Studies on fat in some chicken products with trial to prevent its oxidation

El- Shater, M.A*; Hanan, G. Seadawy and Maha, M. Mohamed****
* Animal Health Research Institute (AHRI), Department of Food Hygiene
** Department of Chemistry Food Deficiency
Soshater 2020 @ yahoo. Com

Abstract
A total of 100 frozen half cooked chicken nuggets and shawerma (50 of each) were collected from grocery markets in Giza and Cairo governorates. The samples were subjected to chemical analysis (Fat %, Cholesterol, Acid value %, free fatty acids%, peroxide value m Eq/ kg and TBA value mg (MD/ Kg). The mean values of the aforementioned parameters for nuggets and shawerma were 17.78 ± 0.36, 64.32 ± 0.94, 1.88 ± 0.14, 0.95 ± 0.07, 10.13 ± 0.52, 0.71 ± 0.052 and 15.3 ± 0.28, 57.98 ± 0.69, 1.85 ± 0.13, 1.1 ± 0.17, 10.912 ± 0.064, 0.74 ± 0.035 respectively. There were significant decrease of fat % and cholesterol (mg/ 100 gm) at $P < 0.01$ in chicken shawerma lower than chicken nuggets. According to **ES (2005) and Codex Standard (1991**), the rejected samples percent of both nuggets and shawerma were 84and 86 which exceeded the recommends fat percent. On the other hand, the percent of rejected nuggets and shawerma due to the fat oxidation criteria exceeding limits (Acid value, free fatty acids, peroxide value and TBA) were 6 and 8 respectively. There is significant increase in shelf life at. $P < 0.01$ in the treated chicken nuggets and shawerma with ascorbic acid more than untreated samples when stored at (-18°C). The results were statistically analysed and it was recommended to use natural antioxidant for preventing the fat oxidation and extending the shelf life during freezing storage.

Key words: Chicken Products-Fat Oxidation-TBA value-Nuggets-Shawerma.

Introduction

Egypt's modern poultry industry began in 1964 with establishment of the national General poultry company (G.P.C) which aimed to provide Egypt's fast growing human population with high quality a fordable animal protein. Another important goal for G.P.C was the transformation of poultry production into an industry rather than an agricultural activity, through the introduction of modern technology of poultry processing and skilled management to get different chicken product as chicken shawerma, chicken nuggets etc. **(FAO, 2006)**.

Chicken nuggets are one of chicken products consists of chicken meat with seasoning with different shape (each piece 16 ± 2g), preferred (half cooked) with light golden brown and breaded. It must be free from banned antibiotics, pesticides, residues and sanitizer residues, the product is stored at – 18°C **(Venky`s, 2010)**.

Shawerma is a well known precooked product in Middle East countries from beef or chicken meat with animal fat the product kept in freezing state at (-18°C) fat **(Khalid, 2002)**.

For poultry, pre–cooking also represents a "Pasteurization" process to improve the microbiological status–relative particularly to salmonella SPP. Many products are cooked to a center temperature above 70°C. The meat – products uses an enormous range of cooking methods but for poultry the use of fryer and ovens predominant **(Singhal *et al*., 2001)**.

Freezing is as excellent process for preserving the quality of poultry and poultry products as well as other meat for long periods. However, deterioration of quality caused by chemical or physical factors can occur. Many studies have shown that lipid oxidation is one of the primary causes of quality losses of frozen stored poultry and meat products **(Gökalp *et al.* 1983)**.

The most important process in the oxidation of lipids in meat and poultry products is the peroxidation of polyunsaturated fatty acids from cell membrane. The major catalysts are transi-

tional metal ions, such as Fe^{2+} and Cu^{+}. Heam compounds of meat can also contribute to this process due to the participation of heam-iron in accelerating lipid peroxidation **(Decker and Welch 1990; Pikul 1992)**.

During food processing and storage, polyunsaturated fatty acids tend to be oxidized. Cholesterol can be oxidized by the same mechanism as fatty acids. Therefore, lipids radicals formed during the processing and storage foods can accelerate the oxidation of cholesterol and produce cholesterol oxidation products (COPs) **(Chan *et al*., 1993)**.

Aerobic packaging significantly increased cholesterol oxidation products (COPs) and thiobarbituric acid relative substances (TBARS) in cooked poultry and meat products after 7 days storage which were closely related to the fatty acid composition of food **(Du *et al*., 2001)**.

Acid value test measures free fatty acid as an indication of hydrolytic rancidity. Peroxide value is one of the most widely used tests for oxidative rancidity; peroxide value is a measure of the concentration of peroxides and hydro peroxides formed in the initial stages of lipid oxidation. The 2 – thiobarbituric acid (TBA) method is the most widely used test for measuring the extent of lipid oxidation in muscle foods. The test is believed to measure the breakdown products of unsaturated fatty acids oxidation. Saturated aldehyes, 2 – enals, and 2-dienals, produced in the termination phase of lipid oxidation, can be detected by reaction with 2 – thiobarbituric acid **(Haimd, 2011)**.

Biologically active compounds can be destroyed and, in some cases, toxic and carcinogenic substances represents by hydroperoxides, acids, etc. accumulate **(Balev *et al*., 2005)**.

The meats are important sources of fat in the typical diet in the world, many consumers believe that red meat is unhealthful, because it is high in saturated fatty acids (SFA) and cholesterol. Recently, it has been demonstrated that replacement of red meat with chicken is associated with significant decrease in total cholesterol levels in

diabetic patients ,this effect is probably related to the higher PUDA (polyunsaturated fatty acids) content of chicken meat in comparison to beef **(Gross *et al*., 2002)**

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This study was planned to study:-

Part I: Chemical criteria of market half cooked frozen chicken nuggets and shawerma including.

1- Fat %.
2- Cholesterol (mg / 100 gm).
3- Fat Lipolysis.
 3-1- Free fatty acid % as oleic.
 3-2- Acid value % as oleic.
4- Fat oxidation criteria.
 4-1- Peroxide value m Eq/ kg.
 4-2- Thiobarbituric acid value (TBA mg MD/ kg).

Part II

Trial to prevent the lipolysis and fat oxidation through addition of Ascorbic acid as antioxidant (natural) to experimentally produced chicken nuggets and shawerma, then stored at –18 ºC with control samples (without Ascorbic acid).

The experimentally produced chicken nuggets and shawerma (treated with ascorbic acid) and control chicken nuggets and shwerma (untreated with ascorbic) were examined every 2 weeks till spoilage for free fatty acids, acid value, peroxide value and TBA value.

Materials and Methods

Par I:-

A total of 100 frozen chicken nuggets and shawerma (50 of each) were collected from markets of Giza and Cairo governorates. The samples were transported to the laboratory in ice box without delay for the following examinations.

1. Determination of fat %.

The test was carried out according to **(AOAC, 2000)**, in which the traditional technique is the quantitative determination of fat through a solvent extraction with petroleum ether. The soluble material is extracted from dried tested samples by a two – steps treatment with petroleum ether solvent (Soxhlest extraction procedure).

2. Determination of cholesterol content:
Cholesterol was determined according to **Ojiako and Akubugwo (1997)** using spectrophotometer. Only 0.1 ml of extracted fat and standards cholesterol dissolved in chloroform in ratio 1: 10 was evaporated to dryness in water bath at 50 °C. Glacial acetic acid (3 ml) and 3.0 ml color reagent was added to each sample and standards, then shaking vigorously to dissolve the sample. Blank contained 2.0 ml chloroform, 3 ml Glacial acetic acid and 3 ml of color reagent was prepared.
After cooling for 30 min. at room temperature, absorbance of blank sample and standards were measured at 560 nm. The cholesterol content in sample were calculated from the standard curve.

3. Determination of Lipolysis criteria as follows:
3.1. Acid Value:
It was carried out according **IUPAC (1979)** using titration technique against alkali (1 – 10 gm dissolved fat). The acid value was calculated according to the equation.

$$\text{Acid value (\%as Olic)} \quad \frac{\text{Titration (ml)} \;\; 5.61}{\text{Wt of sample used}}$$

3.2. Free Fatty acids:
The official titration with alkali method recommended by **ISO (1980)** (Reference method) was used the F.F.A figure in usually calculated as oleic (percent).

4. Determination of Fat oxidation criteria:
4. 1 Peroxide Value:
The sample was extracted for fat. To quantify peroxide value, (0.01– 0.05g) was placed in 10 ml screw capped test tube and dissolved in: 1 ml chloroform / acetic acid (2: 3), with addition of 100 ml Fe (II) solution, mix for 15 sec. on vortex mixer and left it in dark place for 10 min. Deionized water (2 ml) was added and 4 ml of diethyl ether (containing 7 ppm BHT). One ml of aqueous phase was mixed with 100 ml of saturated ammonium thiocyanate solution. The sample was measured against a water blank at wave length 470 nm. after 10 min.
The peroxide value was measured using calibration curve. For calibration, a set of Fe (III) concentration in range 0 – 10 µg / m. The method was carried out according to **Shantha and Decker (1994)** the P.V was expressed as m E q / kg.
4. 2 Thiobarbituric acid value:
The method according to **Tarlidgis *et al* (1960)** was used, in which the reaction is applied to a distillate produced under standardized conditions from an acidified macerated food. The results are expressed as malonaldehyde by reference to a standard graph prepared by using 1, 1, 3, 3 – tetra ethoxy propane which yields malonaldehyde by acid bydrolysis TBA no (as mg malonaldehyde/ Kg) = 7.8 D where D (absorbance against blank at 358 nm).

Part II:
1. Production of chicken Nuggets experimentally:
It was carried out according to **Yavas and Bilgin (2010)** using fresh poultry breast meat in addition to seasoning (control), the other group was treated with antioxidant (Ascorbic acid 500 ppm).
The samples (control and treated) were fried in vegetable oil for 2 – 3 min (half cooked). The control and treated chicken nuggets were put in suitable polyethylene bags then put in carton package.

2. Production of chicken shawerma exprimenrally:
It was carried out according to **Odu and Akamo (2012)**. Fresh boneless chicken breast was sliced, put in a pan, seasoned with salt, curry, thyme, black paper, nutmeg and garlic (control). The treated sample was made as mentioned in addition to (500 ppm) of ascorbic acid was added. The control and treated prepared shawerma were heated for 10 min (half cooking) after addition of water and vegetable oil. After cooling, control & treated shawerma were wrapped as mentioned in chicken nuggets.

3. Storage of Experimental samples (chicken Nuggets and chicken shawerma):
The Experimental samples were kept at –18°C and examined every 2 weeks for lipolysis and fat oxidation criteria till spoilage of the products appear as mentioned before.

4-Statistical Analysis: Data obtained were statistically analyzed using **SPSS14 (2006)**.

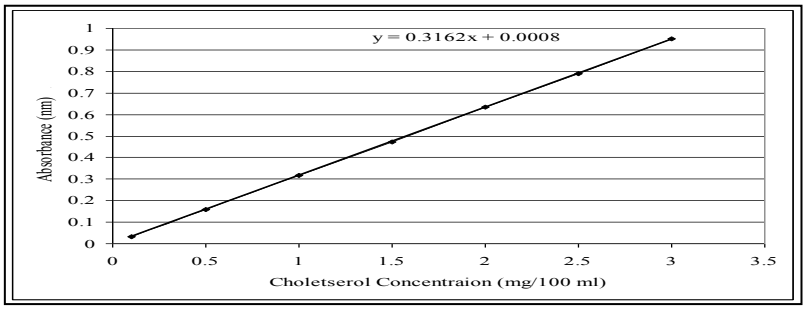

Fig. (1). Cholesterol standard curve.

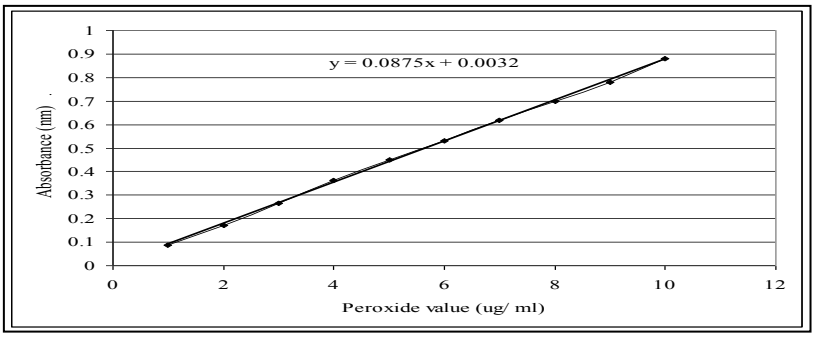

Fig. (2). Peroxide standard curve .

Results

Table (1). Fat and cholesterol percent of market frozen chicken nuggets and shawerma.

		Chicken Nuggets		Chicken Shawerma	
		Fat (g/100 gm)	Cholesterol (mg/100 gm)	Fat (g/100 gm)	Cholesterol (mg/100 gm)
Rejected	No	42	0	43	0
	%	84	0	86	0
Accepted	No	8	50	7	50
	%	16	100	14	100
Min		14	55	12	50
Max		24	79	19	70
Mean		17.78	64.32	15.3*	57.98*
SE		0.363	0.936	0.282	0.693

*Significant at $P < 0.01$ using t-student test comparing with Chicken Nuggets

Table (2). Statistical analytical results of chemical analysis (lipolysis and fat oxidation) of market frozen chicken nuggets and shawerma (n = 50 of each).

			Acid value	Free FA	Peroxide Value	TBA
Chicken Nuggets	Rejected	No	3	3	3	3
		%	6	6	6	6
	Accepted	No	47	47	47	47
		%	94	94	94	94
	Min		1.02	0.56	6.2	0.52
	Max		5.9	2.95	23	1.44
	Mean		1.8832	0.9512	10.13	0.7104
	SE		0.14	0.07	0.52	0.025
Chicken Shawerma	Rejected	No	3	5	4	4
		%	6	10	8	8
	Accepted	No	47	45	46	46
		%	94	90	92	92
	Min		1.1	0.55	6	0.5
	Max		6	9	28	1.9
	Mean		1.8504	1.1	10.912	0.7404
	SE		0.13	0.17	0.064	0.035

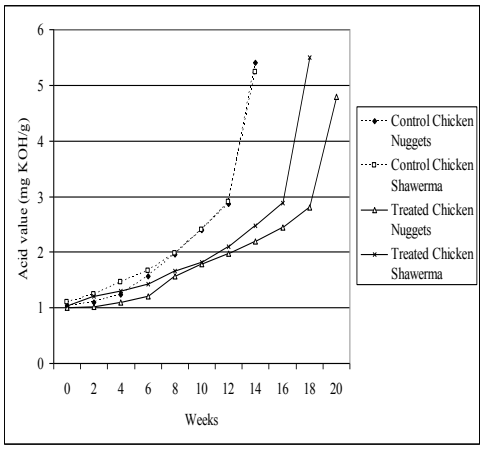

Fig. (3). Changes of acid value of chicken nuggets and shawerma during freezing storage at (-18°C).

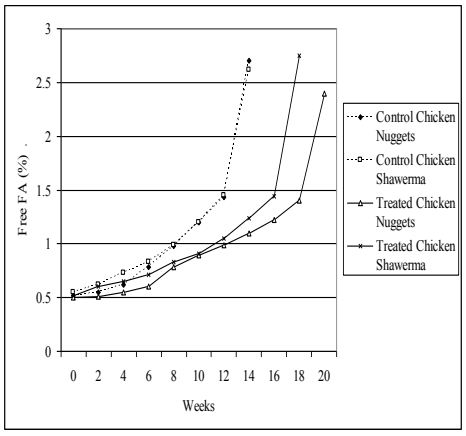

Fig. (4). Changes of free fatty acids of chicken nuggets and shawerma during freezing storage at (-18°C).

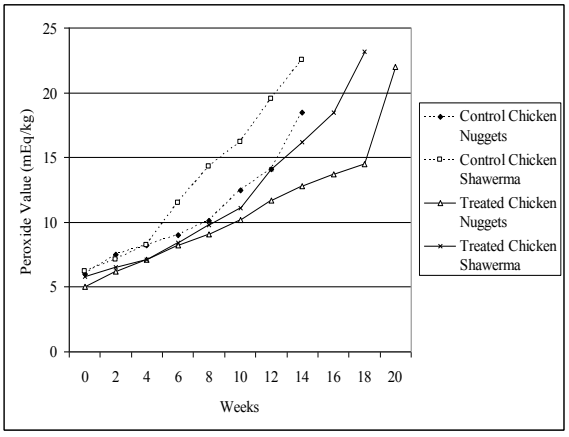

Fig. (5). Changes in peroxide value of chicken frozen nuggets and shawerma during freezing storage at (-18°C).

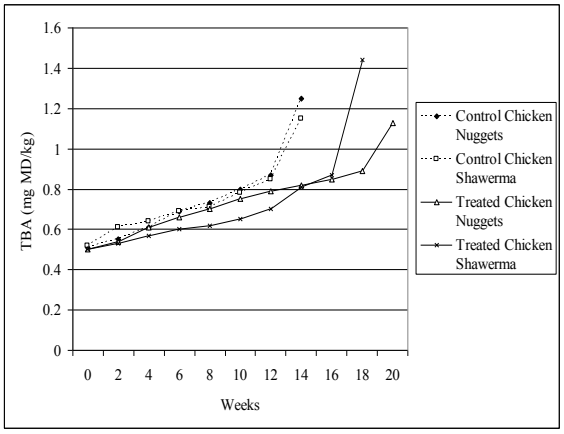

Fig. (6). Changes in TBA value of chicken frozen nuggets and shawerma during freezing storage at (-18°C).

Discussion

In present study, the market samples of nuggets had mean values of fat % and cholesterol (mg / 100 gm) were 17.78 ± 363 & 64.32 ± 0.936 while the mean values for chicken shawerma (frozen) were 15.3 ± 0.282 and 57.98 ± 0.693 respectively the fat percent and cholesterol content (mg/ 100 gm) of frozen chicken shawerma were significantly lower than frozen chicken nuggets at $P < 0.01$.

Concerning the fat %, it was found that 8 samples of chicken nuggets (16%) and 7 samples of chicken shawerma (14%) were only accepted according to maximum fat (15% for nuggets and 12% for shawerma) recommended by **ES (2005)** table (1).

Microbial activities are considered the major factor of foods alteration during storage and manipulation, when these activities are under efficient control, the foods alteration will be of chemical nature, lipid oxidation is a principal chemical change of foods, which depends on the level of oxygen, (energy/ heat) and metals. Lipid oxidation products are responsible for the development of rancidity by the production of low molecular weight compounds that cause undesirable flavor **(Frankel, 1985; Frankel *et al*., 1987)**, thus affecting the quality and limiting shelf life of food products. Cholesterol is also oxidized in similar reaction mechanisms to those observed of fatty acids. Many of the cholesterol oxidation products have adverse effects such as cytoloxicity and modifications of enzyme activity **(Erickson *et al*., 1978; Sevanin and Petreson, 1986; Bosinger *et al*., 1993)** atherosclerosis **(Kumar and Singal, 1991)** carcinogenicity and mutagenicity **(Ansari and Smith, 1979)**.

In this study there was positive correlation between the fat content in both chicken nuggets and shawerma and their cholesterol content. This result was in accordance with that reported by **Dinh *et al* (2008)**.

Major sources of cholesterol in the human diet are meat from domestic livestock, although seafood is also rich in cholesterol content in this study in both nuggets and shawerma of chicken ranged from (55-79) and (50-70) mg / 100 g. Nearly similar results were reported by **(Chizolini *et al*. 1999; Mourot and Hermier 2001; Pironen *et al*., 2002; Valsta *et al*., 2005; Bragagnolo, 2009** and **Honikel, 2009)** who recorded that the cholesterol content in poultry products ranges from 40 – 90 mg / 100 gm. Higher concentration of cholesterol content was recorded by **(USDA, 2011)** for cooked chicken dark meat.

Table (2) illustrated the acid value, free fatty acids, peroxide value and TBA for both chicken nuggets and chicken shawerma. The chicken nuggets mean values of the mentioned parameters were 1.88 ± 0.14, 0.95 ± 0.07, 10.13 ± 0.52 and 0.71±0.025 while for chicken shawerma were 1.8504 ± 0.13, 1.1 ± 0.17, 10.912 ± 0.064 and 0.74 ± 0.035 respectively.

According to the maximum TBA (mg MD/ kg) recommended by **ES (2005)** (0.9 mg MD/ kg). It was found that 3 samples (6%) of chicken nuggets and 4 samples (8%) of chicken shawerma were rejected due to rancidity.

The acid value and the free fatty acid of control and treated chicken nuggets and shawerma experimentally produced and stored(-18)were shown in Figs (3 & 4).

The treated chicken nuggets and chicken shawerma exceeded the acid value recommended by **codex standard(1991**) limit at the weeks 20, 18 weeks respectively.

It was noticed that the control chicken nuggets and shawerma were within limit (0.5 – 1.2) percent as oleic recommended by **IUPAC (1979)** till the week (12) of frozen storage while treated nuggets and shawerma till the week 18 and 16 respectively.

Free fatty acids are the products of enzymatic or microbial degradation of lipids and determination of FFA give information about the stability of fat during storage, this agrees with that reported by **(Das *et al*., 2008)**. The free fatty acids of antioxidant treated nuggets and shawerma were significantly lower than control (non-treated) throughout the storage period, this result agreed with that reported by **(Yavas and Bilgin 2010)**.

The experimentally produced chicken nuggets and chicken shawerma (with antioxidant) were

stored with experimentally control (without antioxidant) at -18ºC till spoilage criteria of lipolysis and fat oxidation appear. The acid value of chicken nuggets and chicken shawerma of both experimentally control and treated at zero day were 1.04, 1, 1.1, 1.04 respectively. The acid value of chicken nuggets and chicken shawerma of control samples exceeded the maximum limit recommended by **Codex (1999)** (max 4.0 mg KOH/ g fat) at week (14).

The initial peroxide value of the control and treated chicken nuggets and shawerma stored at -18ºC at zero week were 6, 5 and 6.2 and 5.8 respectively. The peroxide value gradually increased throughout the storage period. At weeks 2, 4, 6, 8, 10, 12 and 14, the peroxide values of chicks nuggets control and treated were 7.5, 8.2, 9.5, 10.1, 12.5, 14.1, 18.5 and 6.2, 7.1, 8.2, 9.1, 10.2, 11.7, 12.8 respectively. It was noticed that at 4th week the peroxide value of the control nuggets exceeded the maximum limit recommended by **Codex Standard (1999)** (max. 12.5 m Eq of active O_2/ kg). The treated nuggets exceeded this limit at 20^{th} week.

On the other hand, the peroxide value of chicken shawerma exceeded the maximum limit for control at the 10^{th} week while at 16th for treated shawerma (Fig., 5). The peroxide value is the most commonly used parameter to measure lipid hydroperoxides. It also named primary lipid oxidation products. Chicken products have considerably fat and particularly vulnerable to lipid oxidation which leads to quality and nutritional value deterioration **(Olafsdottir *et al*., 1997; Yimaz, 1998)**. The peroxide values were significantly increased at $P < 0.05$ during storage period in both nuggets and shawerma, this result in current study is in accordance with that of **Sallam (2007) and Yavas and Bilgin (2010)**. Nutritionist and buyers had established maximum peroxide value levels between 5 – 20 meq. O_2 / kg of fat **(Hamiliton and Kirestein, 2008)**.

The TBA (mg MD/ kg) of control nuggets and shawerma at weeks 0, 2, 4, 6, 8, 10, 12, 14, were 0.5, 0.52, 0.61, 0.69, 0.73, 0.8, 0.87, 1.21 and 0.52, 0.61, 0.64, 0.69, 0.71, 0.78, 0.85, 1.15 respectively. The TBA exceeded the maximum limit (0.9 mg MD/ kg) recommended by **ES (2005)** at 14th week in both control chicken nuggets and shawerma.

The use of antioxidant (Ascorbic acid) extend the shelf life of treated chicken nuggets and shawerma to 18th, 16th weeks at which the TBA were within the permissible limit recommended by **ES (2005)**. At the weeks 20 and 18 the treated chicken nuggets and shawerma had TBA 1.13 and 1.44 mg MD/ kg which exceeded the maximum limit of TBA respectively (Fig., 6). The treatment of chicken nuggets and shawerma had statistically significant effect ($P < 0.05$) on TBA value during storage at – 18 Cº. The lowest TBA in treated chickens nuggets and shawerma with ascorbic were 0.5 mg/ MD/ kg for each, while the highest TBA values were 1.13 and 1.44 mg MD/ kg. TBA values were significantly lower ($P < 0.05$) in all treated samples of nuggets and shawerma as compared to the control. This results agreed with that reported by **Ozgul and Cemalettin (2010)**.

In industrial processing, mainly synthetic antioxidant such as butylated hydroxytoluene, butylated hydroxyinsol and propylated gallate used prolongue the storage stability of food. However the demand of natural antioxidants has recently increased because of the toxicity and the carcinogenicity of synthetic antioxidants **(Juntachote *et al* 2006)**. In addition, synthetic antioxidants have limited application because of their low water solubility **(Bekhit *et al*, 2003)**. BHA, however, has a high solubility in animal fats **(Allen & Hamlton 1994; Coppen 1994)**. In meat processing, the Ascorbic acid is used as antioxidant (natural antioxidant) for preventing the off – flavor **(Bauernfiend 1985)** as well as maintaining the cured color.

The anti-oxidation mechanism of ascorbic acid is to activate the primary antioxidants, to be an oxygen scavenger, and to inactivate antioxidants **(Bauernfiend and Pinkert, 1970)**. At low concentrations, ascorbic acid promotes lipid oxidation; however, at high concentrations it inhibits lipid oxidation **(Decker and XU, 1998)**.

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دراسات على الدهون فى بعض منتجات الدواجن مع محاولة لمنع اكسدتها

*** محمد أحمد الشاطر - * حنان جودة سعداوى - ** مها محمود محمد**

* معهد بحوث صحة الحيوان – قسم صحة الأغذية ** قسم الكيمياء والنقص الغذائى

المخلص العربى

تم فحص 100 عينة من كل من ناجيتس الدجاج وشاورما الدجاج المجمدة والموجودة بأسواق محافظة القاهرة والجيزة (50 عينة من كل نوع) كيميائيا (نسبة الدهن – نسبة الكوليستيرول – الأحماض الدهنية الحرة – قية الحمض – قيمة البيروكسيد – قيمة حمض الثابوباربتوريك). كان متوسط قيم الاختبار السابقة لكل من الناجيتس والشاورما 0.36 ± 17.78، 0.9 ± 63.32، 0.14 ± 1.88، 0.07 ± 0.95، 0.52 ± 10.13، 0.052 ± 0.71، 0.289 ± 15.3، 0.69 ± 57.98، 0.13 ± 1.85، 0.17 ± 1.099، 0.064 ± 10.912، 0.13 ± 0.74 على التوالى.

كان هناك نقص معنوى فى نسبة محتوى الدهن فى عينات شاورمة الدجاج مقارنة بالناجيتس عند $P < 0.01$ وطبقا لمحتوى الدهن وجد أن 43% من عينات الشاورمة و40% من عينات الناجيتس قد كانت مرفوضة نظراً لاحتوائها على نسبة أعلى من الحدود التى قررتها المواصفات القياسية المصرية (2005). وقد وجد أن 6%، 8% من عينات الناجيتس والشاورما الموجودو بالأسواق كانت مرفوضة لأنها تخطت الحدود المسموح بها لاجتيازات تزنخ الدهون طبقا للمواصفة المعدية (2005) ومواصفات الكودكس 1991.

وجد فى الجزء الثانى من الدراسة أن إضافة حمص الاسكوربيك للعينات التجريبية للناجيتس والشاورما قد زاد من فترة حفظها عند درجة حرارة التجمد (-18ºم) معنويا عند مقارنة بالعينات التجريبية التى لم يضاف إليها حمض الاسكوربيك (عينات ضابطة).

وقد نوقشت النتائج إحصائيا واوصت الدراسة باضافة حمض الاسكوربيك عند التصنيع لمنع اكسدة الدهون وزيادة فترة الصلاحية.