Studies on Goat Meat as Influenced by Storage
II. Effect of Pre- and Post-Rigor Freezing and some Storage Variables on the Quality of Meat

FAHMY, A.A. ; AMMAR, K.A. and EL-KADY, S.A.*

Department of Food Technology, Faculty of Agriculture, Kafr El-Sheikh, Tanta University, Egypt.
* Department of Food Science, Faculty of Agriculture, Mansoura University, Egypt.

Introduction

Goat's meat obtained from males, specially when coal fire used in cooking is considered as one of the most oppetizing foods in Egypt. Nevertheless, quality changes of this meat during frozen storage were not studied.

When frozen meat is stored at a low minus temperatures some undesirable physical, chemical and organoleptic changes may occur in tissues. Some of these changes may be taken as indicatives to deterioration and spoilage. The quality of frozen meat after thawing is markedly affected by pre-freezing processes , freezing rate and storage conditions.

Experiments undertaken in this work aimed to study the changes occurring in protein, lipid, drip loss, pH, water holding capacity and organoleptic properties of frozen goat meat at different temperatures. The effect of pre- and post-rigor freezing 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, then samples were packed in 1.5 mil. polyethylene bags (250 g in each). Different treatments applied in this study were as follows:

I. Pre-rigor freezing and storing samples: This treatment in which the meat was directly frozen was divided into two groups:

1. The meat was frozen at -25°C in freezing cabient (RCA) for 24 hours and stored at -10°C.
2. The meat was frozen at -25°C in freezing cabient (RCA) for 24 hours and stored at -25°C.

II. Post-rigor freezing: This treatment where the meat was cooled before freezing was divided into two groups :

1. Samples cooled at first at -1 °C for 2 days, then frozen at -25°C in freezing cabient (RCA) for 24 hours and stored at either -10°C or -25°C.
2. Samples cooled at +4 °C for 2 days, were frozen at -25°C for 24 hours, then stored at either -10°C or -25°C.

All samples were frozen stored for 90 days.

Analytical methods:

The moisture, total nitrogen and fat contents were determined according to the methods recommended by the A.O.A.C. (1975). Total volatile nitrogen was determined according to the modified method of Pearson(1970). Thiobarbituric acid value as an index of fat oxidation was determined according to the method of Pearson (1970). The pH value was measured according 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. The drip loss of different meat samples was determined according to the method described by Awad (1967). The meat samples were allowed to thaw at room temperature for two hours. The separated drip was collected, measured and analyzed. For organoleptic properties, the meat was boiled and roasted according to the methods described by Levie(1970) as follows:

Boiling: Cubic pieces (2 x 2 x 2 cm.) of meat were used for boiling. Tap water was added at the rate of 2.5 water/1 meat followed by addition 2% salt, cooking by boiling lasted for 20 min.

Roasting: Pieces of same size (2 x 2 x 2 cm.) were sprinked with salt and fixed to metal bars for roasting using coal fire until samples were ready for eating.

Organoleptic evaluation (tenderness, flavour, juiciness and overall acceptability) of goat meat samples during storage was rated by a committee of five judges according to Price and Schweigert (1971).

Results and Discussion:

I. Effect of frozen storage on some physical and chemical properties of meat:

Table (1) represents the changes of moisture, total nitrogen and total volatile nitrogen of goat meat during frozen storage. It was evident that, moisture content of treated meat was slightly decreased during the storage period. It was also clear that, there was no marked difference of moisture content between samples under investigation at the end of frozen storage. These results coincided with the findings of Ockerman and Organisciak (1979). Data in table (1) also show that there was a slight decrease of total nitrogen with increasing the period of frozen storage. In addition, the highest decrease of total nitrogen was observed in the case of pre-rigor freezing sample, stored at -10°C, being about 5% but the contrary was observed for the post-rigor freezing sample, stored at -25°C after cooling at +4°C, where loss of nitrogen was about 2% at the end of storage. Generally, the decrease in total nitrogen could be ascribed to the escape of some nitrogeneous compounds with drip (Khan and Lentz, 1977).

For total volatile nitrogen, it was observed that, there was a continuous increase with increasing frozen storage. Moreover, post-rigor freezing samples cooled at +4°C for 2 days before freezing showed the highest total volatile nitrogen after 15 days of frozen storage. Post-rigor, freezing samples, cooled at -1°C before freezing contained moderate amounts of total volatile nitrogen, while samples pre-rigor freezing had the lowest values after 15 days of frozen storage (Table 1). It could be noticed that total volatile nitrogen of frozen meat ranged between 81.44 and 76.09 (mg/100 g on dry basis) after 90 days of storage. Pearson (1970) reported that the increase of total volatile nitrogen was accompanied by parallel deterioration in the lating quality of meat .

Fat content and thiobarbituric acid value of meat samples were determined and the results are given in table (2).

Fat content of samples was decreased slightly as the storage period increased. The highest decrease could be observed for the post-rigor freezing sample, stored for 90 days at -10°C after pre-cooling at +4°C , being about 8%, while the decrease was lowest for pre-rigor freezing sample, stored at -25°C, being about

Table 1. Effect of frozen storage on moisture, total nitrogen* and total volatile nitrogen* of goat meat.

Factors storage time days	Moisture (%)						Total nitrogen (%)						Total volatile nitrogen(mg/100 g)					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Fresh meat	76.33	76.33	76.33	76.33	76.33	76.33	14.01	14.01	14.01	14.01	14.01	14.01	60.35	60.35	60.35	60.35	60.35	60.35
15	76.24	76.02	76.19	76.25	76.17	76.22	13.89	13.80	13.90	13.98	13.94	13.94	69.70	68.47	72.49	71.93	73.93	74.34
30	76.20	76.00	76.18	76.23	76.10	76.20	13.86	13.80	13.90	13.98	13.88	13.90	74.43	70.06	74.47	73.25	75.96	75.02
45	76.17	75.95	76.05	76.19	76.20	76.10	13.73	13.73	13.79	13.90	13.80	13.79	75.43	70.18	75.95	76.23	76.43	76.83
60	75.90	75.88	75.93	76.12	75.96	76.06	13.57	13.70	13.70	13.87	13.64	13.79	76.50	73.29	75.99	76.64	77.69	77.04
75	75.65	75.85	75.86	76.03	75.88	76.05	13.44	13.62	13.54	13.72	13.57	13.75	76.50	75.35	81.19	76.65	80.55	77.20
90	75.60	75.85	75.68	75.87	75.80	75.94	13.37	13.54	13.40	13.58	13.51	13.69	76.60	76.09	81.19	76.80	81.44	77.20

* On dry basis.

Table 2. Effect of frozen storage on fat and thiobarbituric acid value of goat meat (on dry basis).

Factors	Fat (%)						Thiobarbituric acid value (mg.malonaldehyde per kg)					
Storage time (days)	1	2	3	4	5	6	1	2	3	4	5	6
Fresh meat	13.08	13.08	13.08	13.08	13.08	13.08	0.97	0.97	0.97	0.97	0.97	0.97
15	12.94	13.04	12.74	12.88	12.66	12.95	2.65	2.59	3.02	1.94	3.15	2.40
30	12.71	13.00	12.57	12.73	12.55	12.83	2.81	2.75	3.70	1.98	3.89	2.27
45	12.66	12.85	12.47	12.60	12.35	12.75	3.07	3.00	3.93	2.10	4.50	3.68
60	12.60	12.66	12.35	12.51	12.15	12.65	3.32	3.24	4.19	2.14	5.12	3.80
75	12.59	12.65	12.28	12.46	12.10	12.62	4.11	3.35	4.55	3.88	5.60	3.89
90	12.56	12.63	12.23	12.43	12.04	12.60	4.55	3.39	4.61	4.02	6.44	4.53

1. Frozen storage at -10°C, pre-rigor freezing at -25°C.
2. Frozen storage at -25°C, pre-rigor freezing at -25°C.
3. Frozen storage at -10°C, post-rigor freezing at -25°C, pre-cooled samples at -1°C.
4. Frozen storage at -25°C, post-rigor freezing at -25°C, pre-cooled samples at -1°C.
5. Frozen storage at -10°C, post-rigor freezing at -25°C, pre-cooled samples at +4°C.
6. Frozen storage at -25°C, post-rigor freezing at -25°C, pre-cooled samples at +4°C.

3%. These results were given by John et al. (1975). The higher rate of tissue porosity and permeability for pre-cooled meat (post-rigor freezing samples) may be responsible for the increased loss of oil with drip when compared with post-rigor frozen meat. Concerning, the thiobarbituric acid value, it was found that, there was remarkable increase with increasing the period of frozen storage. Moreover, post-rigor freezing, pre-cooled at +4°C sample, stored at -10°C showed the highest increase i.e. (85%), while this increase was lowest (71%) for pre-rigor freezing sample, stored at -25°C. This increase may be due to not only the autooxidation of lipids and formation of malonaldehyde but also to changes in phospholipids which may be hydrolysed to phosphatedylethanol amine that had thiobarbituric acid value (Shorland, 1977).

Data given in table (3) showed that there were two stages of pH value changes during the frozen storage period. The pH decreased at the first stage and reached the minimal value after 45 days for pre-rigor freezing samples, stored at both -10°C and -25°C. However, pre-cooled meat before frozen storage post-rigor freezing sample showed minimum pH values after 30 days of frozen storage.

At the second stage, there was a continuous increase of pH value with increasing of the storage period. Highest pH values were recorded after 90 days storage for pre-rigor freezing samples, while the lowest values were found for post-rigor freezing samples. This may be attributed to that the changes of glycogen to lactic acid were less deep for pre- rigor freezing when compared with the post-rigor freezing samples pre-cooled before freezing and storage. In addition an increase of pH value in the second stage was attributed to the breakdown of protein and formation of basic compounds as mentioned by Assaf and Bratzler (1966).

For water holding capacity, it was evident (table 3) that, such value was affected by the above mentioned treatments and time of storage as well. Variations in water holding capacity followed the changes of pH. Hamm (1962) came to same conclusion.

Table (4) represents the drip loss and its total nitrogen during frozen storage of meat. It was clear that variable amounts of drip were separated from the meat of different treatments. Maximum drip loss was recorded after 90 days storage. Pre-rigor freezing samples, stored at -10°C yielded the highest amount of drip being 11.90%. The lowest amount of drip was obtained from post-rigor freezing samples, pre-cooled at +4°C and frozen stored at -25°C, being 7.79%. Generally, the larger amounts of drip separated from frozen stored samples at -10°C, could be explained by the formation of larger extracellular ice crystally and consequently more pronounced damage of cells when compared with samples stored at -25°C. In addition, rigor mortis which was inhibited by direct freezing of meat pre-rigor was activated during thawing after frozen storage which possibly enhanced the drip loss . It was also noticed that the drip loss decreased for post-rigor freezing samples as the rigor had already developed during the pre-cooling period. These results are in agreement with the findings of Khan and Lentz (1977). Data in table (4) indicated also that total nitrogen content of drip slightly increased during frozen storage. This was found for all treatments. The lowest amount of total nitrogen was observed in the drip of post-rigor freezing meat samples at -25°C, pre-cooled at +4°C and stored at -25°C, being 1.08% at the end of storage period. Pre-rigor freezing samples stored at -10°C showed relatively higher loss being 1.35%. One may notice that total

Table 3. Effect of frozen storage on pH value and water holding capacity of goat meat.

Factors	pH value						Water holding capacity (bound water % of moisture content)					
Storage time (days)	1	2	3	4	5	6	1	2	3	4	5	6
Fresh meat	6.19	6.19	6.19	6.19	6.19	6.19	48.23	48.23	48.23	48.23	48.23	48.23
15	5.90	6.10	5.64	5.80	5.55	5.75	46.11	46.32	47.23	47.11	48.03	47.05
30	5.85	5.83	5.54	5.68	5.50	5.60	45.87	47.07	45.50	45.88	45.33	46.07
45	5.63	5.72	5.63	5.71	5.64	5.70	45.30	46.67	47.00	46.42	47.61	46.54
60	5.90	5.83	5.70	5.86	5.70	5.80	46.30	48.34	47.25	46.50	47.86	46.82
75	5.93	5.94	5.75	5.87	5.74	5.90	46.74	48.66	47.35	46.71	48.66	47.58
90	6.00	5.96	5.79	5.89	5.80	5.90	48.55	48.96	49.20	49.57	49.94	50.50

Table 4. Changes in quantity and total nitrogen content of drip, during frozen storage of goat meat.

Factors	Drip loss (%)						Total nitrogen (%)					
Storage time (days)	1	2	3	4	5	6	1	2	3	4	5	6
15	9.70	7.19	8.00	7.05	7.22	6.17	1.02	1.19	0.89	1.08	1.08	0.83
30	10.63	7.22	8.22	7.39	7.91	6.38	1.05	1.19	1.08	1.13	1.22	1.00
45	11.13	8.28	8.96	7.76	8.44	6.74	1.20	1.22	1.13	1.16	1.23	1.05
60	11.41	8.64	9.35	8.36	8.53	7.00	1.26	1.22	1.18	1.19	1.24	1.05
75	11.75	8.89	9.65	8.60	8.85	7.35	1.27	1.23	1.19	1.21	1.25	1.07
90	11.90	9.15	10.00	9.10	9.30	7.71	1.35	1.26	1.30	1.23	1.26	1.08

1. Frozen storage at -10°C, pre-rigor freezing at -25°C.
2. Frozen storage at -25°C, pre-rigor freezing at -25°C.
3. Frozen storage at -10°C, post-rigor freezing at -25°C; pre-cooled samples at -1°C.
4. Frozen storage at -25°C, post-rigor freezing at -25°C; pre-cooled samples at +4°C.
5. Frozen storage at -10°C, post-rigor freezing at -25°C; pre-cooled samples at +4°C.
6. Frozen storage at -25°C, post-rigor freezing at -25°C; pre-cooled samples at +4°C.

Table (5): Organoleptic evaluation of boiled and roasted goat meat previously frozen stored at -10°C and at -25°C .

Storage temperature	* - 10 °C						* - 25°C						** - 10°C						** - 25°C					
Storage period (days)	15	30	45	60	75	90	15	30	45	60	75	90	15	30	45	60	75	90	15	30	45	60	75	90
Boiled meat :																								
Tenderness	7.2	7.2	6.8	7.0	6.8	6.6	7.4	7.4	7.4	7.0	7.0	7.0	8.0	7.6	7.2	7.2	7.2	6.8	7.8	7.8	7.6	8.0	7.8	7.4
Flavour	7.0	7.2	6.4	6.8	6.8	6.0	7.6	7.4	7.4	7.2	7.0	7.0	7.4	7.4	7.0	7.2	7.2	7.0	7.6	7.6	7.8	8.0	7.8	7.4
Juiciness	7.0	7.2	6.6	6.8	7.0	6.4	8.0	7.8	7.8	7.6	7.4	7.4	8.0	8.0	7.6	7.4	7.0	6.8	8.0	8.0	7.8	8.2	7.6	7.4
Overall acceptability	7.0	7.0	6.8	6.8	6.4	6.8	7.4	7.4	7.2	7.2	7.0	6.8	7.8	7.6	7.2	6.8	6.8	6.7	7.8	7.8	7.8	8.0	7.8	7.4
Roasted meat :																								
Tenderness	7.4	7.2	7.2	7.0	6.8	6.8	7.8	7.4	7.4	7.4	7.2	7.0	7.6	7.8	7.4	7.2	6.7	6.7	8.0	8.4	7.4	7.8	7.6	7.4
Flavour	7.6	7.8	7.4	7.4	7.2	6.8	7.4	7.0	7.0	7.0	6.8	6.8	7.4	7.4	7.6	7.2	7.0	6.8	8.2	8.4	8.0	7.8	7.4	7.6
Juiciness	7.4	8.0	7.2	6.8	7.2	6.6	8.0	8.0	7.8	7.4	7.0	7.0	7.4	7.2	7.2	7.0	7.0	6.8	8.2	8.0	8.0	7.8	7.6	7.4
Overall acceptability	7.6	8.0	7.2	7.0	7.6	7.0	7.0	7.2	7.2	7.2	7.8	7.4	7.8	7.6	7.8	7.6	7.2	7.0	8.4	8.4	7.9	8.6	7.6	7.4

* Pre-rigor frozen samples at -25°C for 24 hours before storage.
**post-rigor frozen samples: pre-cooled at -1°C for 2 days and frozen at -25°C for 24 hours before storage.

Score sheet

Like extremly	9	Like very much	8	Like moderately	7	Like slightly	6	Neither like nor dislike	5
Dislike slightly	4	Dislike moderately	3	Dislike very much	2	Dislike extremly	1		

Table 6. Organoleptic evaluation of boiled and roasted goat meat previously frozen stored at -10°C and at -25°C.

Storage temperature	-10°C*						-25°C*					
	Storage period (days)											
	15	30	45	60	75	90	15	30	45	60	75	90
Boiled meat:												
Tenderness	8.0	7.8	7.4	7.0	7.0	6.8	8.6	8.2	7.8	8.2	7.8	7.5
Flavour	7.2	7.2	7.0	7.0	6.8	6.8	8.0	7.8	7.9	8.0	8.0	8.0
Juiciness	8.0	7.8	7.2	7.2	7.0	7.0	8.2	8.0	7.9	8.6	7.8	8.0
Overall acceptability	7.8	7.6	7.6	7.0	6.8	6.7	8.6	8.2	8.0	8.0	7.9	7.6
Roasted meat:												
Tenderness	7.2	7.8	7.4	7.4	6.8	6.8	8.0	8.4	7.6	7.8	7.6	7.4
Flavour	7.6	7.6	7.8	8.0	6.4	6.8	8.2	8.5	8.0	8.0	8.0	7.8
Juiciness	7.4	7.8	7.6	7.4	7.4	7.0	8.0	8.0	8.4	8.4	7.8	7.4
Overall acceptability	7.6	8.0	8.0	7.8	7.6	7.0	8.6	8.4	8.0	8.0	7.8	7.6

* Post-rigor samples; pre-cooled at +4°C for 2 days and frozen at -25°C for 24 hours before storage.

Score sheet

Like extremly = 9 | Like very much = 8 | Like moderately = 7 | Like slightly = 6 | Neither like nor dislije = 5

Dislike slightly = 4 | Dislike moderately = 3 | Dislike very much = 2 | Dislike extremly = 1

nitrogen per cent in drip increased by increasing the drip volume. These results coincided with the findings of Khan and Lentz (1977).

II. Effect of frozen storage on organoleptic properties of meat:

Tenderness, flavour, juiciness and overall acceptability were evaluated organoleptically and tabulated in tables (5 and 6). Comparing these treatments, it was evident that roasted samples had higher scores than the boiled ones. On the other hand, lower storage temperature (-25°C) generally gave meat of higher score for tenderness, flavour, and juiciness than the higher temperature of storage (-10°C). It was also observed that samples previously cooled before frozen storage (post-rigor freezing samples) gave higher score of organoleptic evaluation than for pre-rigor freezing stored at same temperature . Moreover, pre-cooling at +4°C gave meat of better quality than pre-cooling at -1°C before frozen storage.

It should be mentioned that as indicated by organoleptic tests, storage of pre-cooled goat meat for 2 days at +4°C by freezing at -25°C showed the best results, since this treatment gave the highest score of organoleptic properties.

References

Anglemier, A.F., A.A. El-Badawi and R.F. Cain, 1964. J. Food Sci., 29: 837.

Assaf, S.A. and L.J. Bratzler, 1966. J. Agric. and Food Chem. 14 : 787.

A.O.A.C., 1975. Official methods of analysis of the association of official analytical chemist. Published by the Assoc. of Offic. Analyt. Chemist., Washington, D.C.

Awad, A.A., 1967. Chemical and physical alteration of frozen white flesh and bovine skeletal muscle. Ph.D. Thesis, Univ. of Wisconson.

Hamm, R., 1962. The water binding capacity of mammalian muscle, IX.The revesibility of the pH influence of water binding capacity. (acid denaturation).C.F. Chem. Abst., 57: 185.

John, E.O., R.A. Lawrie and B. Hardy, 1975. J. Sci. Food Agric. 26: 31.

Khan, A.W. and C.P. Lentz, 1977. J. Meat Sci., 1: 263.

Levie, A., 1970. The meat handbook. The AVI Publishing Co. Connecticut, Westport.

Ockerman, H.W. and C.S. Organisciak, 1979. J. Food Protection, 42: 126.

Pearson, D. 1970. The chemical analysis of food. National College of Food Technology. Univ. Reading, Weybridge, survey, T. & A. Churchill.

Price, J.F. and B.S. Schweigert, 1971. The science of meat and meat products. Freeman and Co., San Francisco.

Shorland , F.B. 1977. Deteriorative change in frozen meat, FSTA, 9: 181.