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Studies on Goat Meat as Influenced by Storage
I. Alterations During Cold-Storage at two Different Temperatures

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Introduction

The lack of animal feed and the shortage of meat in Egypt, calls for great efforts in producing meat from goat. Since, as meat procedures, this animal can thrive, in conditions where it is difficult for other species of domestic livestock to live and goates will accept a great variety of feed(Williamson and Payne, 1959). The reproductive efficiency of goat is well known. According to same authors the average carcass percentage is about 45 %.

Goates are kept mainly as suppliers of milk, and the other products derived from them, that is, meat, hair and skins are subsidiary. Some peoples prefer goat flesh to mutton or, in fact, to any other meat.

Very little information is available in the literature concerning goat meat. Therefore, the primary objective of the present study included the effect of cold storage on some physical, chemical and the organoleptic properties as well as the microbial count of goat meat. Comparison of two storage temperatures was also in the scope of this investigation.

Materials and Methods

Materials:

Samples were selected from the rear legs of male goat (Caprae hiricus) 10-12 months age. The meat immediately transferred to the laboratory, bones and visible fat removed and, the samples were packed in 1.5 mil. polyethylene bags (250 g. in each). Two different temperatures for preservation were applied in this work (i.e. at +4°C and at -1°C).

Analytical methods

The moisture, fat and total nitrogen (Kjeldahl method) contents were determined according to the A.O.A.C. (1975). Total volatile nitrogen was determined according to the modified method of Pearson (1970).

Free amino acids were determined. Extraction was carried out with distilled water (Spell, 1974) and the proteins were precipitated by adding 8 ml. absolute alcohol to 2 ml.of filterate(Mihalyné et al.,1975). The suspension was left for 12 hrs. in a refrigerator before filteration 5 mil. of the filterate was used for analysis with an automatic amino acid analyzer type AAA 881 Mikro-teknike. Amino acids were eluted sequentially using three buffer solution as follows :

A) pH 3.25 for elution of amino acids from asparatic to cystine.
B) pH 4.26 for elution of amino acids from valine to phyenylalanine.
C) pH 8.00 for elution of amino acids from histidine to arginine.

The thiobarbituric acid value as an index of fat oxidation was determined according to the method of Pearson (1970). The pH value was measured to the method described by John et al.(1975), using Beckman pH-meter.

Water holding capacity was measured using the method of Anglemier et al. (1964). Water holding capacity was presented as bound water % of moisture content.

Total bacterial count was made by plating on nutrient agar medium (NA), according to Frazier and Foster (1950).

For evaluation of the organoleptic properties, the meat was boiled and roasted, as the method described by Levie (1970) as follows :

Boiling:
Cubic parts (2 x 2 x 2 cm.) of meat was used for boiling in tap water (2.5 V. water/1 w.meat) with 2% salt; cooking lasted for 20 min.

Roasting:
Salt was sprinkled on meat pieces, having the above mentioned size. These samples were then hung on metal bars for roasting using coal fire until it the meat became suitable for eating.

Organoleptic evaluation (tenderness, flavour, juiciness and overall acceptibility) of samples during cold storage were rated by a committee of five judges according to Price and Schegiert (1971).

Results and Discussion

Table 1 represents the changes of moisture content, total nitrogen, total volatile nitrogen, fat, thiobarbituric acid, pH and water holding capacity of goat meat as affected by temperature and time of storage .

Moisture content in fresh meat samples was 76.33%. Such value showed slight decrease, at the end of the cold storage period being 75.10 and 75.27% at temperature of +4°C and -1°C, respectively. These results are in accordance with those reported by Ockerman and Organisciak (1979).

Total nitrogen in fresh meat samples was 14.01%, this value decreased slightly during cold storage and reached 13.07% and 13.25% at the end of storage for +4°C and at -1°C, respectively. These results coincided with the findings of Mohamed et al. (1975). The decrease of total nitrogen during storage may be due to autolysis of protein and breakdown of nitrogeneous compounds (Khan et al. , 1963).

Table 1. The effect of cold storage (at +4°C and at -1°C) on some physical and chemical properties of goat meat.

Storage temp.	Indices	Storage period (days) 0	2	7	14	21	28
+4°C	Moisture (%)	76.33	75.93	75.51	75.37	75.27	75.10
	Total nitrogen* (%)	14.01	13.74	13.50	13.32	13.17	13.07
	Total volatile nitrogen* (mg/ 100 g)	60.35	73.25	78.21	88.39	89.53	96.56
	Fat* (%)	13.08	12.92	12.85	12.56	12.30	12.00
	Thiobarbituric acid value* (mg. malonaldehyde/kg)	0.97	1.95	2.73	5.90	7.66	10.92
	pH value	6.19	5.95	5.76	5.90	5.90	5.92
	Water holding capacity**	48.23	46.30	46.16	46.19	48.49	48.94
-1°C	Moisture (%)	76.33	76.00	75.58	75.52	75.48	75.27
	Total nitrogen* (%)	14.01	13.84	13.57	13.50	13.46	13.25
	Total volatile nitrogen* (mg/ 100 g)	60.35	68.89	71.75	72.13	77.97	87.18
	Fat* (%)	13.08	12.98	12.91	12.84	12.73	12.56
	Thiobarbituric acid value* (mg.malonaldehyde/kg)	0.97	1.42	2.17	2.53	4.22	5.31
	pH value	6.19	6.00	5.80	5.75	5.85	5.88
	Water holding capacity**	48.23	45.85	45.80	45.55	46.05	46.95

* On dry basis.
** Bound water % of moisture content.

From the same table, it was noticed that, total volatile nitrogen of the samples was affected by temperature and duration of storage. Total volatile nitrogen of goat meat increased continuously with increasing the time of storage. Moreover, samples stored at +4°C had higher values of total volatile nitrogen than others stored at -1°C. This could be attributed to the higher storage temperature, the larger enzyme activity and hence more pronounced protein destruction. These results were confirmed by the findings of Cantoni et al. (1976).

From the above mentioned table (1), it is evident that the initial fat content i.e. (13.08%) was somewhat decreased by increasing of the cold storage period. These values were 12.0 and 12.56% after 28 days storage at +4°C and -1°C, respectively. This may be due to the autooxidation and hydrolysis of fat.

Table 1 represents the thiobarbituric acid value of goat meat as an indication of fat oxidation. Thiobarbituric acid value of such samples showed marked and progressive increase as the storage time increased. The rate of thiobarbituric acid value increase was higher during storage at +4°C than -1°C. After 28 days storage value increased by 11.3 and 5.5 times compared to intial value, respectively.

These results were confirmed by Younathan et al. (1980), being explained by the higher autooxidation and breakdown of fatty acids at +4°C than at -1°C. It should be noted that the loss of fat was also more pronounced at +4°C than -1°C. Nevertheless ,the slight loss in fat may be ascribed to the escape of some oil droplets with the small amounts of fluids separated upon cold-storage.

The pH value of fresh meat was 6.19. This value was lowest (pH 5.76) after 7 days of storage at +4°C than showed slight increase during further storage; being 5.92 at the end of storage period. The decrease of pH value may be due to the breakdown of glycogen in muscles to lactic acid , while the increase of such value was possibly due to breakdown of protein and the formation of amino compounds along the accumulation of amonia(Assaf and Bratzler, 1966). The rate of these autolytic changes was more slow at -1°C where minimum pH value was recorded after 14 days in contrast with 7 days for storage of goat meat at +4°C (Table 1).

It is clear from Table 1 that, the lowest level of water holding capacity were obtained after 7 days and 14 days of storage at +4°C and -1°C, respectively. Gradual improvement in the water holding capacity was noticed at the end of storage period, it reached 48.94% and 46.95% for the above mentioned treatments. The decrease of the water holding capacity during the first 7 days and 14 days storage at +4°C and at -1°C , respectively, may be due to the development of rigor mortis, while resolution of rigor mortis, aging increased the water holding capacity. Soloviev (1966) and El-Sanafiri (1974) found that during rigor mortis the water holding capacity decreased because of the decrease of the pH value towards the isoelectric point of muscle protein.

One may notice the direct relation between the pH and water holding capacity of goat meat subjected to autolysis during cold storage.

Table 2. The effect of cold storage (at +4°C and at -1°C) on free amino acids of goat meat (mg / 100 g meat).

Storage temperature	+4°C						-1°C					
period (days)	0	2	7	14	21	28	0	2	7	14	21	28
Free amino acids												
Cystine and cysteine	5.10	8.20	11.56	25.35	30.42	38.53	5.10	6.25	9.00	9.57	14.10	14.84
Aspartic acid	7.34	11.52	16.52	37.09	45.05	57.52	7.34	9.31	13.81	14.56	21.65	21.98
Threonine and serine	1.81	2.93	6.97	12.25	15.34	17.91	1.81	1.93	1.99	2.01	2.38	2.59
Glutamic acid	17.18	25.63	41.53	56.29	60.19	75.11	17.18	20.32	27.64	40.32	49.26	54.83
Proline	0.00	0.00	0.00	0.25	0.54	0.81	0.00	0.00	0.00	Trac.	0.21	0.32
Glycine	10.10	23.10	36.45	52.14	67.21	77.40	10.10	14.26	23.26	32.43	36.64	47.17
Alanine	19.92	24.36	47.75	57.00	73.91	87.44	19.92	22.59	30.26	35.52	57.28	69.77
Valine	0.43	0.57	2.18	8.13	11.51	13.42	0.43	1.23	3.32	6.32	8.58	8.30
Methionine	1.25	1.87	2.10	4.59	4.81	6.43	1.25	1.56	1.98	2.06	2.11	2.83
Isoleucine	4.68	8.75	16.01	33.28	40.40	43.38	4.68	4.98	10.44	17.33	22.62	23.22
Leucine	5.24	8.57	20.25	29.69	36.01	51.30	5.24	9.28	15.46	24.30	26.25	37.26
Tyrosine	0.00	0.00	0.00	Trac.	Trac.	0.21	0.00	0.00	0.00	0.00	Trac.	Trac.
Phenylalanine	0.00	0.00	0.00	Trac.	0.10	0.17	0.00	0.00	0.00	0.00	0.00	Trac.
Histidine	60.92	77.58	93.31	145.56	195.30	235.40	60.92	67.25	83.54	106.42	157.46	182.65
Lysine	17.76	23.55	27.21	37.64	40.64	48.62	17.76	19.51	23.99	26.36	29.28	33.57
Arginine	3.47	5.99	10.64	13.28	15.33	16.64	3.47	4.18	4.36	6.28	6.69	7.74
Total	155.20	222.62	332.48	512.55	636.76	770.33	155.20	182.61	249.05	323.48	434.61	508.07

The effect of cold storage on free amino acids content was studied and the results were tabulated in Table 2. Free amino acids content was 155.20 mg/100 g in fresh meat. This value increased progressively during cold storage of meat at +4°C and at -1°C, and reached 770.33 and 508.07 mg/100 g meat, respectively, at the end of storage period. The increase of free amino acids during storage could be naturally attributed to hydrolysis of proteins by proteolytic enzymes. These results coincided with the findings of Parrish et al. (1969).

Meanwhile, proline, tyrosine and phenylalanine were not detected as free amino acids during the first period of storage indicating that, the peptide linkages of these acids were not readily hydrolysed to give the free amino acids. This conclusion, however, calls for more fundamental research to follow the breakdown of these peptides and formation of free amino acids using goat proteins.

At +4°C of storage proline, tyrosine and phenylalanine were released and identified at 14 days of storage.

On the other hand, at -1°C, proline, tyrosine and phenylalanine separated and were indicating the slow rate of proteolysis at -1°C when compared with +4°C. It should be mentioned that total free amino acids increased by 5.0 and 3.3 times after 28 days storage at +4°C and -1°C, respectively.

Table (3) shows the total bacterial count of meat during cold storage.

Table 3 . Effect of cold storage at +4°C and -1°C on total bacterial count of goat meat (count x 10^3 / g meat).

Storage period (days)	Storage temperature +4°C	Storage temperature -1°C
0	1.09	1.09
2	1.56	1.24
7	20.33	1.69
14	73.54	22.21
21	204.41	72.96
28	615.32	243.47

It was observed that, the total bacterial count progressively increased as the time of storage increased. It was also noticed that, samples stored at +4°C showed higher bacterial count than the others stored at -1°C, being 615.32 x 10^3/1 g and 243.47 x 10^3/1 g after 28 days of storage , respectively. One, may conclude that, there was direct relation between the total bacterial count and free amino acids content of meat samples; the higher the total bacterial count, the higher the free amino acids were found. After 28 days storage bacterial counts increased in goat meat by 565 and 223 times for samples stored at +4°C and -1°C, respectively. Bacterial decomposition of proteins as well as the lipids oxidation as indicated by the increase of thiobarbituric acid value were apparently affected by the total bacterial count as mentioned by El-Sanafiri (1974).

Table 4. Organoleptic evaluation of stored boiled and roasted goat meat.

Storage temperature	+4°C					-1°C				
	Storage period (days)									
	2	7	14	21	28	2	7	14	21	28
Boiled meat:										
Tenderness	8.4	7.6	7.4	7.4	7.4	7.6	7.6	7.6	7.6	8.6
Flavour	7.8	7.4	3.4	3.2	2.0	7.6	7.8	7.6	3.8	3.0
Juiciness	7.8	7.8	6.8	7.6	7.2	7.4	7.6	7.2	7.4	8.0
Overall acceptability	7.6	7.8	7.2	6.4	6.0	7.6	7.8	7.8	6.6	6.2
Roasted meat:										
Tenderness	8.8	7.8	7.8	7.4	7.6	8.0	7.8	7.6	7.6	8.6
Flavour	8.2	8.2	3.6	3.4	2.0	8.2	8.8	8.4	4.0	2.8
Juiciness	8.0	7.8	6.8	7.8	7.5	7.8	8.0	7.8	8.0	8.4
Overall acceptability	7.8	8.0	7.6	6.6	6.4	8.4	8.6	8.2	7.0	6.4

Score sheet

Like extremly = 9 | like very much = 8 | like moderately = 7 | like slightly = 6

Neither like nor dislike = 5 | Dislike slightly = 3 | Dislike moderately = 3

Dislike very much = 2 | Dislike extremly = 1

Tenderness, flavour, juiciness and overall acceptability of goat meat were evaluated organoleptically during cold storage at +4°C as well as at -1°C after boiling and roasting; results are given in Table(4).

From Table (4), it could be noticed that the quality of stored samples showed very slight decrease during storage at -1°C except for flavour estimated after 21-28 days.

Organoleptic properties of stored meat at +4°C decreased markedly at the 14th day of storage. In all samples roasted meat gained higher organoleptic score than boild meat according to the test panel(Table 4). Similar results were reported by Levie (1970). Also,the judges observed that after 14 days of storage at +4°C and after 21 days at -1°C samples had dislike odour accompanied by pronounced viscous touch.

As indicated by the chemical, physical and organoleptic properties goat meat may be widely accepted in Egypt either for direct consuming or for processing of different meat products.

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