Changes in the lipids of frozen chickens

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INTRODUCTION

Lipids form the second major component of chicken muscles, the first being protein. Lipids may accumulate in certain regions of the chicken body forming depot fat. Another fraction of lipids in the chicken body is the fat distributed throughout the muscles, whether in the form of simple lipid or in a complexed form with protein. This fraction is considered to be muscle lipid. In the case of young chickens as those used in this work, lipids are localised only below the skin and in a limited region around the tail end.

Survey of literature

Cook and White (1) found that slaughtering and freezing accelerate the development of rancidity in the fat of poultry and during subsequent frozen storage, as indicated by the formation of peroxide-oxygen. The free fatty acids content is not seriously affected unless the conditions prior to freezing enhance microbial development.

Wagoner, et al., (2) studied the influence of preliminary holding conditions on the deterioration of frozen poultry. They found that when poultry is stored at 3 to 5 °C for 24 hours or longer before evisceration or when it is frozen and thawed before evisceration, the stability of its fat in frozen storage decreases. The free fatty acid, peroxide and aldehyde contents of the fat decreased under such conditions. When the exposed surface of poultry in frozen storage is reduced, the stability of its fat increased.

The changes in lipids during the frozen storage of bovine muscle have been observed by *Callow* (3), who showed an increase in the oxygen uptake by fatty tissues and in the formation of peroxides.

Golovin (4), observed that during 7 months storage of whole meat at -6 °C to -16 °C, no essential changes occurred in the fat and volatile fatty acid content. According to *Marion and Woodroof* (5), lipid from chicken breast and leg muscle contains about 2 – 5 % free fatty acid.

Fishwick (6), found that free fatty acids increased during storage at 0, -3, -10, and -20 °C. At -60 °C no changes were observed. Both lipase and phospholipase were active during frozen storage.

Keskinel et al., (7) showed an increase in the thiobarbituric acid number from 0.13 to 3.80 in frozen lamb during a 14.5 months storage period, at -18 °C. A smaller change in the thiobarbituric acid number was noted when the meat was coated with acetylated monoglycerides prior to freezing.

Jacofson, et al., (8) studied the development of rancidity during the short-time storage of cooked poultry meat. He found that chicken meat showed small flavor losses in both light and dark meat after short term frozen storage. For light chicken meat, the thiobarbituric acid number increased as the flavour progressively deteriorated. The test, however did not indicate significant differences in the thiobarbituric acid number. For dark chicken meat under the storage treatment with cooked light and dark turkey meat, the thiobarbituric acid number correlated significantly with flavour changes indicating that oxidative changes occur as flavour deteriorates during refrigeration.

Awad, et al., (9) studied the lipid from unfrozen and frozen, stored bovine muscle. The peroxide value of lipid from unfrozen muscle was 3.5, a value indicating the presence of a small amount of peroxide in the lipid. Within a 2 week frozen storage period, the peroxid value of muscle lipid rose to 44.7 and then with subsequent storage periods, the values dropped untill a constant value of about 7 was attained after 6 and 8 weeks of storage.

Materials and methods

I. *Materials:*

Samples for the present work were taken from "Dokki 4" chickens of an age of three months. These chickens were slaughtered, bled for 5 mins., scalded for 5 mins. at 55 °C, plucked by hand, eviscerated, rinsed with water and strained. 60 chickens were used in this experiment grouped in 4 equal groups,

1. Control samples (no treatment).
2. Steam-treated samples: Fresh samples were steamed by water vapor at 100 °C for 15 mins,
3. Frozen samples: Fresh samples were frozen at -20 °C for 12 hours and stored at -4 °C for 24 weeks.
4. Steamed frozen samples: Fresh samples were steamed by water vapor at 100 °C for 15 mins., frozen and stored in the same way as mentioned in (3) samples from each of breast and leg muscle tissues of fresh, steamed, frozen and steamed frozen were taken periodically for analysis.

The depot tail end fat and the fat of the skin were mixed altogether and examined for total lipids, acid value, peroxide value, free fatty acid, and thiobarbituric acid (T.B.A.) contents.

II. *Methods:*

1. Extraction and determination of lipids.
   Lipids were extracted from thawed muscle homogenate by the method of Bligh and Dyer (10). Extracts were calculated as % of the total muscle used as a sample and the lipids.
2. Peroxide value (PV).
   The peroxide value of lipids in the extract was determined by the modified method described by *Dyer* and *Marton* (11).
3. Thiobarbituric acid number. (TBA).

Thiobarbituric acid number was determined as described by *Pearson* (12).

4. Free fatty acids % (F.F.A.).
   The free fatty acids of lipids in an extract were determined according to the A.O.A.C. method (13). The free fatty acids were calculated according to the equation:

$$\text{Free fatty acid } \% = \frac{\text{Titration (ml 0.1.N) X 2.82}}{\text{Wt. of Sample used}}$$

The free fatty acid (FFA) value was calculated as oleic acid (1 ml. 0.1 N = 0.0282 g. oleic acid) in which case the acid value = 2×2F.F.A.

Results

Data presented in table 1 show the total lipids of unsteamed and steamed breast and leg tissues of chicken as affected by frozen storage at -4 °C for 24 weeks. From the table it can be seen that initially the leg muscle tissues contained higher amounts of lipids (12.82%) than breast tissues (9.45%). This agrees with the findings of *Hornstein et al* (14) who found that total lipid % showed variations between different muscles.

The steaming of muscles of breasts or of legs decreased the total lipid contents which could be due to melting and separation of some fatty substances when exposed to the high temperature of steaming.

The loss of lipids was as high as 4.13% of the initial value in breast muscle, while in leg muscle tissues it was far less (being 2.81%). The more dense connective tissues in leg muscles could from a barrier that delays the removal of lipids from tissues on steaming (*Scharp*, and *Narion* (15).

The total lipid contents in unsteamed breast and leg muscle tissues were 9.45%, and 12.82%, respecrively, while in steamed tissues the percentages were 9.06% and 12.46, respectively.

After 24 weeks storage the total lipid contents in unsteamed tissues were 8.71% and 11.90% in breast and leg muscle tissues, respectively, while in steamed tissues they were 8.75% and 12.03% respectively. The decrease of lipid contents, before storage, in steam treated tissues, could be also due to oxidation and hydrolysis on the effect of high temperature.

Lipids of depot and skin tissues:

The percentage of total lipids of depot and skin tissues of steam treated and unsteamed samples during frozen storage at -4 °C for 24 weeks are shown in table 2 which indicates that the amount of total lipids in depot and skin tissues before storage was as high as 85.66%, while the percentage shown in table 1 was very low in breast and leg tissues, being 9.45 and 12.82% respectively.

Table 1.

Effect of frozen storage on total lipid percentage of chickens breast and leg muscles

Frozen storage time (weeks)	Breast muscle				Leg muscle			
	Unsteamed	Steamed	% Decrease		Unsteamed	Steamed	% Decrease	
			Unsteamed	Steamed			Unsteamed	Steamed
Before freezing	9.45	9.06	0.00	4.13	12.82	12.46	0.00	2.81
0	9.34	8.99	1.16	4.86	12.68	12.38	1.09	3.44
6	9.12	8.89	3.49	5.93	12.40	12.24	3.28	4.53
12	8.94	8.81	5.40	6.78	12.18	12.15	4.99	5.70
18	8.81	8.78	6.67	7.09	12.02	12.09	6.24	5.70
24	8.71	8.75	7.83	7.41	11.90	12.03	6.18	6.17

On dry weight basis

Tab'e 2.

Effect of frozen storage on total lipids content of chickens depot and skin fats

Frozen storage time/weeks	Depot and Skin fats			
	Unsteamed	Steamed	% Decrease	
			Unsteamed	Steamed
Before freezing ...	85 66	84.19	0.0	1.8
0	84 70	83.39	1.1	2.7
6	82.58	81.89	3.5	4.5
12	80 68	80 98	5.8	5.4
18	79 58	80 39	7.1	6.2
24	78.68	80.02	8.2	6.6

Calculated on dry weight basis

Peroxide value

The peroxide values of depot and skin lipids of steam-treated and unsteamed samples during frozen storage were studied. Before freezing, the peroxide value of unsteamed tissues was 3.01, while after steaming it was 3.12, the increase may be due to the effect of high temperature, which accelerates the fat oxidation. The presence of small amounts of peroxides in the chicken samples before any treatment confirm the results of *Awad et al.*, (9).

The peroxide value of depot and skin tissues increased as the time of frozen storage increased, up to 12 weeks storage, reaching 32.19 in unsteamed tissues and 26.31 in case of steamed samples. This difference might be due to the effect of heat on the inhibition of lipases or of microorganisms that secrete lipases.

At the end of frozen storage the peroxide value was lower on steamed tissue as compared with unsteamed samples, being 12.34 and 10.85 in unsteamed and steamed tissues, respectively. However, the decrease of the peroxide value may be explained by the degradation of the hydroperoxides to carbonyl compounds and or the interaction of the hydroperoxide with muscle proteins (*Narayan et al.*,16).

Thiobarbituric acid number (T.B.A.)

The thiobarbituric acid numbers of steamed and unsteamed depot and skin tissues during frozen storage at -4 °C for 24 weeks were determined. It could be observed that the T.B.A. before frozen storage at -4 °C was 0.23 mg malonic-aldehyde per kg sample. On steaming the value increased, reaching 0.39 mg per kg sample, which may be due to the partial oxidation of lipids on the effect of high temperature.

The thiobarbituric acid number progressively increased as the time of storage increased. However, the rate of the rise of T.B.A. was relatively slow in the steam treated samples as compared with unsteamed ones. The lower T.B.A. in steamed samples could be due to the same factors previously mentioned in explaining the changes in peroxide value.

However the effect of steam-treatment on lowering the rate of fat oxidation as indicated by T.B.A. was slight as compared with their effect on fat hydrolysis as indicated by the F.F.A. content, since after 24 weeks storage the T.B.A. of unsteamed and steamed samples increased by 11 and 6.5 times, respectively, while in case of F.F.A. content the increase was 17 and 7 times, respectively.

Free fatty acids %:

The free fatty acids contents of unsteamed and steamed depot and skin tissues during frozen storage were studied. It was observed that steaming resulted in the increase of the F.F.A. content from an initial value of 0.17 to .0.22%. Such a result may be due to oxidative changes of lipids during the heat treatment (steaming).

The F.F.A. percentage increased progressively with the length of frozen storage. At the end of 24 weeks frozen storage the free fatty acids percentage of unsteamed samples was more than twice the value of the free fatty acids content of steamed samples being 3.01 and 1.42% resp.

REFERENCES

(1) *Cook W. H.* and *White W. H.:* Frozen storage of poultry. IV. Further observations of surface dnying and peroxide oxygen formation. C. A. 1941 Vol. 35. p. 528.
(2) *Wagoner C. E., E. E. Vail Glodys,* and *Conrad R. M.:* The influence of preliminary holding conditions on deterioration of frozen poultry. J. Poultry Sci. 1947 Vol. 26 p. 170–72.
(3) *Callow, E. N.:* J. Sci. Food Agric. *3*, 145, 1952.
(4) *Golovin A. N.:* Changes in whole meat in frozen storage C. A. 1966 Vol. *64*. p. 25883. 1966.
(5) *Marion, J. E.* and *Woodroof, J. G.:* J. Food Sci. *3*, c, 38, 1965.
(6) *Fishwick, M. J.* 1968.
(7) *Keskinel, A. Ayres, J. C.* and *Snyder, H. E.:* J. Food Technol. *18*, 101, 1964.
(8) *Jacofson, Marion: H. Helen:* J. Agr. Food Chem. *18*, 1069, 1970.
(9) *Awad, Powrie, A. A. Fennema, O.:* J. Food Sci. *33*, 227, 1968.
(10) *Bligh, E. G.* and *Dyer, W. J.:* Can. J. Biochem-Physiol *37*, 911, 1959.
(11) *Dyer, W. J., Marton, M. L.:* J. Fischeries Research Board Can. *13*, 129, 1956.
(12) *Pearson, D.:* The chemical analysis of food. National college of food technology. University of Reading Weybridge, Surrey J. A Churchill, 1970.
(13) *A. O. A. C.:* „Association of official Agricultural chemists" Official methods of analysis, 10 *th* Ed. A.O. C. Washington O.C.
(14) *Hornstein, I., Crowe, P. F.* and *Puck, J. B.:* Anal. Chem. *39*, 352, 1967.
(15) *Scharp, L. G.* and *Narion, W. W.:* J. Food science, *36*, (5), 1159, 1964.
(16) *Narayan, K. A., Sugai, M.* and *Kummerow, F. A.:* J. Am. Oil Chem. Soc. *41*, 254, 1966.

VÁLTOZÁSOK FAGYASZTOTT CSIRKÉK LIPIDTARTALMÁBAN

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A szerzők fagyasztott, egyes mintáknál előzetesen hőkezelt egyiptomi csirke zsír- és bőrszövetének összes zsírtartalmát, peroxid-számát, thiobarbitursav-számát és szabad zsírsavtartalmát vizsgálták.

A fagyasztást −20 °C-on végezték, a fagyasztott mintákat −4 °C-on tárolták.

Megállapították, hogy a peroxid-szám, thiobarbitursav-szám, a szabad zsírsav %-os értéke, valamint a lipidtartalom változása a zsír oxidációja és hidrolízise a tárolás során jelentősebben növekedett a hőkezeletlen mintákban, mint a hőkezeltekben.

ИЗМЕНЕНИЯ ПРОИСХОДЯЩИЕ В СОДЕРЖАНИИ ЛИПИДОВ В ЗАМОРОЖЕННЫХ ЦЫПЛЯТАХ

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Авторы исследовали содержание всего жира, числа перекиси, числа тиобарбитуровой кислоты и содержание свободных жирных кислот тканей – жира и тканей кожи замороженных и предварительно термообработанных жира и тканей кожи замороженных и предварительно термообработанных обдазцах Египетских цыплят.

Замораживание проводили при температуре –20°С, а замороженные образцы хранили при температуре –4°С.

Установили, что процентное значение числа перекиси, числа тиобарбитуровой кислоты и свободной жирной кислоты, а так же изменение содержания линидов, окисление жира и гидролиз при хранении бонении более значительно повышались в термически не обработанных, чем в термообобработанных образцах.

VARIATIONS DANS LA TENEUR EN LIPIDES DES POULETS CONGELÉS

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Les auteurs ont étudié, dans des échantillons de poulets d'Egypte, dont quelques-uns avaient subit un traitement thermique préalable, la teneur en graisse totale du tissus adipeux et de la peau, les valeurs de péroxyde et d'acide thiobarbiturique ainsi que la teneur en acides libres.

La congélation s'est effectuée à –20° C et l'entreposage des échantillons congelés à –4° C.

On a établi que, lors de l'entreposage, les valeurs de péroxyde et d'acide thiobarbiturique, le pourcentage d'acides libres ainsi que les variations de la teneur en lipides, l'oxydation et l'hydrolyse de la graisse, ont augmenté de façon plus prononcée dans les échantillons non traités que dans ceux qui avaient subit un traitement thermique.