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STUDIES ON THE EXTRACTION OF ANTIOXIDANTS FROM AGRICULTURAL WASTES AND THEIR USE IN SOME MEAT PRODUCTS

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ABSTRACT

One of the critical problems in the animal foods has been their susceptibility to oxidative rancidity. In the present work, oxidative rancidity in the product called Kufita which prepared either from beef or chicken meat was determined by 2-thiobarbituric acid value (T.B.A), malonaldehyde/kg sample), peroxide value (PV, meq/kg oil), fatty acids composition (F.A.C.) and sensory evaluation. Also, some physico-chemical properties were determined. All Kufita samples were evaluated immediately after processing and during storage at –18°C for 4 months. The extraction of phenolic compounds as antioxidations from agricultural peel wastes (vegetables and fruits peel wastes, potatoes, red onion, red garlic and pomegranate peel wastes) and their addition in beef and chicken kufita were investigated and evaluated.

The results indicated that there was an increase in rancidity with storage time for all un-treated samples of beef and chicken kufita, beef and chicken kufita treated with phenolic showed a slower rate of deterioration. Rancidity in beef and chicken kufita were effectively controlled by treating with antioxidants (natural and BHT). The untreated samples of chicken kufita was un-safety after 60 days of storage at –18°C, also chicken kufita was more susceptible to oxidative rancidity than beef one. Generally, the use of phenolic compounds extracted reduction and/or replacement of synthetic antioxidants; lowered assumed toxicity due to their natural origin as components of food.

INTRODUCTION

Phenolic compounds are mainly found in fruits and vegetables which give astringent taste characteristics to these foods. Different types of phenolic compounds such as phenolic acid, hydrolyzable tannins and flavonoids were reported to have anticarcinogenic; antimutagenic; antioxidative; antihypersensive; enzyme inhibiters and antimicrobial effects (Newmark *et al.,* 1992 and Noroozi *et al.,* 1998). Phenolic compounds widely distributed within plants (Wong, 1973 and Gross, 1981) are commonly isolated using aqueous or organic solvents. Potato peel contains many phenolic compounds, some in free form and some bound (Lisinska and Leszezynski, 1987). Food phenolic antioxidants, such as butylated hydroxyanisole (BHA), tetrabutylated hydroquinone (TBHQ), and propyl gallate are used as antioxidants in food stuffs against oxidative rancidity (Cuvelier *et al.*, 1992). Such antioxidants are used, but many questions regarding human health effects related to them are unresolved. Also general public concern exists regarding food additives and their safety. Some components of extracts isolated from plant materials have been proven in model systems to be as effective antioxidants like synthetic antioxidants, potato peel contains phenolic acids and the largest portion

consists of chlorogenic acid (CGA), Rodriguez De Sotillo *et al.* (1994 b). Natural antioxidants as are necessary biocompounds to protect human body and it can be used in the food industry. Antioxidants are considered as of synthetic antioxidants such as BHT, BHA and TBHQ and natural antioxidants such as flavonoids, isoflovonoids, saponins, tannins, minerals, vitamins, tocopherols, some enzymes, sterols, volatile oils and poly-unsaturated fatty acids. Vegetables, fruits, cereals, legume and herbs are the main sources of natural antioxidants and the genetic engineering and tissue culture can be used to increase the natural antioxidants, (Sandak and El-Hadidy, 2004).

Oxidation is a major cause of deterioration of food because of its negative effects on organoleptic qualities (flavor, color, etc). Oxidation of lipids can also have a marked negative effect on nutritional value, and may be responsible for the production of toxic compounds capable of triggering metabolic disorders such as mutagenesis, carcinogensis, circulatory disorders and ageing (Kanner, 1994 and Ruiz *et al.,* 1999).

Polyphenols had potentially beneficial effects on health including anti-inflammatory, antiviral, antimicrobial and antioxidant activity. Antioxidant activity is defined as the ability to reduce free radical formation and scavenge reactive oxygen species (ROS), (Narayana *et al.,* 2001 and Liu, 2003).

The synthetic compounds as butylated hydroxyanisole, butylated hydroxytoluene and propyl gallate are commonly used antioxidants for foods. Naturally occurring antioxidants available an either a small or large scale might provide a simple mean of controlling warmed-over flavor (WOF) in some foods. A widely occurring group of such compounds are the flavonoid pigments (Pratt and Watts, 1964).

Consumption of free radicals and oxidation products may be a risk factor for cancer and cardiovascular disease (Namiki, 1990) and dietary phenolics may have health benefits (Huang *et al.,* 1992). Conventional synthetic phenolic antioxidants such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG), and tertbutylhydroquinone (THBQ) are limited (FDA) to 200 ppm based on lipid composition. Health protection and economic reasons have necessitated investigations aimed to enhancing the oxidation stability of lipids and lipid containing products. There is an increasing trend towards adding suitable harmless natural antioxidants to these products (Pokorny, 1991).

Lipid oxidation is one of the major problems encountered in meat processing following cooking and subsequent refrigerated or frozen storage. It affects the quality of the product due to the loss of desirable color, odor and flavor and a reduced shelf life. The rate of lipid oxidation can be effectively retarded by the use of antioxidants (Ruiz *et al.,* 1999). Natural antioxidants are of main interest now a days, synthetic antioxidants were widely used in the meat industry but consumers concern over their safety and toxicity pressed the food industry to find sources of antioxidant.

MATERIALS AND METHODS

A- Source of beef and chicken meat and preparation of samples:

Fresh beef and fresh chicken meat were considered the raw materials used for this study. Samples were obtained from the local market in

Qaluobia and transported using ice box to the Lab. of Meat and Fish Res. Dept., Food Technol. Res. Inst., then after arriving to the lab, it was washed with tap water. Beef and chicken kufita were prepared by the common method either control or treatments according to the formulations presented in Tables (1 and 2), control and treatments were evaluated immediately after processing for sensory, physico-chemical properties and some oil constants. Also, some physico-chemical properties and some oil constants were determined during storage at –18°C for four months.

B- Source of Agriculture and fruits peel wastes:

Potatoes, red onion, red garlic and pomegranate peel wastes were obtained from local marked (green grocer's) in Qaluobia.

C- Isolation of phenolic compounds from agriculture and fruits peel wastes:

Extraction: The method of Rodriquez De Sotillo *et al.* (1994 a) was used for extraction as follow: phenolic compounds were extracted from agriculture and fruits peel waste using methanol (MeOH) or petroleum either (40-60 bp). Ten grams peeled waste were diced to small pieces, and then homogenized for 4 min in a blender with 100 ml cold MeOH or petroleum either 40-60 bp (4°C).

The resulting slurry was centrifuged using an (HARRIE 18/80 CFCFREE) refrigerated centrifuge (made in uk) at 6000 xg for 10 min at 5°C. The supernatant liquid was filtered through whatman No. 1 paper, and the filtrate was collected. The first extraction, the residue was extracted on more time. Supernatant liquid after centrifugation from the second extraction collected. Finally, the first and second extraction collected in amber-colored bottles after removed the solvent evaporated under vacuum on a rotary evaporator.

The phenolic compounds fraction remaining collected in amber colored bottles and stored at -18°C until used in the processing.

D- Analytical methods:

1- Some physico-chemical properties

Moisture content, crude fat, protein (total nitrogen x 6.25), peroxide value (PV) were determined according to A.O.A.C. (1995). The W.H.C. was measured by filter press method of Soloviev (1966). Cooking loss % of samples was calculated as a percentage of weight change from raw to cooked state. The total volatile basis nitrogen was measured according to the method mentioned by Winton and Winton (1958). Thiobarbituric acid value (T.B.A.) as an indicator of fat oxidation was determined as mentioned by Pearson (1970), optical density value at 538 nm was multiplied by 7.8 to obtain the content of malonaldehyde as mg/kg sample (w.w).

2- KS value:

KS value (indicating the rate of lipids oxidation) was calculated according to Semyonov *et al.* (1979) as follow:

$$KS = \frac{\% \text{ total unsaturated fatty acids}}{\% \text{ total saturated fatty acids}}$$

7- Separation and identification of fatty acids:

a) Separation of fatty acids:

The lipid extracted from treated and untreated samples (ground beef and chicken meat) was saponified with methanolic KOH (20% w/v) for 24 hr at room temperature. The unsaponifiable matter was extracted three times with diethyl ether.

The aqueous layer (Soap) was acidified with HCl (1: 1 v/v) and the liberated fatty acids were washed extracted with petroleum ether (40-60 b.p). The fatty acids were washed several times with distilled water, then dried over anhydrous sodium sulphate.

b) Methylation of fatty acid:

The fatty acids were converted to methyl esters as follows: the solvent was distilled off, the residue was dissolved in anhydrous dimethyl ether (0.5-1 ml) and methylated by addition drop of diazomethane solution prepared as reported by Vogel (1975) until the yellow color persists. The mixture was then left at room temperature for 15 min. and the solvent was evaporated on a water bath. Finally, the fatty acid methyl esters were dissolved in chloroform. A liquors of this solution was subjected to gas-liquid chromatography (for the identification of the methylated fatty acids).

d) Identification and determination of fatty acids methyl ester by gas-liquid chromatography (GLC):

GLC apparatus was shimadzu GCV-CM Unicom gas chromatograph equipped with dual flame ionization detector. The fractionation of fatty acids methyl esters was conducted using silver column 10% on gas chromatograph Q11 80/100. The separation conditions were: the column temperature was programmed at 3°C/min., initial temperature was 190°C and final temperature was 220°C. Chart speed was 5 mm / min., detector temp. was 270°C and injection temperature was 270°C flow rate of gases were: nitrogen 30 ml/min., hydrogen 1 ml/min., air 0.50 ml/min. and sensitivity 16 x 10^2. The peak identification was performed by comparing the relative retention times of each peak with those of standard materials. Fatty acid was calculated as percentage of the total identified acids after measuring the peak areas by triangulation.

e) Sensory evaluation:

Sensory evaluation was carried out on treated samples immediately after treatment and by the end of storage.

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Samples were prepared (the prepared kufita samples were fried in plant oil at 180°C till samples had a golden color and subkected to a 5 member trained sensory panel to find out the treated sample) that will be have more palatability by evaluating color, odor, texture, taste and overall acceptability of these products. A 9-point hedonic scale was used for the sensory evaluation according to Teeny and Mjyauchi (1979).

f) Statistical analysis:

The method used for the statistical analysis of the results is according to (Kurtz, 1983).

RESULTS AND DISCUSSION

a) Chemical composition:

From the results (Table 3), it could be observed that at zero time, beef meat kufita (control) recorded relatively lower contents of moisture and fat than that of chicken meat kufita (control), while, the reverse was recorded concerning the contents of protein, T.V.N. On the other hand, also at zero time, data represented in Table (3) indicated that addition of antioxidants had no effect on moisture, fat protein content compared with control, while kufita treated with potato peel extract or pomgerment peel extract showed lower T.V.N. than other treatments. The end of storage at -18°C for 120 days, highly significant differences between the controls and treatements were recorded either for beef or chicken kufita. Samples with antioxidants were better than the untreated one. This may be due to addition extracts of red onion, garlic, potato, pomgerment peel that may contains many naturally occurring phenolic compounds which have antioxidant activity.

b) Some physical quality attributes:

Data of Tables (4 & 5) show the cooking loss and W.H.C. of beef and chicken kufita as affected by addition of extracts from red onion, garlic, potato and pomgerment peel (natural antioxidants) and butylated hydrozytoluene (BHT, synthetic antioxidants) and storage at –18°C for 4 months.

1- Cooking loss and WHC:

From the results shown in Table (4), it could be noticed that the differences in cooking losses between control and treated meats were recorded slight significantly different until 60 days, after that, with increasing storage time, all treated samples showed slightly cooking losses compared with control which recorded highest values. This may be due to physical disruption of cell structure or to protein denaturation during frozen storage. On the other hand, from the results in Table (5), initially and after all storage periods, all treated samples showed lower W.H.C. values than controls for beef and chicken kufita. Although there was no significant difference among treatments, there was a tendency for values to be lowest for samples treated with pomgerments and potatoes peel extract. This may be due to naturally occurring antioxidants available on small or large scale. A widely occurring group of such compounds are the flavonoid pigments (Pratt and Watts, 1964).

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Table (4): Cooking loss of beef and chicken kufita as affected by addition of antioxidants (natural and synthetic antioxidant) and storage at –18°C for 120 days.

Storage of days / Treatments		Zero time* (0)	30	60	90	120
		Beef meat (kufita)				
1	Control	15.59±0.51^{ed}	16.44±0.11^{g}	15.84±0.04^{fe}	17.48±0.07^{h}	19.65±0.13^{j}
2	A	15.10±0.47^{bc}	15.29±0.35^{cd}	15.81±0.08^{f}	16.54±0.21^{g}	17.51±0.21^{h}
3	B	15.31±0.11^{de}	15.51±0.57^{de}	15.68±0.04^{e}	16.66±0.13^{g}	16.62±0.13^{g}
4	C	15.10±0.26^{bc}	15.40±0.52^{cd}	15.81±0.08^{f}	17.35±0.36^{h}	17.30±0.20^{h}
5	D	14.79±0.32^{ab}	15.45±0.67^{c}	15.82±0.21^{f}	16.06±0.15^{f}	16.61±0.17^{g}
6	E	15.36±0.07^{c}	14.56±0.19^{a}	15.26±0.35^{cd}	15.98±0.47^{f}	16.59±0.14^{g}
		Chicken meat (kufita)				
1	Control	18.89±0.15^{f}	20.50±0.06^{ih}	20.36±0.12^{h}	22.59±0.12^{j}	24.34±0.14^{k}
2	F	17.85±0.53^{e}	18.44±0.09^{e}	18.02±0.10^{c}	19.04±0.22^{g}	20.61±0.12^{hi}
3	G	18.56±0.07^{e}	18.55±0.06^{de}	18.07±0.23^{c}	18.52±0.06^{e}	20.38±0.12^{h}
4	H	18.10±0.38^{e}	18.57±0.15^{de}	18.48±0.10^{ed}	18.93±0.35^{f}	20.71±0.07^{i}
5	I	17.51±0.15^{b}	17.93±0.35^{de}	17.58±0.10^{b}	18.47±0.08^{d}	18.88±0.44^{gf}
6	J	17.59±0.16^{b}	17.38±0.12^{be}	17.41±0.05^{ba}	17.19±0.47^{a}	18.69±0.31^{f}

*** Immediately after processing and treatment**
L.S.D. of Beef meat kufita = 0.37 L.S.D. of Chicken meat kufita = 0.28

Table (5): Water holding capacity (WHC) of beef and chicken kufita as affected by addition of antioxidants (natural and synthetic) and storage at –18°C for 120 days.

Storage of days / Treatments		Zero time* (0)	30	60	90	120
		Beef meat (kufita)				
1	Control	0.46±0.02^{a}	0.64±0.01^{g}	0.83±0.01^{jk}	1.24 ±0.03^{o}	1.83±0.01^{p}
2	A	0.49±0.03^{b}	0.55±0.02^{d}	0.64±0.02^{g}	0.88±0.02^{lm}	0.86±0.01^{l}
3	B	0.55±0.02^{d}	0.58±0.03^{e}	0.71±0.02^{h}	0.86±0.02^{l}	0.89±0.03^{m}
4	C	0.48±0.03^{ba}	0.57±0.02^{ed}	0.71±0.01^{h}	0.82±0.08^{k}	0.93±0.09^{n}
5	D	0.47±0.01^{ba}	0.56±0.01^{ed}	0.65±0.01^{g}	0.63±0.01^{g}	0.79±0.02^{j}
6	E	0.47±0.02^{ba}	0.51±0.01^{c}	0.61±0.00^{f}	0.57±0.03^{ed}	0.75±0.02^{i}
		Chicken meat (kufita)				
1	Control	0.75±0.05^{ba}	0.88±0.00^{c}	1.48±0.03^{f}	1.26±0.34^{d}	2.85±0.52^{g}
2	F	0.74±0.03^{a}	0.79±0.01^{ba}	0.95±0.04^{c}	1.40±0.04^{e}	1.53±0.04^{f}
3	G	0.80±0.01^{ba}	0.82±0.01^{bac}	0.89±0.05^{c}	1.36±0.05^{e}	1.45±0.07^{fe}
4	H	0.78±0.04^{ba}	0.87±0.01^{c}	0.93±0.01^{c}	1.36±0.05^{e}	1.42±0.01^{e}
5	I	0.76±0.02^{ba}	0.75±0.02^{ba}	0.83±0.00^{b}	1.32±0.05^{ed}	1.32±0.06^{ed}
6	J	0.78±0.02^{ba}	0.74±0.03^{a}	0.76±0.02^{ba}	0.87±0.01^{c}	0.89±0.02^{c}

*** Immediately after processing and treatment ** WHC = Water holding capacity (cm^2/0.3g sample) L.S.D. of Beef meat kufita = 0.03 L.S.D. of Chicken meat kufita = 0.09**

c) Sensory evaluation:

From the results presented in Table (6), it could be noticed that immediately after treating (at zero time) with antioxidants (phenolic compounds) that were extracted from red onion peel, garlic peel and potato peel, (vegetables peel wastes); pomgerment peel (fruits peel wastes) and butylated hydroxytoluene (BHT, synthetic antioxidants) of beef and chicken kufita, a slight significant difference (P = 0.05) was shown between the control and treatments, while by the end of storage at –18°C for 4 months, there was

a highly significant difference in panel scores between the control and treatments. Panel members were not as sensitive to color, taste, texture, odor and overall acceptability in beef kufita samples as they were to those in chicken kufita samples. Sensory evaluation were significantly better in treated samples as compared to control samples (either beef or chicken kufita).

d) Peroxide value and TBA:

Data presented in Table (7) show the peroxide value (meq/kg oil) of beef and chicken kufita as affected by adding of antioxidants (natural or synthetic) at level of 0.03% and storage at -18°C for 4 months.

It is evident that with very few exceptions, chicken kufita samples were than that of beef specifically after 90 or 120 day of storage at -18°C.

At zero time treatments showed decreasement of the peroxide value when . compared with untreated samples (control). This may be due to the phenolic compounds presented in the vegetable and fruits extracts that interrupted free radical mechanism of glyceride.

Such values indicated that the loss of fat was increased with increasing of storage time, being less pronounced for treated with natural antioxidants than control, and lower for beef than the chicken kufita. Generally, the treated samples with natural antioxidants were the best when compared with treated samples with synthetic antioxidants, BHT and then control. This may be due to plant tissue contained numerous flavone aglycones, many of these compounds have active metal chelating sites as well as orthodihydroxy groups on the same molecule, making them effective antioxidants (Younathan *et al.,* 1980).

From the results in Table (8), it could be noticed that thiobarbituric acid (T.B.A.) of control (beef or chicken kufita) increased to reach 1.2824 and 2.5584 mg malonaldehyde / kg sample respectively. T.B.A. increased with increasing of storage period but at different significant rates. However, the antioxidative activity of fruits and vegetables extracts varies considerably. In addition to the flavonoids, these plant tissues contain potential antioxidants as sulfur compounds and ascorbic acid (Green *et al.,* 1971 and Chang *et al.,* 1961).

On the other hand, chicken kufita samples during storage had a higher values of T.B.A. compared with beef one in all storage periods, this may be due to the higher content of polyunsaturated fatty acids (PUFA), in chicken kufita. Generally, initially after all storage periods, all treated samples showed lower TBA values than controls.

From the same table, kufita treated with vegetables and fruits extract had lower TBA values followed by samples treated with BHT (higher values) then controls (tha highest values of TBA). Oxidation was greatest for untreated chicken sample (control) after 60 days of freezing at -18°C, it may be due to its higher content of poly unsaturated fatty acids in chicken meat (Fernandez-Espla and O'neill, 1993 and Houben and Krol, 1985).

T6

Table (7): Peroxide value (PV*) of beef and chicken kufita as affected by adding antioxidants and storage at –18°C for 120 days.

Storage of days / Treatments		Zero time** (0)	30	60	90	120
		Beef meat (kufita)				
1	Control	5.34±0.55^{d}	8.49±0.15^{g}	10.83±0.06^{j}	12.60±0.10^{k}	15.50±0.27^{l}
2	A	3.38±0.46^{ab}	2.97±0.13^{a}	5.78±0.09^{e}	10.10±0.40^{i}	19.13±0.37^{m}
3	B	4.95±0.28^{d}	3.66±0.15^{b}	5.19±0.33^{d}	6.42±0.13^{f}	9.72±0.31^{h}
4	C	4.86±0.70^{d}	3.95±0.37^{bc}	4.99±0.38^{d}	3.38±0.08^{ab}	9.44±0.45^{h}
5	D	3.74±0.53^{b}	3.95±0.15^{bc}	5.11±0.40^{d}	6.31±1.20^{fe}	6.03±1.62^{fe}
6	E	3.10±0.43^{ba}	3.61±0.08^{bc}	4.15±0.29^{c}	6.69±0.32^{f}	8.65±0.30^{g}
		Chicken meat (kufita)				
1	Control	3.67±0.07^{c}	10.48±0.03^{h}	12.49±0.11^{i}	19.45±1.58^{h}	23.26±0.53^{m}
2	F	2.74±0.60^{ab}	5.42±0.09^{d}	8.60±0.20^{g}	12.09±0.29^{i}	16.24±0.33^{l}
3	G	3.07±0.17^{b}	5.36±0.61^{d}	8.26±0.47^{g}	15.27±0.43^{k}	12.88±0.64^{j}
4	H	3.66±0.18^{c}	4.98±0.87^{d}	6.65±0.19^{e}	12.13±0.26^{i}	12.90±0.36^{j}
5	I	2.73±0.12^{ab}	4.89±0.18^{d}	8.63±0.16^{g}	7.45±0.66^{f}	15.59±0.14^{k}
6	J	2.20±0.36^{a}	4.14±0.38^{c}	7.51±0.20^{f}	7.92±0.22^{f}	10.38±0.17^{h}

*** PV = Peroxide values (meq/kg soil) ** Immediately after processing and treatment**

L.S.D. of Beef meat kufita = 0.60 L.S.D. of Chicken meat kufita = 0.57

Some components of extracts isolated from plant materials have been proven in model systems, to be as effective antioxidants as synthetic antioxidants (Rodriquez De Sotillo *et al.,* 1994-b).

Table (8): T.B.A* values of beef and chicken kufita as affected by adding antioxidants and storage at –18°C for 120 days.

Storage of days / Treatments		Zero time** (0)	30	60	90	120
		Beef meat (kufita)				
1	Control	0.4204±0.001^{d}	0.6860±0.03^{h}	0.7918±0.05^{i}	0.9498±0.00^{k}	1.2824±0.03^{l}
2	A	0.3224±0.01^{b}	0.3455±0.01^{b}	0.3775±0.01^{c}	0.5074±0.09^{e}	0.8562±0.04^{j}
3	B	0.3888±0.00^{cd}	0.4114±0.02^{c}	0.4104±0.00^{c}	0.4815±0.05^{e}	0.6595±0.04^{h}
4	C	0.4055±0.00^{dc}	0.4932±0.01^{e}	0.4703±0.01^{e}	0.5537±0.11^{f}	0.7658±0.02^{i}
5	D	0.4008±0.00^{dc}	0.3718±0.01^{c}	0.4244±0.00^{d}	0.4918±0.06^{e}	0.6241±0.05^{g}
6	E	0.3144±0.00^{b}	0.3263±0.00^{b}	0.3054±0.00^{b}	0.2429±0.01^{a}	0.5104±0.02^{k}
		Chicken meat (kufita)				
1	Control	0.2952±0.00^{l}	0.7944±0.01^{hg}	1.1801±0.03^{d}	2.5584±0.22^{a}	0.8861±0.06^{f}
2	F	0.2088±0.01^{mn}	0.4354±0.00^{k}	0.5986±0.02^{i}	0.8898±0.02^{f}	1.5361±0.05^{b}
3	G	0.2562±0.00^{ml}	0.4763±0.00^{kj}	0.5852±0.00^{ji}	0.8237±0.01^{g}	1.3354±0.07^{c}
4	H	0.2948±0.00^{l}	0.5216±0.01^{j}	0.7400±0.00^{h}	0.9208±0.02^{ef}	0.9764±0.01^{e}
5	I	0.2344±0.00^{nm}	0.4131±0.01^{k}	0.6188±0.01^{i}	0.8854±0.01^{f}	0.9014±0.02^{f}
6	J	0.2009±0.00^{nm}	0.2932±0.00^{l}	0.4204±0.01^{k}	0.7838±0.01^{gh}	0.8100±0.01^{g}

*** T.B.A = Thiobarbituric acid (mg malonaledhyde/kg sample w.w) ** Immediately after treatment L.S.D. of Beef meat kufita = 0.04 L.S.D. of Chicken meat kufita = 0.06**

e) Fatty acids composition:

Results of fatty acids composition (as % of total fatty acids, of beef and chicken kufita as affected by adding red onion, garlic, potatoes, pomegranate peel extracts (natural antioxidants as sources of phenolic compounds) and BHT (synthetic antioxidants) and frozen storage at -18°C for 120 days are given in Tables (9 & 10).

From the results, it could be observed that samples treated with vegetables and fruits peel extracts or synthetic antioxidants and frozen storage for 120 days, affected the fatty acids composition of beef and chicken kufita whereas, some fatty acids were absent, others were increased and vice-versa. This may be due to the hydrolysis or/and oxidation occurred for lipids of beef and chicken kufita during storage period. Also, from results of Tables (9 & 10), it could be noticed that progressive increase of some fatty acids ($C_{14:0}$, $C_{16:0}$ and $C_{18:0}$) were observed during frozen storage of the tested chicken meat samples, except treated samples with pomegranate peel extract but, the increasing rate in control samples was higher when compared with treated samples, either beef or chicken kufita.

f) Fatty acids fractions:

Data of fatty acids fraction (% of total fatty acids) of beef and chicken kufita as affected by treating with vegetables and fruits peel extracts, (natural antioxidants) or BHT (synthetic antioxidants) and frozen storage for 120 days are presented in Table (9 & 10). From the results, it could be noticed that the data confirmed and supported the previous conclusions obtained from results of the same Tables (9 & 10). Immediately after treatment (zero time). It is clear that the total saturated fatty acids (TSFA) were decreased by treated with vegetable and fruits peel extracts or BHT. This may be due to free radical termination the primary means by which phenolic compounds retard oxidation, Brune *et al.* (1989). Also, the total saturated fatty acids (TSFA) were increased by increasing of frozen time, nevertheless the increasing rate was lower for treated samples by natural antioxidants than that of samples treated by synthetic antioxidants. The increasing rate was highest for untreated samples (control) of beef and chicken kufita but the percent increase was higher for chicken meat (control) than beef one. Moreover, the total saturated fatty acids (TSFA) were increased during frozen storage of all the tested samples either controls or treatments but chicken kufita recorded higher increment when compared with the beef samples.

Contrariwise, at zero time, the total unsaturated fatty acids (TUFA) increased after treatment with antioxidants, while it was decreased by increasing the storage time (for all tested samples, but the decreasing of TUFA was higher in control followed by samples treated with (BHT) synthetic antioxidants of chicken samples compared with the beef samples, which had the lowest decreasing of TUFA. Also, the samples treated with natural antioxidants were the best followed by the samples treated with synthetic antioxidants then the untreated samples, which had a moiré poor fatty acids composition for beef and chicken samples. This may be due to phenolic antioxidants are widely used to protect fat and many fat-containing foods (including some meats) from oxidative rancidity (Chastain *et al.,* 1982).

T9

T10

This means that hydrolysis and oxidation of lipid were high in untreated samples (control) followed by samples treated with BHT. Also, it could be noticed that the oxidation rate of chicken samples (untreated or treated with antioxidant) was higher when compared with untreated or treated beef samples (after 90 days of frozen), this may be due to that the total unsaturated fatty acids of chicken samples (control or treatment) was higher when compared with beef one. From the results, it could be summarized that the percentage of TMUFA (the total mono-unsaturated fatty acids) nearly increased after adding antioxidants (natural or synthetic) immediately, then decreased till the end of frozen storage for all the samples either control or treatments of beef and chicken kufita. On the other hand, according to the total percent of the poly unsaturated fatty acids (PUFA), $C_{18:2}$ plus $C_{18:3}$ the chicken samples treated with pomegranate peel extract recorded the highest (23.85%) followed by the samples treated with potatoes peel extract (22.97%) then samples treated with BHT (20.84%). On the other hand, the beef sample treated with BHT recorded the highest (21.73%) followed by the samples treated with potatoes peel extract (20.93%) and with pomegranate peel extract (20.83%).

This means that peels extrats may be a source for a useful components with antioxidative effect for the food industry. Many naturally occurring phenolic compounds have antioxidant activity (Lisinska and Leszczynski, 1987). The (TPUFA) decreased by increasing of storage time over all the tested samples.

Moreover, the KS (TUFA / TSFA) as an indicator or of the unsaturated degree confirmed the previous results. The higher KS the lower the oxidation of beef and chicken lipids and the vice versa will be found.

All the samples of chicken kufita had higher KS than that of beef samples at zero time. Furthermore, after 120 days of frozen storage at -18°C, untreated chicken kufita samples (control) recorded the highest decreased of KS followed by samples treated with BHT. Control samples (beef and chicken kufita) recorded the lowest KS and accordingly the highest oxidation of lipid, but the chicken sample (control) was had the lowest KS, may be due to chicken meat is more susceptible to oxidative rancidity than red meat due to its higher content of polyunsaturated fatty acids.

Generally, chicken kufita acceptably of the oxidation was more than beef one. Adding extracts (vegetables and fruits peel) for beef and chicken kufita enhanced the oxidation stability of lipid, specifically pomegranate, potatoes and red onion peel extracts, respectively.

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دراسات علي استخلاص مضادات الأكسدة من المخلفات الزراعية واستخدامها في بعض منتجات اللحوم

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واحدة من المشاكل الرئيسية والمهمة في الأغذية الحيوانية animal foods قابليتها العالية للتزنخ الأكسيدي ، منتج الكفتة المصنعة من لحوم البيف ولحوم الدواجن قدر فيها التزنخ الأكسيدي بواسطة حمض الثيوباربيتوريك (T.B.A) ورقم البيروكسيد (P.V) و Fatty acid composition بالإضافة إلي التقييم الحسى Sensory evaluation وبعض خواص الجودة الفيزيوكيميائية . كل عينات الكفتة المصنعة من لحوم البيف ولحوم الدواجن والمعاملة بمضادات الأكسدة الطبيعية المستخلصة من قشور المخلفات الزراعية (قشور البطاطس – قشور البصل

الأحمر وقشور الثوم وقشور الرومان) قيمت مباشرة بعد التصنيع (Zero time) وأثناء التخزين لمدة أربعة شهور علي - ١٨ °م .

وقد دلت النتائج علي زيادة التزنخ الأكسيدي إلي حد الفساد في عينات الكفتة الغير معاملة بمضادات الأكسدة الطبيعية والصناعية (BHT) العينة (control) بينما لوحظ انخفاض في العينات المعاملة بمضادات الأكسدة المستخلصة من المصادر الطبيعية عن مضادات الأكسدة الصناعية BHT بالمقارنة بالكنترول أيضا أوضحت النتائج أن الكفتة المصنعة من لحوم الدواجن أصبحت غير آمنة بعد ٦٠ يوم من التخزين علي - ١٨ °م وكانت الكفتة المصنعة من لحوم الدواجن سواء المعاملة بمضادات الأكسدة الطبيعية أو الصناعية أو الغير معاملة أكثر قابلية للفساد والتزنخ من الكفتة المصنع من لحوم البيف .

عموما استخدام المركبات الفينولية المستخلصة من مصادر طبيعية (أنسجة نباتية أو قشور المخلفات الزراعية) ربما يكون مفضل وله فوائد صحية مهمة ويجب أن يقنن استخدام مضادات الأكسدة الصناعية أو يتم استبدالها بمضادات الأكسدة المستخلصة من مصادر طبيعية في الصناعة حيث يكون سميتها قليل بالمقارنة بالصناعية .

Table (1): Beef kufitas formulations.

Control	Treatments				
	A	B	C	D	E
Ground beef + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3%	Ground beef + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + butylated hydroxytoluene (BHT, 0.03%).	Ground beef + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + red onion peel extract, 0.03%	Ground beef + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + red garlic peel extract, 0.03%	Ground beef + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + potatoes peel extract, 0.03%	Ground beef + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + pomegranate peel extract, 0.03%

Table (2): Fresh chicken meat kufitas formulations.

Control	Treatments				
	A	B	C	D	E
Fresh chicken meat + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3%	Fresh chicken meat + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + butylated hydroxytoluene (BHT, 0.03%).	Fresh chicken meat + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + red onion peel extract, 0.03%	Fresh chicken meat + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + red garlic peel extract, 0.03%	Fresh chicken meat + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + potatoes peel extract, 0.03%	Fresh chicken meat + spices mix. (cumin, 0.50% + white pepper, 0.50%) + sodium pyrophosphate, 0.5% + NaCl, 2% + animal fat from tail sheep 12% + corn oil, 3% + pomegranate peel extract, 0.03%

Table (3): Chemical composition and total volatile nitrogen (T.V.N, mg/100 g) of beef and chicken kufita as affected by adding antioxidants and the end of storage at –18°C for 4 months.

Factors / Treatments		% Moisture	% Fat w.w.	% Protein w.w.	T.V.N. mg/100g (w.w)	% Moisture	% Fat w.w.	% Protein w.w.	T.V.N. mg/100g (w.w)
		Beef meat (kufita)							
		Zero time				After 4 months			
1	Control	58.90±0.34^{de}	16.82±0.57^{bac}	22.26±0.34^{ab}	8.40±0.81^{f}	59.64±0.37^{b}	10.46±0.13^{h}	19.06±0.44^{e}	20.11±1.64^{a}
2	A	58.79±0.09^{de}	16.57±0.17^{bc}	22.28±0.27^{ab}	8.40±0.81^{f}	59.29±0.30^{cb}	13.95±0.43^{g}	19.87±0.24^{d}	16.10±0.40^{c}
3	B	58.75±0.08^{de}	16.45±0.32^{b}	22.57±0.60^{a}	7.93±0.93^{f}	60.15±0.27^{a}	14.28±0.24^{fg}	20.58±0.12^{c}	17.73±1.68^{b}
4	C	58.84±0.03^{de}	16.90±0.33^{ac}	22.00±0.48^{b}	7.93±0.87^{f}	58.62±0.42^{d}	14.37±0.12^{f}	20.40±0.35^{c}	13.30±0.40^{e}
5	D	58.84±0.26^{de}	17.06±0.33^{a}	22.46±0.09^{a}	6.47±0.53^{g}	59.07±0.42^{ce}	14.84±0.02^{e}	20.46±0.18^{c}	14.90±0.80^{d}
6	E	58.69±0.46+	16.92±0.41^{ac}	22.60±0.15^{a}	7.40±0.50^{fg}	58.79±0.43^{de}	15.57±0.29^{d}	20.76±0.11^{c}	14.47±1.23^{d}
L.S.D.		0.39	0.38	0.40	1.17				
		Chicken meat (kufita)							
		Zero time				After 4 months			
7	Control	60.23±0.35^{b}	17.37±0.06^{c}	20.46±0.34^{cb}	6.07±0.47^{f}	62.16±0.49^{a}	9.61±0.75^{f}	16.07±1.30^{g}	28.93±1.68^{a}
8	F	59.85±0.03^{cf}	18.17±0.34^{a}	20.26±0.36^{cb}	7.50±0.50^{e}	60.39±0.31^{b}	13.46±0.49^{e}	17.47±0.44^{f}	23.33±1.68^{b}
9	G	59.85±0.03^{cf}	17.97±0.50^{a}	20.84±0.46^{ba}	7.40±0.50^{e}	59.84±0.06^{c}	13.51±0.11^{e}	17.89±0.38^{edf}	21.00±0.81^{c}
10	H	59.52±0.34^{de}	17.84±0.08^{ba}	21.15±0.31^{a}	6.06±1.23^{f}	59.91±0.17^{c}	13.26±0.19^{e}	17.79±0.39^{ef}	19.83±0.62^{c}
11	I	59.55±0.38^{df}	17.45±0.10^{cb}	20.03±0.19^{c}	5.60±0.00^{f}	59.98±0.11^{c}	14.17±0.39^{d}	18.41±0.36^{d}	16.80±0.00^{d}
12	J	59.24±0.06^{e}	17.84±0.31^{ba}	20.49±0.41^{cb}	5.77±1.13^{f}	59.32±0.16^{de}	14.07±0.18^{d}	18.18±0.22^{de}	17.70±1.18^{d}
L.S.D.		0.31	0.43	0.62	1.20				

Control = Beef kufita without antioxidants.
A = Beef kufita treated with BHT (0.03%)
B = Beef kufita treated with red onion peel extract
C = Beef kufita treated with garlic peel extract
D = Beef kufita treated with potatoes extract
E = Beef kufita treated with pomegranate peel extract

Control = Chicken kufita without antioxidants.
F = Chicken kufita treated with BHT (0.03%)
G = Chicken kufita treated with red onion peel extract
H = Chicken kufita treated with garlic peel extract
I = Chicken kufita treated with potatoes extract
J = Chicken kufita treated with pomegranate peel extract

Table (6): Effect of antioxidants (natural and synthetic antioxidants) on sensory properties of beef and chicken kufita stored at –18°C for 120 days.

Characteristics / Treatments		Color	Taste	Texture	Odor	Overall acceptability	Color	Taste	Texture	Odor	Overall acceptability
		Beef meat (kufita)									
		Zero time					After 4 months				
1	Control	7.70±0.37^{dce}	8.40±0.33^{a}	8.00±0.45$^{bc d}$	8.90±0.29^{ab}	7.90±0.48^{ba}	5.40±0.37^{g}	4.50±0.27^{e}	6.20±0.12^{f}	6.10±0.19^{f}	5.70±0.49^{e}
2	A	8.60±0.19^{a}	8.20±0.37^{a}	7.90±1.56^{bd}	9.00±0.32^{a}	8.20±0.37^{a}	6.60±0.33^{f}	6.80±0.20^{cd}	6.60±0.19^{fe}	6.40±0.33^{fe}	6.90±0.19^{cd}
3	B	8.60±0.43^{a}	8.40±0.64^{a}	8.30±0.26^{ac}	8.40±0.24^{bc}	8.40±0.34^{a}	7.60±0.24^{d}	7.10±0.19^{bc}	7.80±0.34^{d}	7.00±0.16^{d}	7.40±0.29^{bc}
4	C	7.40±0.19^{e}	7.90±0.33^{a}	8.40±0.20^{ab}	8.20±0.41^{c}	8.20±0.37^{a}	6.70±0.20^{f}	6.36±0.24^{d}	6.80±0.26^{e}	6.40±0.33^{fe}	6.50±0.20^{d}
5	D	8.40±0.24^{ba}	8.20±0.37^{a}	8.30±0.23^{ab}	8.00±0.57^{c}	8.20±0.24^{a}	6.90±0.24^{f}	7.00±0.32^{c}	6.90±0.19^{e}	7.00±0.22^{d}	7.00±0.24^{cd}
6	E	8.10±0.27^{cb}	8.16±0.43^{a}	8.60±0.40^{a}	8.50±0.32^{bac}	8.20±0.33^{a}	7.90±0.19^{cd}	7.60±0.24^{b}	6.80±0.22^{e}	6.80±0.30^{de}	7.30±0.37^{c}
L.S.D.		0.44	0.55	0.50	0.51	0.54					
		Chicken meat (kufita)									
		Zero time					After 4 months				
7	Control	7.00±0.16^{b}	7.70±0.20^{b}	7.50±0.45^{b}	7.80±0.41^{ba}	7.90±0.58^{a}	4.50±0.24^{e}	3.90±0.62^{e}	3.50±0.32^{f}	3.20±0.37^{e}	3.20±0.37^{d}
8	F	8.30±0.34^{a}	8.30±0.26$^{b a}$	7.80±0.54^{ab}	7.80±0.41^{ba}	8.00±0.22^{a}	6.40±0.33^{c}	6.60±0.33^{c}	6.10±0.19^{d}	6.40±0.19^{de}	6.60±0.29^{d}
9	G	7.80±0.40^{a}	8.20±0.37$^{a b}$	8.00±0.47^{ab}	8.30±0.54^{a}	8.10±0.43^{a}	6.30±0.34^{c}	6.50±0.22^{c}	6.10±0.24^{d}	5.90±0.26^{d}	6.20±0.54^{bc}
10	H	7.90±0.33^{a}	7.90±0.43^{b}	8.00±0.47^{ab}	7.90±0.46^{ba}	7.90±0.26^{a}	5.70±0.26^{d}	5.70±0.34^{d}	5.50±0.44^{e}	5.88±0.42^{d}	5.70±0.20^{c}
11	I	7.90±0.43^{a}	7.80±0.20^{b}	8.20±0.26^{a}	7.50±0.22^{b}	7.90±0.29^{a}	6.50±0.16^{b}	6.30±0.30^{c}	6.80±0.30^{c}	6.60±0.19^{c}	6.36±0.09^{b}
12	J	7.80±0.46^{a}	8.70±0.34^{a}	8.10±0.29^{a}	7.70±0.37^{b}	8.00±0.32^{a}	5.50±0.32^{d}	6.10±0.19^{cd}	6.30±0.20^{cd}	6.30±0.20^{de}	6.50±0.47^{b}
L.S.D.		0.52	0.53	0.58	0.56	0.58					

Control = Beef kufita without antioxidants.
A = Beef kufita treated with BHT (0.03%)
B = Beef kufita treated with red onion peel extract
C = Beef kufita treated with garlic peel extract
D = Beef kufita treated with potatoes extract
E = Beef kufita treated with pomegranate peel extract

Control = Chicken kufita without antioxidants,
F = Chicken kufita treated with BHT (0.03%)
G = Chicken kufita treated with red onion peel extract
H = Chicken kufita treated with garlic peel extract
I = Chicken kufita treated with potatoes extract
J = Chicken kufita treated with pomegranate peel extract

Table (9): Fatty acids composition and fractions (% of total fatty acids) of beef kufita as affected by adding vegetables and fruits peel extracts (natural antioxidants) and BHT (synthetic antioxidats) and frozen storage at –18°C for 120 days.

Treatments / F.A.C.F.	Control	A	B	C	D	E	Control	A	B	C	D	E
	Beef meat (kufita)											
	Zero time						After 120 days					
$C_{12:0}$	0.45	0.82	1.46	0.82	-	-	5.61	4.31	-	3.29	-	1.32
$C_{14:0}$	4.21	3.61	2.63	1.41	2.10	0.79	10.21	9.31	6.54	9.31	8.98	5.41
$C_{15:0}$	-	-	1.41	0.81	1.61	2.11	-	-	0.20	1.43	1.21	1.15
$C_{16:0}$	18.98	15.62	17.46	20.82	16.41	16.74	30.21	20.31	18.85	19.36	20.32	15.61
$C_{16:1}$	16.31	16.92	15.48	10.36	17.41	10.20	10.31	18.61	17.34	13.21	12.39	14.87
$C_{17:0}$	-	1.41	1.66	1.27	2.44	1.94	-	3.10	-	-	-	1.50
$C_{18:0}$	5.61	8.63	8.44	8.45	10.50	7.37	15.31	4.61	6.84	10.26	9.86	13.41
$C_{18:1}$	23.41	18.32	25.41	28.73	21.41	29.00	5.84	12.31	15.69	12.86	18.89	14.61
$C_{18:2}$	14.31	13.62	12.67	15.78	16.42	18.42	5.33	9.31	12.67	9.64	10.38	10.31
$C_{18:3}$	6.42	8.11	7.59	4.42	4.51	2.41	-	3.20	5.33	3.91	3.98	8.69
$C_{20:0}$	1.62	2.62	1.41	2.41	1.23	2.53	5.61	7.21	8.30	-	2.99	3.41
$C_{22:0}$	7.54	4.31	3.34	2.56	1.54	2.53	2.19	2.11	2.60	9.31	3.69	3.40
$C_{22:1}$	-	4.21	0.87	1.79	2.21	3.09	9.38	5.61	0.34	7.40	6.10	6.31
$C_{24:0}$	1.14	1.80	0.17	0.37	2.21	2.87	-	-	5.30	-	1.21	-
T. sat.	39.55	38.82	37.98	38.92	38.04	36.88	69.14	50.96	48.63	52.96	48.26	45.21
T. unsat.	60.45	61.18	62.02	61.08	61.96	63.12	30.86	49.04	51.37	47.04	51.74	54.79
T. mono.	39.72	39.45	41.76	40.88	41.03	42.29	25.53	36.53	33.37	33.49	37.38	35.79
T. di.	14.31	13.62	12.67	15.78	16.42	18.42	5.33	9.31	12.67	9.64	10.38	10.31
T. tri	6.42	8.11	7.59	4.42	4.51	2.41	-	3.20	5.33	3.91	3.98	8.69
T. poly.	20.73	21.73	20.26	20.20	20.93	20.83	5.33	12.51	18.00	13.55	14.36	19.00
KS	1.53	1.58	1.63	1.57	1.63	1.71	0.44	0.96	1.06	0.89	1.07	1.21

T. sat = Total saturated fatty acids. **T. unsat. = Total unsaturated fatty acids.**
T. di. = Total di-unsaturated fatty acids **T. mono. = Total mono-unsaturated fatty acids**
T. tri. = Total tri-unsaturated fatty acids **T. poly. = Total poly unsaturated fatty acids**
KS = T. unsat/T. sat. **F.A.C.F. = Fatty acid composition and fractions**

Table (10): Fatty acids composition and fractions (% of total fatty acids) of chicken kufita as affected by adding vegetables and fruits peel extracts (natural antioxidants) and BHT (synthetic antioxidats) and frozen storage at –18°C for 120 days.

Treatments / F.A.C.F.	Control	F	G	H	I	J	Control	F	G	H	I	J
	Chicken meat (kufita)											
	Zero time						After 120 days					
$C_{12:0}$	-	-	-	1.44	-	-	5.40	-	-	-	-	-
$C_{14:0}$	3.21	3.44	4.68	2.00	2.90	4.32	15.20	13.61	14.21	14.66	10.21	13.21
$C_{15:0}$	-	-	1.63	10.31	-	-	1.62	1.60	2.11	-	-	1.61
$C_{16:0}$	21.31	16.31	18.63	13.22	20.45	19.63	30.32	18.77	20.45	20.98	23.31	17.31
$C_{16:1}$	9.66	15.22	12.81	9.22	13.23	10.21	5.83	15.41	18.21	8.11	9.61	20.21
$C_{17:0}$	1.21	1.67	-	-	-	0.44	1.21	-	2.17	-	-	1.35
$C_{18:0}$	8.12	9.96	6.31	6.41	7.95	4.41	20.25	19.32	10.62	13.99	15.31	12.32
$C_{18:1}$	30.28	26.61	28.67	28.61	30.30	30.40	5.45	8.32	15.33	15.33	10.21	5.31
$C_{18:2}$	19.42	13.63	14.85	10.81	18.63	21.35	3.31	8.32	7.35	10.22	10.21	10.34
$C_{18:3}$	4.14	7.21	5.72	9.74	4.34	2.50	2.61	5.21	3.31	4.65	6.32	6.21
$C_{20:0}$	-	-	0.83	-	0.53	-	4.80	5.32	5.21	9.61	-	4.21
$C_{22:0}$	0.93	1.61	0.72	-	1.67	1.67	2.81	2.12	-	-	6.71	1.61
$C_{22:1}$	1.72	3.62	3.84	7.74	-	2.00	1.19	-	1.03	2.45	8.11	5.97
$C_{24:0}$	-	0.72	1.31	0.50	-	3.07	-	2.00	-	-	-	-
T. sat.	34.78	33.71	34.11	33.88	33.50	33.54	81.61	62.74	54.77	59.24	55.54	51.96
T. unsat.	65.22	66.29	65.89	66.12	66.50	66.46	18.39	37.26	45.23	40.76	44.46	48.04
T. mono.	41.66	45.45	45.32	45.57	43.53	42.61	12.47	23.73	34.57	25.89	27.93	31.49
T. di.	19.42	13.63	14.85	10.81	18.63	21.35	3.31	8.32	7.35	10.22	10.21	10.34
T. tri	4.14	7.21	5.72	9.74	4.34	2.50	2.61	5.21	3.31	4.65	6.32	6.21
T. poly.	23.56	20.84	20.57	20.55	22.97	23.85	5.92	13.53	10.66	14.87	16.53	16.55
KS	1.87	1.97	1.93	1.95	1.99	1.98	0.23	0.59	0.82	0.69	0.80	0.92

T. sat = Total saturated fatty acids. **T. unsat. = Total unsaturated fatty acids.**
T. di. = Total di-unsaturated fatty acids **T. mono. = Total mono-unsaturated fatty acids**
T. tri. = Total tri-unsaturated fatty acids **T. poly. = Total poly unsaturated fatty acids**
KS = T. unsat/T. sat. **F.A.C.F. = Fatty acid composition and fractions**