

Full Length Research Paper

Utilization of ostrich oil in foods

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Ostrich (*Struthio camelus*) was used as a new source of animal fats. Some physical and chemical properties for the ostrich oil were compared with other fats (beef, baffle, cattle, sheep and chicken), fatty acid composition and unsaponifiable matter were determined. Ostrich oil was fractionated to liquid and solid fractions and some characteristics of two fractions determined. Blending sunflower oil with olein fraction showed oxidative stability, which was evaluated by the Rancimat method at 100 °C was obtained from ostrich oil by dry fractionation. The results indicated that blending sunflower oil with olein fraction is an effective method to prepare more stable vegetable oils. Ostrich olein was mixed separately with sunflower oil at (8:2, 7:3 and 5:5, v/v). The frying process was conducted at 180 °C ± 5 °C for 20 hr, 5hr per day. Some physicochemical properties of non-fried and fried oil mixtures were measured at various heating periods. The results demonstrate that mixing ostrich olein with sunflower oil increased the stability and hence improved the quality of sunflower oil during frying process. Ostrich stearin was used to replace fat in cake manufacture at ratios (0.00, 25.00, 50.00 and 75.00%). Sensory evaluations of cakes were determined. Data revealed that replacements of fat with ostrich stearin improved sensory characteristics of baked cake.

Key words: Ratite family, ostrich oil, fractionation, blending, frying process, bakery products.

INTRODUCTION

The Ratite family includes flightless birds with a flat, keelless breastbone (the keel is where the flight muscles connect). Most of their muscle is in their legs and thighs. In the wild, ratites eat seeds, herbaceous plants, insects, and small rodents. Currently there are three major species of birds from the ratite family being raised in the US, namely ostrich, emu and rhea. These birds are reared primarily for their red meat, oil and the hide makes fine leather products (Gegener, 2001 and Hernandez, 2003). Currently the main market for ratite oils is in cosmetics. Examples of some commercial products from ratite oils includes moisturizing creams, body lotion, soap and lipbalm (Grompone, *et al.*, 2005). The ostrich, (*Struthio camelus*) the world's largest bird and one of the oldest (having existed as a species over 40 million years), is adapted to living in open, arid country (Chris and Slates, 1999).

Ostrich meat has an excellent taste and high nutritive value, as well as low calorie content at very low

cholesterol content. For this reason it is exceptionally valuable from the point of view of dietetics (Frontczak *et al.*, 2008) and may be used to obtain various meat products (Batura and Lenzion 2004). Ostrich skin is a raw material in the production of luxury leather goods, while feathers are in demand by theatres, variety shows and cafes. Eggs are valuable reproduction material, but they are also used in bakery industry and for everyday consumption (Horbanczuk *et al.*, 1998).

Ostrich oil is almost 100% triglyceride lipids. Triglycerides are abundant in human skin lipids, meaning that the composition of fatty acids in human skin is very similar to that of ostrich oil. This makes the absorption of ostrich oil into human skin faster and more effective. It is high in oleic acid, which increases its ability to carry compounds through the skin. It does not contain phospholipids, which make absorption more difficult. This absence of phospholipids makes ostrich oil highly penetrating and allows it to absorb through the skin more easily (Margaret, 2003).

Characteristics of ostrich oil: antibacterial, a low irritant, anti-inflammatory, enhances growth of skin, stimulates hair follicles to proliferate and grow and can be taken

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orally, ingested and injected (Brown *et al.*, 1995; Krawczyk, 1997; Craig-Schmidt, 1999 and Sales and Franken 1996).

Ostrich oil is a completely safe, 100% natural moisturizer and pain reliever. It is used in skin care and beauty products for the body, skin, nails and hair; in pet products to reduce itchy skin from flea bites and to make a dull coat shine. Most importantly, ostrich oil can be used alone or combined with other ingredients to relieve pain. Ostrich oil contains no steroids or hormones, and is known for its normalizing abilities it can slow down an over performing body function or speed up one that is not performing well enough (Grompone *et al.*, 2005, Knowlton and Pearee, 1993).

The ostrich oil contains 28 % saturated fatty acids, mostly as palmitic acid (20 %) and stearic acid (8 %). The polyunsaturated fatty acids are roughly 20 % linoleic acid and 2 % linolenic acid and the oil is high oleic acid (Krawczyk, 1997 and Bauny, 2007).

Deep-fat frying is an ancient process that has grown exponentially over the last 50 years (Stier, 2004). This process of cooking consists in immersing food in edible oil that is heated to a temperature above the boiling point of water (Kochhar and Gertz 2004). Edible fresh oils are, 96-99 %, mixtures of triglycerides that undergo irreversible degradation during deep-fat frying, mainly due to heat, water, oxygen and light exposure. During the heating or the cooling of oil, at temperature below 100°C, the atmospheric oxygen reacts with the triacylglycerols, producing hydroperoxides (Achir *et al.*, 2006). In the frying stage, at high temperature, the oxidation of unsaturated fats is not accelerated as oxygen is limiting, but a free radical mechanism enhances hydroperoxide decomposition into volatile and non-volatile secondary oxidation compounds as aldehydes, ketones, oxidative dimers and polymers (Farag *et al.*, 2008). Furthermore, during frying, water vapor escape from the food and increases the moisture gives rise to hydrolytic reactions producing free fatty acids, mono and diacylglycerols and glycerol (Warner, 2001). Finally the excess of energy provided to the oil forms chemical cross-links causing polymer formation in the oil (Paul & Mittal, 1997). All these compounds may impair the nutritional value of the food, having adverse nutritional effects and potential hazards to human health (Mathaus, 2006). On the other hand, investigations of commercial frying have generally indicated that these oils have no deleterious effects upon human health (Tyagi and Vasihtha 1996). Apart from this, the nutritional value of frying fats is affected by loss of polyunsaturated fatty acids, which supplements the essential fatty acids requirement in human metabolism (Katsuta *et al.*, 2008).

The aim of this work was to extract oil from ostrich, study physico-chemical properties, fatty acid composition and unsaponifiable matter of ostrich oil compared with other fats. Separate into two distinct phases, a liquid phase and a solid phase and study characteristics of two

phases. Also, assess the ostrich olein mixed with sunflower oil (8:2, 7:3, and 5:5 v/v) for deep-fat frying and to extend the shelf- life of oils and use of ostrich stearin for prepared cake (fat replacer) .

MATERIALS AND METHODS

Materials

Ostrich fat (*Struthio camelus*) was obtained from Faculty of Agriculture Al-Azhar University, beef, baflo, cattle, sheep and chicken fats were obtained from local market margarine and sunflower oil was obtained from Savola Sim Misr 10 th Ramadan, Egypt. – Wheat flour, fresh whole egg, powdered sugar, defatted milk and single baking powder were obtained from local market of Al-Hasa, Saudi Arabia.

All solvents used throughout the whole work were analytical grade and distilled before use.

Methods

Rendering of fats

Ostrich, beef, baflo, cattle, sheep and chicken were extracted from fat tissues by dry rendering method reported by (Bailey's, 1996). The rendering process was conducted at 90°C for 3 hrs. After cooling at 50°C, the fats were filtered through Whatman No.1 filter paper and kept in brown bottles at 5°C until analysis.

Fractionation of ostrich oils

Fat was fractionally for obtaining two fractions of the fat (Bailey's, 1996). Liquid fraction (olein) and solid fraction (stearin).

Blending of olein fraction and sunflower oil

The oil blending were prepared as follows:

100 % ostrich.

100 % sunflower oil.

100 % liquid fraction.

75 % liquid fraction + 25 % sunflower oil.

50 % liquid fraction + 50 % sunflower oil.

25 % liquid fraction + 75 % sunflower oil.

Physico-chemical properties of fats and blends

Refractive index, melting point, viscosity, smoke point, color, acid value, peroxide value, iodine value, thiobarbituric acid, polar content, insoluble polymer

content, saponification number and unsaponifiable matter content were determined according to (A. O. A. C. 2005), fatty acid composition of the samples was determined by analyzing. The fatty acid methyl esters by gas liquid chromatography according to (Farag *et al.*, 1984), unsaponifiable matter composition of the samples was determined by gas liquid chromatography according to the method described by Mordert, (1968) and oxidative stability by Rancimat method at $100^{\circ}\text{C} \pm 2^{\circ}\text{C}$ were determined according to the method of Evangelisti *et al.*, (1997).

Preparation of oil blends for frying process

System 1: Ostrich olein, system 2: sunflower seed oil, system 3: ostrich olein and sunflower seed oil (80:20 v/v), system 4: ostrich olein and sunflower seed oil (70:30 v/v), ostrich olein and sunflower seed oil (50:50 v/v).

Frying process

Ostrich olein, sunflower oil and their blends were used for frying potato chips as follows: A known amount (ca. 2kg) of each system was placed separately in a stainless steel pan fryer (25cm diameter X 20cm height). The aforementioned oils and their mixtures were separately heated at $180^{\circ}\text{C} \pm 5^{\circ}\text{C}$, then a lot of potato chips (2mm thickness) previously soaked in sodium chloride solution (10 %, w/v) were fried. After frying of potato chips and at end of each day, sample oils were withdrawn and stored in brown bottles at 20°C until analysis.

Cake preparation

Cakes were prepared according to the formula of Khalil (1998) using the following recipe: 28gm wheat flour, 24gm margarine, 24 gm sugar, 13.55 gm whole egg, 0.45gm baking powder and 10 ml defatted milk. To prepare the control cake, the sugar and margarine were creamed for 3 min at speed in an Oster kitchen mixture (Model 972-26 H, Sunbeam Corporation, and Milwaukee Wisconsin, USA). The whole eggs were added and mixed in at the same speed for 2 min. The flour, baking powder and defatted milk were added and batter was mixed for 4 min at speed. After scraping down the bowl the batter was mixed for an additional 1 min at speed. To prepare the replacer cakes, the margarine (fat weight basis in the formula was replaced with ostrich stearin (0.00, 25.00, 50.00 and 75.00 %). The same order of mixing as described for the control was followed. Cake batter (100g) was weight into a greased and floured aluminum foil cake pan. Cake batters were baked at 180°C for 45 min. After 5 min the cakes were removed from the pans and cooled for 60 min then wrapped in transparent film to

avoid surface drying and stored at room temperature (25°C) for 24 hour.

Sensory evaluation

Twenty panelists who were graduate students and staff members in the Department of Nutrition and Food Science, King Faisal University performed sensory evaluation. Panelists were selected on the basis of their interest and availability. Two training sessions were conducted in which the panelists were trained to evaluate sensory attributes of cakes. Sensory quality attributes were evaluated using a point hedonic rating scale with 1 for dislike extremely to 9 for like extremely for each attribute. Cakes were evaluated for appearance, crust and crumb colors, flavor, texture and overall acceptability. Cakes were evaluated 24 hour after baking. After cooling, cakes were cut into 1.50 cm radial sections, placed in plastic bags, sealed and stored at room temperature (25°C) until subjected to sensory analysis. Randomly coded samples were presented to the panelists in white plates and served one at a time. Samples were served to panelists in a room with partitions between each seat with overhead fluorescent light panelists were instructed to rinse their mouth with tap water before starting and between sample evaluation.

- **Statistical analysis:** The least significant differences (L. S. D) test was applied to compare treatment differences (Snedecor and Cochran, 1981). Lower case letters (a, b, c and d) were used to indicate significant differences.

RESULTS AND DISCUSSION

Physico- chemical properties of ostrich oil compared with beef, buffalo, cattle, sheep and chicken fats

Table (1) shows the physico- chemical properties of ostrich oil compared with other fats (beef, baflo, cattle, sheep and chicken). The results revealed that the contents of moisture and volatile matter in the ostrich oil and other fats ranged from 0.01 to 0.08 %. Whereas, the values of refractive index at 40°C of ostrich oil and other fats (beef, baflo, cattle sheep and chicken) were 1.4562 and (1.4565, 1.4567, 1.4631, 1.4652 and 1.4567), respectively. Also, the data showed that the color of ostrich oil and other fats was under the limitation that reported by the (Egyptian Standard Specification 1993) which mentioned that the red were 2.00 and (2.1, 2.00, 1.90, 2.20 and 2.50) at yellow 35 for edible oils. Melting point of ostrich oil was lower than those other fats. These data are comparable while the fact that the ostrich oil are semi-solid at room temperature compared with other fats (beef, baflo, cattle, sheep and chicken).

Table (1). Physico-chemical properties of ostrich oil, beef, buffalo, cattle sheep and Chicken fats.

Parameter	Ostrich	Beef	Bafflo	Cattle	Sheep	Chicken	LSD at $p \geq 0.05$
Moisture content %	0.01	0.01	0.08	0.02	0.03	0.07	0.001
Refractive index at 40°C	1.4562	1.4565	1.4567	1.4531	1.4652	1.4567	0.001
Melting point (°C)	25.50	45.10	47.00	46.50	48.30	48.20	5.50
Color							
Yellow	35.00	35.00	35.00	35.00	35.00	35.00	-
Red	2.00	2.10	2.00	1.90	2.20	2.50	0.10
Acid value (% as oleic acid)	0.10	0.15	0.20	0.25	0.27	0.30	0.01
Peroxide value meq./kg oil)	0.90	1.00	1.10	1.45	1.70	1.85	0.15
Iodine value (Hanus)	79.00	60.00	55.00	58.00	53.00	56.00	2.00
Saponification number	205.00	198.00	196.00	198.00	195.00	188.00	2.20
Unsaponifiable matter (%)	1.50	1.00	1.10	1.10	1.00	1.15	0.10

LSD demonstrates to least significant difference test $P \geq 0.05$.

Table (2). Fatty acids composition of ostrich oil compared with animal fats.

Fatty acid (%)	Ostrich	Beef	Bafflo	Cattle	Sheep	Chicken	LSD at $P \geq 0.05$
C _{12:0}	0.81	0.10	0.02	1.10	0.90	0.83	0.01
C _{14:0}	1.00	4.50	3.50	2.50	3.90	2.70	1.00
C _{16:0}	28.50	48.50	49.20	47.50	45.30	50.66	1.10
C _{18:0}	6.20	7.20	8.30	8.50	7.60	10.50	0.50
C _{18:1}	46.75	40.00	38.80	40.30	41.50	30.30	2.30
C _{18:2}	13.29	0.10	0.17	0.10	1.00	0.33	3.10
C _{18:3}	4.95	0.00	0.01	0.00	0.24	0.00	0.01
Saturated fatty acid (%)	36.51	59.90	61.02	59.60	57.7	64.69	5.00
Monounsaturated (%)	46.75	40.00	38.80	40.30	41.50	30.30	2.00
Polyunsaturated (%)	18.24	0.10	0.18	0.15	1.02	0.33	1.50

LSD demonstrates to least significant difference test $P \geq 0.05$.

The results indicated that the acid value as (% oleic acid) of ostrich oil was lower (0.10 %) than other fats (0.15, 0.20, 0.25, 0.27 and 0.30), respectively. The peroxide value of ostrich oil compared with other fats were 0.90 and (1.00, 1.10, 1.45, 1.70 and 1.85 meq./ kg oil), respectively. The iodine value of ostrich oil (79.00 gI₂) is higher than that of other fats (60.00, 55.00, 58.00, 53.00, and 56.00), respectively. Saponification number of ostrich oil is higher (205.00) than those of other fats shown in Table (1). The unsaponifiable matter of ostrich oil is higher (1.50 %) than that of other fats. These results are in agreement with that reported by International Ostrich Oil Standards, (1998).

Fatty acid composition of ostrich oil compared with animal fats

Fatty acid composition of ostrich oil compared with animal fats (beef, buffalo, cattle, sheep and chicken) was identified by gas liquid chromatography and the obtained results are tabulated in Table (2). Oleic acid was found to

be the dominant unsaturated fatty acid in ostrich oil, which represented about (46.75 %), respectively. Palmitic acid was found to be the dominant saturated fatty acid in ostrich oil (28.50 %), respectively. Other fats (beef, buffalo, cattle, sheep and chicken) oleic acid content were (40.00, 38.80, 40.30, 41.50 and 30.30 %) while palmitic acid content were (48.50, 49.20, 47.50, 45.30 and 50.66 %), respectively. The results are in agreement with that reported by Bailey's Industrial Oil and Fat Products, 1996).

Unsaponifiable matter components of ostrich oil compared with animal fats

The hydrocarbons and sterols in the unsaponifiable matter of ostrich oil and animal fats (beef, buffalo, cattle, sheep and chicken) were analyzed by using gas liquid chromatography. The obtained data are illustrated in Table (3). Data in Table (3) shows that C₂₈ is the major hydrocarbon in ostrich oil while other animal fat C₃₀ is the major hydrocarbon. As for the sterols, B-sitosterol is

Table (3). Unsaponifiable matter (%) composition of ostrich oil compared with animal fats.

Compounds	Ostrich	Beef	Bafflo	Cattle	Sheep	Chicken	LSD at P ≥ 0.05
Hydrocarbons:	2.05	6.50	4.67	5.00	6.00	1.50	1.00
C _{12:0}							
C _{14:0}	2.14	4.50	2.50	3.20	5.40	4.00	0.10
C _{16:0}	2.13	1.60	2.30	1.80	2.00	30.30	0.15
C _{18:0}	4.20	3.60	6.40	8.00	6.30	9.20	1.00
C _{20:0}	6.50	4.30	8.90	10.20	8.50	6.30	2.00
C _{22:0}	1.93	6.50	12.10	6.50	8.40	10.50	2.00
C _{24:0}	7.30	10.12	2.30	5.50	0.00	2.30	1.15
C _{26:0}	10.20	9.80	10.70	8.40	9.70	4.70	1.00
C _{28:0}	16.65	1.90	0.40	1.20	4.00	5.50	1.00
Squalene	2.20	2.19	1.00	0.00	2.20	3.00	0.10
C _{30:0}	3.60	16.40	16.50	18.50	15.50	16.30	3.50
Sterols: Choleterol	3.50	28.87	30.30	28.30	30.50	30.30	2.00
β- sitosterol	28.50	2.10	1.10	2.20	0.00	0.00	1.00
Stigmasterol	4.50	1.12	0.50	0.40	0.50	1.10	0.10
Camasterol	4.60	0.90	0.33	0.80	1.00	0.09	0.01

LSD demonstrates to least significant difference test P ≥ 0.05.

Table (4). Characteristics of olein and stearin fraction obtained from ostrich oil.

Characteristics	Fraction		LSD at P ≥ 0.05
	Olein	Stearin	
Refractive index at 40°C	1.4586	1.4472	0.01
Melting point (°C)	20.00	54.00	5.00
Iodine value (Hanus)	58.00	49.00	4.00
Fatty acid composition			
	C _{14:0}	0.13	0.17
	C _{16:0}	17.50	55.83
	C _{18:0}	2.30	17.50
	C _{18:1}	57.37	19.50
	C _{18:2}	15.40	6.10
	C _{18:3}	6.30	0.60

LSD demonstrates to least significant difference test P ≥ 0.05.

the major component in ostrich oil compared with animal fats rich with cholesterol. Cholesterol content in the beef fat is 28.87 %, while ostrich oil 3.50 %, respectively.

Fractionation of ostrich oil

Characteristics of olein and stearin fractions obtained from ostrich oil by deo fractional crystallization and the obtained results are tabulated in Table (4). Melting point (°C) of olein fraction was lower than that of stearin fraction. Also, the refractive index of olein fraction was lower than that of stearin fraction. Iodine value of olein fraction was higher than stearin fraction. The high iodine value and the low melting point and refractive index obtained confirm the unsaturated nature of olein fraction.

Fatty acids compositions of olein and stearin fractions are shown in Table (4). Oleic acid is the major fatty acid of the olein fraction, while palmitic acid is the major fatty acid of the stearin fraction.

Oxidative stability of ostrich oil, olein fraction, sunflower oil and their blends

The changes in oxidative stability (Rancimat method at 100 °c ± 2 °c) hrs of ostrich oil, sunflower oil (SO), olein fraction (OF) and blends (SO/OF) are presented in Table (5). Ostrich oil and olein fraction were the most stable samples having an induction period of 40.00 and 31.00 hrs, while sunflower oil was the least stable sample with an induction period of 7.50 hrs.

Table (5). Oxidative stability (hrs) of ostrich oil, olein fraction, sunflower oil and their blends.

Oils	Oxidative stability (hrs)
Sunflower oil (SO)	7.50
Ostrich oil (40.00
Olein fraction (OF)	31.00
Blends (SO / OF)	11.50
75 : 25	
50 :50	16.30
25 : 75	23.30
LSD at $p \geq 0.05$	3.00

LSD demonstrates to least significant difference test $P \geq 0.05$.

Table (6). Changes in some physical properties of ostrich olein, sunflower and their blends during frying.

Frying time (day)	Systems of frying oils				
	1	2	3	4	5
Refractive index (25 °C)					
0	1.4741	1.4575	1.4730	1.4710	1.4658
1	1.4743	1.4576	1.4731	1.4710	1.4658
2	1.4745	1.4578	1.4733	1.4711	1.4659
3	1.4750	1.4579	1.4735	1.4712	1.4660
4	1.4754	1.4781	1.4736	14714	1.4660
LSD	0.0002				
Smoke point (°C)					
0	230.00	240.00	232.00	234.00	236.00
1	228.00	238.00	230.00	232.00	234.00
2	224.00	236.00	227.00	230.00	233.00
3	219.00	230.00	224.00	229.00	230.00
4	215.00	227.00	221.00	225.00	226.00
LSD	1.00				
Color (red) yellow at 35)					
0	1.30	2.40	1.40	1.65	1.80
1	2.70	2.90	1.90	2.10	2.30
2	5.50	4.50	4.80	4.80	3.90
3	9.40	6.70	7.80	7.10	7.00
4	11.90	8.12	10.00	9.50	8.80
LSD	0.30				
Viscosity (min)					
0	5.50	8.00	5.90	6.00	6.50
1	6.70	10.12	7.00	8.00	8.10
2	8.90	13.50	8.60	10.30	10.00
3	9.40	14.20	10.11	12.40	10.90
4	12.50	15.30	11.50	13.50	11.40
LSD	1.50				

LSD demonstrates to least significant difference test $P \geq 0.05$.

Results in Table (5) shows that the oxidative stability of SO based on induction period was significantly increased by blending with OF. The increase in oxidative stability was proportional to the increase of OF percentage in the blends.

This study showed that mixing SO with different proportions of OF obtained from ostrich oil by dry fraction crystallization provides an effective, simple, safe and available method to prepare more stable edible oils can be used in producing french fried potatoes.

Quality assurance for fried ostrich olein, sunflower oil and their blends during frying:

Refractive index

Table (6) shows that the refractive index values for the non-fried ostrich olein, sunflower oil and their mixtures (8.2, 7.3 and 5.5 v/v). The values demonstrate that ostrich olein refractive index value was higher than that of

the refractive index of sunflower oil and mixed samples. There is a strong relationship between the refractive index and iodine value, with higher iodine values would have higher refractive index and this fact is in line with data of the present work. The value of refractive index of fried ostrich olein, sunflower oil and mixtures of them indicate a linear relationship between their refractive indices and frying period. The increase of the refractive index values over frying time for the oil systems was in the order: ostrich olein > ostrich olein + sunflower oil mixture (5:5 v/v) > sunflower oil + ostrich olein (7:3 v/v) > sunflower oil + ostrich olein (8:2 v/v) > sunflower oil. This sequence is in line index values for the conjugated compounds are higher than that of their non-conjugated isomers. It is established that during oil frying some of the non-conjugated double bonds are converted to conjugated ones and this process cause an increase in the refractive index value (Bailey's, 2006).

Smoke point

Table (6) shows the changes in smoke point of fried oils and their blends at various periods compared with those at zero time. The value of smoke point of fried ostrich olein was gradually decrease compared with sunflower oil. It is worth noting that the smoke points of fried ostrich oil mixed with sunflower oil at various levels (8:2, 7:3 and 5:5, v/v) were generally lower than ostrich olein alone.

Color

In most cases two types of colored glasses of lovibond tintometer, i.e., yellow and red, were used to measure the color of the oils. The yellow glasses were fixed at a value of 35 and the variation in oil color was matched with red glasses. Table (6) illustrated that the initial red colors for ostrich olein, sunflower oil were 1.70 and 2.10 respectively. As a general trend, the intensity of the red color in all oil systems was increased as the frying time increased. The darkness of oil color due to frying at $180^{\circ}\text{C} \pm 5^{\circ}\text{C}$ was arranged according to the sunflower > sunflower oil + ostrich olein mixture (8:2, v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. Accordingly blending ostrich olein with sunflower oil produced lighter frying media.

Viscosity

Table (6) shows the changes in viscosity values of fried ostrich olein, sunflower oil and mixture of them. The viscosity values of the non-fried ostrich olein and sunflower oil were 4.70 min. and 4.50 min, respectively. Frying the oil systems at $180^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 5 hr, 5 day heating caused a gradual increase in the viscosity values

throughout the entire experiment. In other words, there were gradual and significant increases in the viscosity values of the oils and frying time.

Acid value

Acid value is one of the indicators used to assess oil quality. Table (7) shows the changes of acid values for of fried under study. The acid value of fried oils showed gradually increase with frying time. Hence, the increase of the acid value was in the order: sunflower oil > sunflower oil + ostrich olein mixture (8:2, v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. These findings demonstrate the improvement in sunflower oil quality during frying at $180^{\circ}\text{C} \pm 5^{\circ}\text{C}$ when mixed with ostrich olein.

Peroxide value

This fat constant indicator the primary oxidation products of the oils (hydroperoxides). Table (7) show the peroxide value of ostrich olein and sunflower oil at the beginning of the experiment and were 0.20 and 0.33 meq. O_2 /kg oil, respectively. The peroxide values of these oils were within the recommended values for human consumption. The changes in the peroxide values of fried ostrich olein, sunflower oil and mixtures are shown in Table (). The values of peroxide value of the fried oils were progressively and significantly increased during frying process. The values of peroxide values for the oils at the end of frying indicate that the increase of peroxide value were in the order: sunflower oil > sunflower oil + ostrich olein mixture (8:2, v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. It's well known that the degree of oil oxidation is obviously dependent upon oil unsaturation and this order is in line with this fact. In other words, mixing ostrich olein with sunflower oil lowered the peroxide value of sunflower oil during frying process and hence increases the stability of sunflower oil during frying.

Thiobarbituric acid value (TBA)

The results of TBA test (Table 7) indicate the incidence of gradual and significant increase on the TBA values for fried sunflower oil alone and mixed with different ratios of ostrich olein (8:2, 7:3, 5:5, v/v). The results show that the production rate of TBA reacting substances was obviously dependent upon the degree of oil unsaturation. Consequently, mixing ostrich olein with sunflower oil resulted in depression of the production of secondary oxidation substances. According, the increase of the TBA value according to oil type was in the order: sunflower oil: sunflower oil > sunflower oil + ostrich olein mixture (8:2,

Table (7). Changes in some chemical properties of ostrich olein, sunflower and their blends during frying.

Frying time (day)	System of frying oils				
	1	2	3	4	5
Acid value (mg KOH/g oil)					
0	0.15	0.02	0.13	0.11	0.08
1	0.29	0.16	0.31	0.21	0.19
2	0.45	0.31	0.47	0.35	0.25
3	0.99	0.79	0.88	0.73	0.67
4	1.90	1.02	1.71	1.50	1.20
LSD	0.04				
Peroxide value (meq. O ₂ /kg oi)					
0	0.61	0.30	0.55	0.50	0.45
1	2.40	1.20	2.10	2.01	1.91
2	8.50	4.60	7.00	7.00	6.50
3	16.80	9.50	14.30	13.90	12.55
4	25.40	16.90	23.50	22.10	18.10
LSD	0.10				
Iodine value I ₂ / 100 g oil)					
0	140.00	57.30	130.00	115.00	99.00
1	138.00	56.00	129.00	114.00	98.00
2	135.00	54.00	124.00	110.00	96.00
3	131.00	50.00	121.00	107.00	94.00
4	127.00	45.00	117.00	1.04.000	91.00
LSD	1.30				
Thiobarbituric acid (absorbance at 535 nm)					
0	0.001	0.001	0.0005	0.0005	0.0005
1	0.01	0.01	0.001	0.001	0.001
2	0.23	0.18	0.01	0.01	0.01
3	0.64	0.58	0.20	0.18	0.15
4	0.98	0.84	0.65	0.50	0.45
LSD	0.05				

LSD demonstrates to least significant difference test $P \geq 0.05$.

v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. These findings demonstrate that mixing ostrich olein with sunflower oil decreased the formation rate of TBA reacting substances. This means that blending ostrich olein with the other oil improved its quality during frying process.

Iodine value

The iodine value indicates the degree of an oil unsaturation. Table (7) shows the changes of iodine values for fried ostrich olein and sunflower oil during frying at $180^\circ\text{C} \pm 5^\circ\text{C}$ over time. The effect of frying time on the oils under study shows a gradual and significant decrease in the iodine values of the oils and these results may be expected because during oxidation process some of the non conjugated double bonds are converted to complete addition of the iodine to the double bonds (Caponio *et al.*, 2003). The admixture of ostrich olein with sunflower oil at different ratios causes lowering the iodine value of sunflower oil during frying.

Polar content

Changes in polar content of ostrich olein, sunflower oil and mixture of them (8:2, 7:3 and 5:5 v/v) are show in

Table (8). At zero time, non detectable polar compounds were found. Frying of ostrich olein, sunflower oil and their mixture at $180^\circ\text{C} \pm 5^\circ\text{C}$ for 5 hr /5 day caused increase in the polar compounds content of all oil systems. The increases of polar compounds contents of the oil systems were in the order: sunflower oil > sunflower oil + ostrich olein mixture (8:2, v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. In addition blending ostrich olein with sunflower oil induced lowering effect on the formation of polar content.

Polymer content

At zero time, non detectable polymer compounds were found for ostrich olein, sunflower oil and its admixtures were nil (Table 8). The changes in polymer contents of the fried oil systems showed an increase with time. The increase of polymer contents of the oil systems were in the order: sunflower oil > sunflower oil + ostrich olein mixture (8:2, v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. These results indicate that blending ostrich olein with sunflower oil at different ratios possessed lower effect on the formation pf polymers during frying process. It is well established that the degree of polymer formation largely depends on the oil unsaturation.

Table (8). Changes in some chemical properties of ostrich olein, sunflower and their blends during frying.

Frying time (day)	System of frying oils				
	1	2	3	4	5
Polar content (%)					
0	0.00	0.00	0.00	0.00	0.00
1	0.72	0.50	0.65	0.60	0.52
2	4.90	3.80	4.10	3.90	3.80
3	11.80	8.40	10.40	9.11	9.00
4	23.50	11.30	19.80	15.11	14.30
LSD	1.70				
Polymer content (%)					
0	0.00	0.00	0.00	0.00	0.00
1	0.30	0.20	0.30	0.27	0.25
2	1.50	1.05	1.41	1.32	1.00
3	2.11	1.60	1.90	1.80	1.70
4	4.15	2.50	3.11	2.90	2.61
LSD	0.30				
Oxidized fatty acids (%)					
0	0.00	0.00	0.00	0.00	0.00
1	0.10	0.05	0.09	0.09	0.006
2	0.30	0.22	0.28	0.25	0.23
3	0.85	0.56	0.81	0.78	0.65
4	1.41	0.95	1.31	1.25	1.00
LSD	0.09				

LSD demonstrates to least significant difference test $P \geq 0.05$.

Table (9). Sensory properties of cakes prepared with different ostrich stearin levels.

Property	Replacer level				LSD at $P \geq 0.05$
	0.00%	25.00%	50.00%	75.00%	
Appearance	8.30b	8.80a	7.70c	6.50d	0.28
Crust color	8.70a	8.80a	7.60b	6.60d	0.24
Crumb color	8.60a	8.80a	7.50b	6.90c	0.25
Flavor	8.50a	8.70a	7.60b	6.70c	0.27
Texture	8.80a	8.90a	7.90b	6.50c	0.29
Overall acceptability	8.70a	8.90a	7.80b	7.60c	0.26

LSD demonstrates to least significant difference test $P \geq 0.05$.

a-d means in the same raw with different letters are significantly different.

Oxidized fatty acids

The results in Table (8) showed the formation of oxidized fatty acids in all oil systems. The changes in oxidized fatty acids of the fried oil systems showed increases with time. Accordingly, the increase of the oxidized fatty acids contents were in the order: sunflower oil > sunflower oil + ostrich olein mixture (8:2, v/v) > sunflower oil + ostrich olein (7:3, v/v) > sunflower oil + ostrich olein (5:5, v/v) > ostrich olein. These results showed that blending ostrich olein with sunflower oil at different ratios led to the decrease of oxidized fatty acids contents during frying at

180 °C ± 5 °C.

Sensory evaluation of cakes

The sensory evaluation of cakes revealed that cake prepared from ostrich stearin (fat replacer) was more acceptable with the best taste, flavor, color and texture compared with control (Table 9). Cakes prepared from ostrich stearin had significantly ($P > 0.05$) improved flavor, texture and general acceptability. While, no significant differences were found in texture and color between cakes (fat replacer) and control.

CONCLUSION

Results of this study recommend using ostrich oil in food to meet part of the gap in oils and fats. This is also the advantage of being low fat and cholesterol that is beneficial for heart disease as it is characterized by high content of unsaturated fatty acids unlike other animal fats. And finally characterized by fat ostrich cheap price were it is remnants of an ostrich as fat represents 25 % of the weight of ostrich.

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