406 for the GDP samples stored at 37°C.

Protein and fat contents

The mean initial protein content was 61.3% for GDR samples and 61.1% for GDP samples. After 4 months, the protein content of both GDR and GDP was 60.2% when storage was at 25°C and 62.4% when storage was at 37°C.

The mean initial fat content was 27.1% for GDR samples and 25.8% for GDP samples. After 4 months, it changed to 26.3% for the GDR and 25.2% for the GDP samples when storage was at 25°C and to 27.0% for the GDR and 26.3% for the GDP samples when storage was at 37°C.

Both GDR and GDP samples has similar protein contents, but because of fat cook-out, GDP samples had lower (P<.05) fat contents.

pH

The mean initial pH value was 5.66 for GDR and 5.99 for GDP samples. After 4 months of storage, it changed to 5.58 in GDR samples stored at 25°C, 5.55 in GDR samples stored at 37°C, 5.74 in GDP samples stored at 25°C and 5.73 in GDP samples stored at 37°C.

Microbiological analysis

Aerobic mesophilic counts

Raw meat used for preparing the dried samples contained 1.3 x 10^6 colony forming units (CFU) aerobic mesophiles/g. These counts were reduced by dehydration of the GDR samples to 7.4 x 10^2 CFU/g and by cooking and dehydration of the GDP samples to 6.4 x 10 CFU/g.

Counts from GDR samples continued to decrease during storage until, after 4 months, they reached 1.5 x 10^2 CFU/g in GDR samples stored at 25°C and 2.3 x 10 CFU/g in GDR samples stored at 37°C. In the GDP samples, mesophilic counts fluctuated slightly and after 4 months, they reached 3.8 x 10 CFU/g in GDP samples stored at 25°C and 1.8 x 10 CFU/g in GDP samples stored at 37°C.

Table 5 shows percentages of the major groups of mesophiles isolated during storage of dried meat. The major groups that survived the drying process included: *Enterobacteriaceae* (36.7%), staphylococci (23.3%), micrococci (16.7%), bacilli (10%) and others (13.3%) in the GDR samples, and *Enterobacteriaceae* (16%), staphylococci (20%), micrococci (12%), bacilli (16%) and other (36%) in the GDP samples. The association of these groups with dried foods has also been reported by Silverman and Cohen *(26)*, Ray et al. *(23)*, Miller et al. *(18)*, Johnson and Elliot *(15)*, Mossel and Shennan *(20)*, and Faparusi *(7)*.

Because *Enterobacteriaceae* species are more sensitive to high heat during cooking than the other groups, their percentage was higher (P<.05) in the GDR than in the GDP samples.

While the percentages of *Enterobacteriaceae* and staphylococci continued to diminish in both GDR and GDP samples, regardless of the storage temperature, the percentages of bacilli and micrococci continued to increase until, after 4 months, members of these 2 genera constituted 80 to 93.3% of the major groups in the dried meat. This increase in percentage is probably due to die-off of other groups rather than a true increase of population of micrococci and bacilli. Micrococci and bacilli have also been shown to predominate in other dried foods. For instance, Shewan *(25)* found that micrococci were the only survivors in a dried fish meal stored above 10°C. Higginbottom *(13)* found that bacilli survived better than all other bacteria in dried milk with less than 10% moisture.

TABLE 5. *Percentages of major bacterial groups isolated during storage of dried meat*[1].

Meat samples	Storage temperature	Time (months)	*Enterobacteriaceae*[2]	Staphylococci	Micrococci	Bacilli	Others[3]
GDR[4]	25°C	0	36.7	23.3	16.7	10.0	13.3
		1	23.3	26.7	13.3	26.7	10
		2	20.0	0	20	36.7	23.3
		3	8	8	32	32	20
		4	8	0	40	42	10
	37°C	0	36.7	23.3	16.7	10	13.3
		1	30	26.7	6.7	30	6.7
		2	13.3	3.3	36.7	40	6.7
		3	4	4	40	40	12
		4	0	0	40	50	10
GDP[5]	25°C	0	16	20	12	16	36
		1	13.3	13.3	23.3	40	10
		2	10	0	20	53.3	16.7
		3	0	0	30	50	20
		4	0	0	40	53.3	6.7
	37°C	0	16	20	12	16	36
		1	6.7	26.7	10	43	13.3
		2	4	4	24	56	12
		3	0	5	30	60	5
		4	0	6.7	26.7	53.3	13.3
Samples from Sudan[6]	25°C	4	15	25	23.3	28.3	8.3

[1]30 isolates were studied for each time, temperature, and meat type combination of meat samples prepared in the laboratory.
[2]Identities of the species of *Enterobacteriacae* are shown in Table 6.
[3]Identities of "Others" are shown in Table 7.
[4]GDR = Ground Dried Raw Meat.
[5]GDP = Ground Dried Precooked Meat.
[6]A total of 120 isolates from samples obtained from Sudan were studied.

Aerobic spore counts

The mean aerobic spore count for the raw meat used in preparing the dried samples was 35/g. After dehydration, GDR samples contained 110 aerobic spores/g and GDP samples contained 52 aerobic spores/g. After 4 months of storage at 25°C, GDR samples contained 95 spores/g and GDP samples contained 48 spores/g, whereas at 37°C, GDR samples contained 45 spores/g and the GDP samples contained 11 spores/g.

In general, considering that aerobic spore-forming bacteria are the most common contaminants in dried foods *(20)*, it appears that both GDR and GDP dried meat samples had very low microbial loads.

Staphylococcus aureus *MPN*

Staphylococci are of common occurrence in foods from animal origin *(14)*. They tolerate low Aw levels better than most bacteria *(4,10,17,24,27)*. Their importance is primarily due to the heat-stable toxins they produce in foods.

Because of injury to the cells during cooking and dehydration, recovery of staphylococci from dried foods is best achieved by pre-enrichment in trypticase soy broth before determining their MPN *(9,22)*.

The MPN of staphylococci in the fresh meat used for preparing the dried samples was 9 cells/g. After dehydration, the MPN was .8 cells/g in GDR and 3.7 cells/g in GDP samples. The numbers changed to 3.5 cells/g in GDR in 13.7 cells/g in GDP samples stored at 25°C, and to 5 cells/g in GDR and 36 cells/g in GDP samples stored at 37°C after one month. In the GDR samples, at either temperature, staphylococci were non-detectable after the third month. Similarly, GDP samples stored at 25°C did not contain detectable numbers of staphylococci. At 37°C,

TABLE 6. *Identities of* Enterobacteriaceae *species from Table 5.*

Enterobacteriaceae isolated from dried meat samples prepared in the laboratory:	
Species	Number of Isolates
Enterobacter agglomerans	32
Serratia liquefaciens	15
Escherichia coli	2
Klebsiella pneumoniae	2
Shigella sp.	2
Enterobacter cloacae	1
Yersinia sp.	1
Enterobacteriaceae isolated from dried meat obtained from Sudan:	
Species	Number of Isolates
Serratia liquefaciens	10
Enterobacter agglomerans	8
Escherichia coli	4
Enterobacter cloacae	4
Klebsiella pneumoniae	4
Shigella sp.	4

TABLE 7. *Identities of the species described in Table 5 as "Others".*

Isolates from dried meat prepared in the laboratory:	
Bacteria	Number of Isolates
Gram-positive catalase negative cocci	22
Lactobacilli	17
Coryneforms	15
Gram-negative oxidase positive rods	10
Gram-negative cocci	8
Isolates from dried meat obtained Sudan:	
Bacteria	Number of Isolates
Gram-positive catalase negative cocci	5
Coryneforms	3
Gram-negative cocci	1
Gram-negative oxidase negative cocci	1

however, GDP samples, even after 4 months of storage, still contained a MPN of 1.7 staphylococci/g. The numbers found in these samples were very low and probably not significant in terms of health hazard.

Detection of Clostridium perfringens

Large numbers of *Clostridium perfringens* in a food may be indicative of mishandling *(6)*. Spores of some strains are known to tolerate heating at 100°C for more than one hour *(12,21,30)*. The spores may survive in dormant condition under low Aw conditions.

None of the fresh meat and dried meat samples contained any detectable levels of *C. perfringens*.

Mold and yeast counts

Due to their ability to withstand dry conditions, molds, especially mycotoxins producing ones, are of concern in dry foods *(1,19,24,28,29)*.

The fresh meat used for preparing the dried samples contained 6.8 x 10^2 CFU of molds and yeasts per g. After dehydration, GDR samples contained 7.3 x 10 CFU of molds and yeasts per g. The counts increased during the first 3 months to 1.8 x 10^2 CFU/g, then dropped to 5.5 x 10 CFU/g by the end of the fourth month in GDR samples stored at 25°C. In GDR samples stored at 37°C, the mold and yeast counts decreased continually until they reached 1.2 x 10 CFU/g by the end of the fourth month.

Because of the high heat treatment, GDP samples did not contain any detectable levels of mold and yeast either initially or during storage.

Analysis of dried meat samples obtained from Sudan

Samples (4 month old) obtained from Sudan were similar (P>.05) in moisture content 11.3% and Aw 0.513 to dried samples prepared in the laboratory (Tables 1-4). However, they had higher pH 5.80 and protein content 76.9% but lower fat content 7.7%. Therefore, the fresh meat used for preparing the samples obtained from Sudan must have been leaner than that used for preparing samples made in the laboratory.

Microbiological analysis showed that samples obtained from Sudan contained 2.2 x 10^5 CFU/g mesophiles, 2.6 x 10^3/g aerobic spores, 7.1 x 10^2 CFU/g molds and yeasts, and a MPN of 5/g *Staphylococcus aureus*. Each of these counts is higher (P<.05) than that in GDR meat samples prepared in the laboratory (Tables 1-4). Furthermore, while none of the laboratory samples contained detectable levels of *Clostridium perfringens*, 83% of the samples obtained from Sudan did.

The results of this study have provided useful chemical and microbiological information concerning the preparation and storage stability of dried meat.

Precooked meat is better for preparing dried meat than either raw meat strips or raw ground meat. It dries faster and yields lower microbial loads in the final product.

Microbial counts from dried meat samples prepared in the laboratory continued to decrease during storage. However, microbial counts from samples obtained from Sudan remained considerably higher even after 4 months of storage.

While staphylococci and *Enterobacteriaceae* were the most common major bacterial groups isolated from dried meat samples at the beginning, micrococci and bacilli predominated during the late stages of storage.

The moisture contents of dried meat samples stored at 37°C continued to decrease during storage, resulting in an accompanying decrease in the Aw. On the other hand, the moisture contents of dried meat samples stored at 25°C continued to increase during storage, resulting in an accompanying increase in the Aw.

The Aw values during storage of dried meat samples remained below the levels required for bacterial growth.

In addition to being rich in proteins, fat, and other nutrients, the powdered dried meat is easy to produce and transport and does not require refrigeration. Additional uses of this product can be sought in many foods, especially dehydrated soups.

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