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Original paper

Physicochemical, cooking and sensory properties of Mackerel fish burger fortified with globe artichoke *Cynara scolymus* L.

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Abstract

The present study aims to characterize the globe artichoke parts, receptacle (AR) and bracts (AB), and to evaluate the quality characteristics of fish burger formulated by partial substitution of Mackerel fish meat with different level of both AR and AB. Physicochemical, cooking measurements and sensory characteristics of fish burgers were analyzed. The study results showed that the used artichoke parts had high protein, crude fiber, inulin and ascorbic acid contents. Total phenolics content of AR and AB was 43.1 and 38.2 (mg galic acid equivalent/g), respectively. The addition of artichoke parts to fish burger showed improvement in the cooking properties for instance increase cooking yield and decrease cooking loss and shrinkage, without noteworthy differences in sensory properties. Moreover, it was concluded that artichoke parts could be a great source of health-promoting phenolic compounds with high antioxidant activity. Therefore, our results could promote the consumption of artichoke parts and their using in different industrial food applications.

Keywords

Globe artichoke, receptacle, bracts, fish burger, cooking and sensory properties

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Introduction

The globe artichoke (*Cynara scolymus* L.) is a large thistle and herbaceous perennial plant, that belongs to the family of *Asteraceae* (sunflower family). It is an ancient crop and medicinal plant, the therapeutic potential of artichoke was known to the ancient Egyptians, Greeks and Romans (Lattanzio et al., 2009). As of 2017, the total production/yield quantities of artichokes in the world were 1505328 tons over an area of 122390 ha. Top globe artichoke producers in 2017 were Italy (387803 ton), Spain (223150 ton) and Egypt (185695 ton) (FAO, 2017). In addition, in 2018, Italy, Egypt and Spain recorded the highest volumes of artichoke consumption with 394.000, 319.000 and 196.000 K tons, respectively, which represents about 54% of global consumption. In 2019, the total world production of artichokes was approximately 1.6 million tons (FAOSTAT, 2019).

The artichoke fruit can be consumed in many ways, raw, steamed, fried, boiled, and used as ingredient in many recipes (Pandino et al., 2011). The edible part, lower part (receptacle), of artichoke accounts 10–18% of the total weight head whereas, the core parts (inner bracts and receptacle) represent about 40%. The by-products of artichoke fruit (stems, leaves, outer bracts) account around 80% of the biomass. They can be used to extract nutraceuticals and food additives (Lattanzio et al., 2009; Ciancolini et al., 2013). Fresh artichokes have a low calories and fat content (Fratianni et al., 2007; Pandino et al., 2011), are an excellent source of vitamins and rich in dietary fiber, polyphenolic compounds, hydroxylcinnamates, flavones, antioxidants and minerals (potassium, sodium, phosphorus). These compounds help to improve the body's immunity against many diseases (Lattanzio et al., 2009; Abd-Elhak et al., 2014). Plant polyphenolic compounds are the richest source of antioxidants in our diet (Manach et al., 2004). El-Sohaimy (2014) found that classic globe artichoke contain 72% moisture, 14 % protein, 2% lipids, 73% carbohydrates and 30 mg GAE/g DM total phenolic compounds. Artichoke parts (receptacle and bracts) are good source of inulin. Inulin, a highly water-soluble carbohydrate, is used in human nutrition and food industry due to its healthy and long chain length inulins (López-Molina et al., 2005; Clifford & Brown, 2006; Lattanzio et al., 2009; Costabile et al., 2010).

Burgers are one of the most preferred fast foods, which contain more trans fatty acids, so it can cause obesity, coronary disease and diabetes. Vegetables and fruits are part of a healthy diet, which could help prevent major diseases, if consumed daily in sufficient amounts. They are an excellent and cheap source of minerals. Dietary fiber intake through meat replaced with fruits and vegetables is related to prevent against the risk of major dietary problems and many diseases (Abd-Elhak et al., 2014). Recently, the usage of natural plant parts in improving the shelf-life of foods is a promising technology due to its substances that have nutritional and functional properties (Burt, 2004; Badawy & Ali, 2018). Meat replacement with added non-meat constituents has been applied in meat industries. This replacement is used for several reasons for example, health, quality and economic purposes. Egbert and Payne (2009) and Badawy and Ali, (2018) replaced the animal meat source with plant parts in food industry such as burger To our knowledge, the bracts and receptacle of artichoke were not thoroughly researched. Therefore, the goal of this study was to characterize two different parts of artichoke fruit (bracts and receptacle). Moreover, incorporation of these parts with different quantities in fish burger preparation by replacing of meat to test its effect on their chemical, cooking, nutritional and sensory properties.

Materials and methods

Materials

The globe artichoke fruits, *Cynara scolymus* variety, were obtained from a farm at Kafr El-Dour origin, EL-Behera, Egypt. Mackerel fish and ingredients of burger such as: spices, starch onion, salt, garlic, and refined sunflower oil were bought from Kafr El-Sheikh local market, Egypt. Standards phenols, 1,1 Diphenyl-2-Picrylhydrazyl (DPPH) and 6-hydroxi-2,5,7,8-tetramethylcromane-2-carboxylic acid (Trolox, TE), were acquired from Sigma company, St. Louis, MO, USA.

Methods

Preparation of artichoke powders

Artichoke fruits were washed with water and manually cleaned. Subsequently artichoke receptacle and bracts were manually separated and dried in an electric oven at 50±2 ºC for 48h. Afterwards, these parts were cut into small pieces and powdered in a Moulinex hammer mill. Finally, the powders were stored in polyethylene airtight bags at refrigerated temperatures (4 ºC) until analysis and use in burger formulations.

Preparation of fish burgers

Four Mackerel fish burger formulations were designed according to Yousefi et al., (2018) with minor modifications. The fish meat was replaced with different levels (2.5, 5 and 10 %) of artichoke parts. All ingredients (2% NaCl, 2% oil, 2% spices, onion, ginger, hot spices, garlic, green chili paste) were mixed together in a blender and the prepared paste was added to minced fish and mixed with artichoke parts. After that, samples with a weight of 60 g, thickness of around one cm and diameter of around seven cm were

prepared. The burger samples were stored at -18±2 °C until further analyses.

Thermal treatment

Fresh prepared burgers were fried using sunflower oil in stainless steel pan at 160± 10 °C for about 6 min (3 min for each side).

Determination of chemical composition of AR and AB and burgers

Moisture content was determined as the loss in weight after drying in an electrical air oven at 105 ºC to reach a constant weight. Crude protein content was determined by the Micro-Kjeldahl method using the nitrogen- to protein conversion factor of 6.25. Ether extract was performed in a Soxhlet apparatus for 6 hours using petroleum ether (40-60 ºC) as a solvent. Ash content was determined using the muffle at 550 ºC. The crude fiber was determined in sample free from moisture and fat that remained after digestion with weak acid and base. All the above mentioned determinations were carried out followed the methods described in the AOAC (2011). The total carbohydrates were calculated as follows: Total carbohydrates (%) = 100 - (protein + ash + fat). All analyses were carried out in triplicate determinations.

Preparation of AR and AB extracts

Methanolic extracts were obtained from dried powders as follows:1.5 g of dried powders was mixed with 20 ml of absolute methanol. The mixtures were stirred at 100 rpm for 24 h at room temperature. Then, the mixtures were filtrated and stored at refrigerated temperatures (4 ºC) till analysis (Ziada, 2002)**.**

Determination of total polyphenolics content

The total polyphenolics content of extracts were evaluated as described in Bonoli et al., (2004). one gram of sample was macerated in 50 ml of different solvents (99% methanol, 95% ethanol, 70% aqueous methanol, 70% aqueous ethanol and water) at room temperature for 1, 2, 3, 4, 6, 8 and 24 hrs. Moreover, 60 and 90 ºC for 5 and 10 min were used. The extracts were filtrated. 300 µl of filtrates were added to 300 µl of Folin Ciocalteu's reagent, then 2.4 ml of 7.5% sodium carbonate solution was added and the mixture was incubated in the dark for half hour. Absorbance was then read at 760 nm using a UV spectrophotometer (Varian, Melbourne, VIC, Australia). Gallic acid was used as the standard. The content of total polyphenolics was calculated as mg gallic acid equivalent (GAE)/ g dried powders.

Determination of antioxidant capacity of artichoke parts

Antioxidant capacity of artichoke parts was determined using DPPH assay as illustrated in details in Badawy and Ali, (2018). One mL of 0.15 mM DPPH solution in 95% ethanol was added to one mL extract. The mixture was stored for 30 min in the dark at room temperature. The absorbance was measured at 517 nm using PG Instruments T80 UV/VIS Spectrophotometer. Trolox (TE) was used to make the standard curve and the antioxidant activity was calculated as µM TE/100g dried powders.

Determination of inulin in artichoke parts

The procedure recommended by Prosky and Hoebregs (1999) was used to determine the inulin content in artichoke receptacle and bracts. One gram of dried powder was extracted with 25 ml distilled water at 40 oC. The extract was mixed with 5 ml of 1.0 N lead acetate solution and 5 ml saturated solution of sodium phosphate dibasic then filtered and the supernatant was removed. The residue was washed again with distilled water after that, the combined supernatant and washing water were diluted to 100 ml using distilled water. Two ml of the extract was added to 2 ml of folin reagent and the mixture was heated for 90 minutes in a water bath. After heating, the mixture was titrated with 0.01 N standard potassium-permanganate solution until a faint rose colour appeared. The inulin content was estimated using the following equation:

1.85 ml of 0.01 N potassium permanganate solution = 1 mg inulin

Determination of ascorbic acid in AR and AB

Ascorbic acid content of artichoke receptacle and bracts was evaluated using Folin- Ciocalteu Reagent depending on the method reported by Dashman et al., (1991). Twenty ml of extract was transferred into 100 ml volumetric flask followed by 2 ml of 10% TCA solution and diluted to 100 ml with distilled water. The mixture was swirled gently for 1 minute and left to stand for 1 minute and filtered with Whatman filter (no 542). Briefly 30 mg of ascorbic acid were added to 10 ml distilled water to prepare the standard solution. One ml of the standard solution and extract was mixed with 3 ml of distilled water and 0.4 ml of Folin reagent. After that, the mixture was incubated for 10 min at room temperature. The absorbance of the mixtures was read at 760 nm using a UV spectrophotometer (Varian, Melbourne, VIC, Australia). The results were expressed as g per 100g fresh weight.

Determination of mineral contents:

Mineral contents (Ca, Mg, Na, Fe, P, Zn, and Mn) were determined depending on the methods of AOAC (2011). Five grams of dried sample were dry ashed in muffle furnace maintained at 550°C for 2 hr. The ash was cooled in desiccators and then weighed. After weighing, the ash was dissolved in a solution of 1:1 ratio of H2O: HCl, in which

the concentration of the final mixture was 6N HCl. Calcium, Magnesium, iron and zinc were determined using the atomic absorption sepectrophotometer (Zeiss FMD3). Sodium and potassium were determined by flame photometer. Phosphorus (P) was estimated photometrically of phosphorus molybdate complex by spectrophotometer at a wavelength of 650 nm, using a standard curve according to the methods described in the AOAC (2011).

Energy value of prepared burgers

Energy value of prepared burgers (on wet weight basis) was calculated as reported in AOAC (2011). Where, one gram of protein, lipid and available carbohydrates gives 4.27, 9.02 and 4.10 Kcal, respectively.

Physical properties of prepared burgers

Protein-water-fat coefficient (PWFC), water-protein coefficient (WPC) and protein - water coefficient (PWC) were calculated as reported by Tsuladze (1972) and Feder value as reported by Pearson (1970).

Cooking properties of burgers

The percentage of burger shrinkage, cooking yield, moisture retention and the cooking loss of the prepared burgers were calculated according to equations planned by Berry (1992), Aleson-Carbonell et al., (2005) and Akwetey and Knipe (2012). respectively and found in Badawy and Ali (2018).

Sensory evaluation of prepared fish burgers

Sensory properties of cooked fish burgers fortified with artichoke parts were evaluated through hedonic test, by 25 panelists from the staff members of the Food Industry Department, Faculty of Agriculture, Kafrelsheikh University, as mentioned in Meilgaard et al., (2007). Panelists were asked to give numerical values ranging from 0 to 10 for the sample's characteristics, taste, odor, texture, color, appearance and overall. The panelists were asked to have mouths rinsed with water between each sample.

Statistical Analysis

The results were statistically analyzed using T test analysis of variance (ANOVA) procedure by SPSS (Version 16.0) software.

Results and Discussion

Chemical composition of AR and AB

The chemical composition of studied artichoke parts (AR and AB) was determined, and the results are shown in Table (1). The results reported that receptacle from artichoke contained 84.4, 11.50, 2.6, 4.1, 9.51 and 81.8 % for moisture, crude protein, fat, ash, crude fibers and total carbohydrates (on dry weight basis), respectively. While, the chemical composition of bracts was 74, 5.2, 2.1, 3.9, 10.6 and 88.8 % for moisture, crude protein, fat, ash, crude fibers and total carbohydrates, respectively. Shalaby (2000) found that chemical composition of artichoke bracts was 85.32±0.4 moisture, 69.11±1.2% total carbohydrates, 11.10±1.0% crude protein, 2.85±0.2% ether extract, 26.0±2.1% crude fibers, 16.10±1.2% ash (on dry weight basis). While, Gomaa (2010) and Claus *et al.,* (2015) stated that artichoke receptacle was found to have 12.90 and 24.27% protein, 1.41 and 1.34 % fat and 6.20 and 12.32 % ash and artichoke bracts recorded low protein (11.60 and 10.35%), fat (1.31 and 2.04 %) contents, where ash content was (10.10 and 5.37 %), respectively. These differences may be related to the varieties, origin and conditions of agriculture.

The results presented in Table (1) show that inulin and ascorbic acid were found in two studied parts. Furthermore, Table (1) indicated remarkable differences in inulin and ascorbic acid contents among the different parts, where receptacle showed 32.9 and 0.89%, while bracts showed 21.8 and 0.34 %, respectively. These data are in the line with (Lattanzio et al., 2000; Sharara & Ghoneim, 2011) who reported that inulin content in artichoke is more than 30%. Shalaby (2000) re-

Table 1. Chemical composition (on dry weight basis) of some artichoke parts

Parameters	AR	AB
Moisture %	84.5± 0.10^{a}	74±1.20^{b}
Crude Protein %	11.5±1.10^{a}	5.2±0.17^{b}
Ether extract %	2.6±1.30^{a}	2.1±1.11^{b}
Ash %	4.1±0.23^{a}	3.9±1.00^{a}
Crude fibers %	9.5±0.19^{b}	10.6±0.30^{a}
Total carbohydrates %	81.8±2.7^{b}	88.8±3.21^{a}
Inulin %	32.9±0.22^{a}	21.8±0.31^{b}
Ascorbic acid %	0.89±0.23^{a}	0.34±0.21^{b}
Total phenolics mg GAE/g	43.1±0.12^{a}	38.3± 0.21^{b}
Total flavonoids mg QE/g	8.6±0.14^{a}	7.8±0.17^{b}
Antioxidant activities (μM TE/g sample)	53.5± 1.10^{a}	31.9± 1.14^{b}

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a row are not significantly different $P \leq 0.05$

ported that the inulin content of bracts was 10.89±1.1%. The results of assays of total phenolics and flavonoids content and antioxidant activity assays of receptacle and bracts are also listed in Table (1). The results of total phenolics content are in agreement with El Sohaimy (2014), who found that the total phenolic content (TPC) in methanol extract of globe artichoke was 30.70±1.87 mg GAE/g dry sample). While, they are higher than the results reported by Rejeb et al., (2020), who found that the TPC content for the bracts of two different artichoke varieties was (15.262 and 10.726 mg GAE/ g DW). These differences may be related to the varieties, origin and conditions of agriculture. As shown in Table (1) the total flavonoids and antioxidant activity contents differ also depending on the fruit parts. The highest values were recorded for receptacle compared to bracts. The significant differences between the results were found, where it was clear that receptacle had the highest phenolics and flavonoids content and antioxidant activity compared to bracts part. This trend is similar to the results found by El Sayed et al., (2018). The highest antioxidant activity content of receptacle compared to bracts is related to the total phenolic and flavonoids content.

Minerals content of some artichoke parts

The results in Table (2) indicate that artichoke is a great source of minerals such as potassium, sodium, manganese and calcium. Potassium presented as the highest value of mineral, 1807.5 and 1875.0 (mg/100g DM) by receptacle and bracts, respectively. While, sodium existing as 1285.0 and 365.3 mg/100 g DM by receptacle and bracts, respectively. Moreover, trace elements such as iron and copper were detected in both artichoke parts. These results are similar to the findings of El Sayed et al., (2018) who reported that macro elements of artichoke extract contained high contents of Na, Ca, and Mg and traces from Zn, Fe, Mn, and Cr.

Table 2. Minerals content (mg/100g on dry weight basis) of some artichoke parts

Elements	Amounts			
	AR	% of total	AB	% of total
K	1807.5	45	1875.0	68.5
Na	1285.0	32	365.3	13.4
Mg	713.7	17.7	387.8	14.2
Ca	191.3	4.8	89.4	3.2
P	9.6	0.24	5.6	0.24
Fe	8.0	0.21	10.1	0.38
Cu	1.9	0.05	1.9	0.08
Total	4016	100	2735	100

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a column are not significantly different $P \leq 0.05$

Influence of the artichoke parts level on chemical composition of prepared fish burgers

The moisture, protein, fat, ash, crude fiber and total carbohydrates contents of the raw and cooked controls and fortified fish burgers with different levels (2.5, 5 and 10 %) of some artichoke parts (receptacle and bracts) were listed in Tables (3 and 4). The results exposed that the control of uncooked burger contained 71.7 % moisture, 46.1 % protein, 12.27% fat, 3.74 % ash, 0.5 crude fiber and 37.89 % carbohydrates, while the control of cooked burger contained 68.3 % moisture, 45.6 %protein, 19.29 % fat, 3.71 % ash, 0.4 crude fiber and 31.4 % carbohydrates.

From the presented data, it could be observed that the moisture content of uncooked burgers decreased as the level of receptacle and bracts increased, but the decreasing rate was not significant. Serdaroglu (2006) stated a reduction in moisture content of beef burgers formed with the flour of oat due to an increase in solid contents., In contrary, the moisture content of cooked burgers increased slowly as the level of artichoke parts increased, but the increasing rate was not significant between the levels of artichoke powders. It has been informed that during cooking, fish burgers lose moisture during evaporation and drip (Sheridan & Shilton, 2002), which could be because the adding of receptacle and bracts decreases evaporation and drip causing a significant increase in the content of moisture of fortified cooked burgers. In addition, protein and ether extract contents of raw burgers decreased as the amount of artichoke parts increased, while, ash, crude fiber and carbohydrates increased with the increasing of artichoke parts. These could be related to the lower content of crude fat and protein in Artichoke parts than in fish. On the other hand, in cooked samples, all determined constituents except protein content increased with the increasing of Artichoke parts. Hassaballa et al., (2009), Al-Juhaimi , (2016) and Badawy and Ali (2018) reported that an increase in protein, fat and ash contents in burgers, fortified with moringa and mashed pumpkin and potato and marjoram after cooking processes was observed.

Influence of the artichoke parts level on physicochemical properties of fish burgers

The results showed that, PWC, PWFC and Feder value of fish burgers were gradually decreased by increasing levels of dried Artichoke parts compared to control sample. While WPC increased with increasing levels of dried Artichoke parts. So that, tenderness of burger was increased. This result might be due to the decrease in protein content of all prepared burgers as a result to denaturation and aggregation of protein. These results are in the line with the results of Hegazy (2004) and El - Refai et al., (2014). Moreover, the

Table 3. Chemical composition (on dry weight basis) of raw fish burgers

Formulations	Moisture	Protein	Fat	Ash	Crude fiber	Total Carbohydrates
Control	71.7±0.12^{ns}	46.1^{a}±0.22^{a}	12.27±0.03^{a}	3.74±0.05^{c}	0.5±0.05^{d}	37.89
2.5% AR	71.6±0.06	45.3±0.07^{a}	12.17±0.08^{a}	3.81±0.07^{c}	0.7±0.03^{c}	38.72
5.0% AR	71.5±0.14	44.2±0.09^{b}	12.04±0.12^{a}	4.06±0.02^{b}	0.9±0.18^{c}	39.7
10% AR	71.3±0.70	43.1±0.03^{b}	11.83±0.04^{b}	4.14±0.09^{b}	1.2±0.07^{b}	40.93
2.5% AB	70.2±0.01	44.9±0.11^{a}	12.21±0.02^{b}	4.05±0.10^{b}	1.1±0.04^{b}	38.84
5.0% AB	70.1±0.09	43.6±0.05^{b}	12.10±0.09^{b}	4.41±0.18^{a}	1.7±0.15^{a}	39.89
10% AB	69.8±0.00	42.3^{c}±0.01^{c}	12.00±0.05^{a}	4.75±0.14^{a}	2.1±0.09^{a}	40.95

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a column are not significantly different P ≤ 0.05

Table 4. Chemical composition (on dry weight basis) of cooked fish burgers

Formulations	Moisture	Protein	Fat	Ash	Crude fiber	Total Carbohydrates
Control	68.3±0.08^{ns}	45.6±0.05^{a}	19.29±0.01^{ns}	3.71±0.21^{c}	0.4±0.02^{d}	31.4
2.5% AR	68.5±0.11	44.7±0.19^{a}	19.47±0.08	3.86±0.06^{c}	0.6±0.05^{c}	31.97
5.0% AR	68.7±0.06	43.9±0.08^{b}	19.71±0.18	3.96±0.02^{c}	0.8±0.03^{c}	32.68
10% AR	68.9±0.02	42.8±0.03^{c}	19.88±0.01	4.10±0.09^{b}	1.1±0.01^{b}	33.22
2.5% AB	68.7±0.09	45.0±0.16^{a}	19.38±0.07	4.10±0.00^{b}	1.0±0.22^{b}	31.52
5.0% AB	69.2±0.20	43.7±0.11^{b}	19.63±0.13	4.51±0.11^{a}	1.6±0.03^{a}	32.16
10% AB	69.6±0.07	42.5±0.11^{c}	19.87±0.00	4.86±0.06^{a}	2.0±0.02^{a}	32.77

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a column are not significantly different P ≤ 0.0

Table 5. Physicochemical properties and energy value of fish burger fortified with different levels of artichoke

Formulations	**PWC**	**PWFC**	**WPC**	**Feder value**	**Energy value**
Control	0.18±0.03^{b}	0.17±0.07^{b}	5.49±0.17^{b}	3.02±0.12^{a}	154.07
2.5% AR	0.18±0.02^{b}	0.17±0.05^{b}	5.56±0.15^{b}	2.99±0.14^{a}	155.56
5.0% AR	0.18±0.02^{b}	0.17±0.04^{b}	5.67±0.16^{a}	2.98±0.15^{a}	155.28
10% AR	0.17±0.01^{c}	0.17±0.07^{b}	5.76±0.17^{a}	2.96±0.11^{a}	153.53
2.5% AB	0.19±0.04^{a}	0.18±0.06^{a}	5.51±0.12^{b}	2.81±0.13^{b}	154.02
5.0% AB	0.19±0.03^{a}	0.18±0.02^{a}	5.54±0.13^{b}	2.80±0.14^{b}	154.28
10% AB	0.18±0.05^{b}	0.17±0.03^{b}	5.58±0.11^{b}	2.77±0.15^{b}	147.98

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a column are not significantly different P ≤ 0.05

results showed that the feder numbers of prepared burgers were less than 4. Therefore, they are in good quality (Pearson, 1970).

Influence of the artichoke parts level on cooking properties of fish burgers

The cooking properties of fortified and unfortified fish burgers are presented in Table (6). The data exposed that, the addition of artichoke parts (receptacle and bracts) to fish burgers influenced on the cooking characteristics of prepared burgers. The cooking yield was increased in burgers with an increase in the artichoke amount compared to control. The cooking yield was increased from 95.24 % for control to 96.12, 96.32 and 97.76 % for burgers fortified with 2.5, 5 and 10 % receptacle, and to 94.30, 94.74 and 95.55 % for ones fortified with 2.5, 5 and 10 %, bracts, respectively. These results agree with Al-Juhaimi et al., (2016) and Badawy and Ali (2018), who stated similar trends for the cooking yield in burgers fortified with moringa seed powder and marjoram leaves, respectively. Alakali et al., (2010) also found the same results for the cooking yield of beef fortified with groundnut seed powder. They explained this observation by the ability of these materials to the water and fat retention capacity, in addition to ability to maintain fat and moisture in the patty matrix.

As apparent in Table (6), the addition of receptacle and bracts of artichoke improved the moisture retention of cooked burgers, where they were increased with the increase of artichoke level compared to control. This results can be explained by the increasing of the water absorption capacity of protein and the gelatinization of starch during cooking process in addition to the swelling of the fiber (Modi et al., 2004). This result is important since high water retention positively influences properties of meat or fish products such as juiciness and texture. The results obtained for fat uptake

Table 6. Cooking properties of fish burgers fortified by different levels of Artichoke

Formulations	Cooking yield (%)	Cooking loss (%)	Shrinkage (%)	Moisture retention (%)	Oil uptake %
Control	95.24±1.67^{d}	4.72±0.16^{a}	7.14±0.12^{a}	95.25±1.07^{c}	57.2±0.37^{e}
2.5% AR	96.12±1.38^{c}	3.80±0.21^{b}	5.71±0.15^{b}	95.67±1.21^{c}	59.98±0.39^{d}
5.0% AR	96.78±1.34^{b}	3.52±0.25^{b}	3.57±0.17^{c}	96.08±1.17^{b}	63.70±0.32^{b}
10% AR	97.87±1.42^{a}	2.68±0.18^{c}	2.85±0.13^{d}	96. 63±1.31^{b}	68.47±0.34^{a}
2.5% AB	96.45±1.51^{b}	4.64±0.17^{a}	4.28±0.18^{c}	97.86±1.27^{a}	58.72±0.37^{d}
5.0% AB	96.10±1.33^{c}	4.53±0.15^{a}	2.86±0.14^{d}	98.71±1.31^{a}	62.23±0.41^{c}
10% AB	96.66±1.61^{b}	4.34±0.18^{a}	1.34±0.16^{e}	99.71±1.19^{a}	65.58±0.38^{b}

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a column are not significantly different $P \leq 0.05$

Table 7. Sensory evaluation of cooked fish burgers fortified by different levels of artichoke

Sensory properties					Formulations
Overall Acceptability	**Texture**	**Odor**	**Taste**	**Color**	
8.42±0.67^{a}	8.58±0.51^{a}	8.67±0.49^{a}	8.08±0.90^{b}	8.75±0.8^{a}	Control
8.83±0.39^{a}	8.75±0.45^{a}	8.67±0.50^{a}	8.92±0.29^{a}	8.67±0.9^{a}	2.5% AR
8.43±0.90^{a}	8.25±0.97^{b}	8.25±0.82^{b}	8.17±0.94^{b}	8.17±1.1^{a}	5.0% AR
7.93±0.79^{b}	7.67±1.83^{c}	8.00±1.51^{b}	8.30±1.22^{b}	8.33±0.7^{a}	10% AR
8.50±0.74^{a}	8.17±0.94^{b}	8.00±0.95^{b}	7.92±1.00^{b}	8.81±1.1^{a}	2.5% AB
7.92±0.90^{b}	7.83±0.83^{c}	8.00±0.82^{b}	7.25±1.24^{c}	7.16±0.7^{b}	5.0% AB
7.17±1.40^{c}	7.08±1.38^{d}	7.42±1.51^{c}	7.08±1.78^{c}	6.83±1.3^{b}	10% AB

Where: AR; Artichoke Receptacle and AB; Artichoke Bracts.

Values followed by the same letter in a column are not significantly different $P \leq 0.05$

of cooked fish burgers (Table 6) showed the same result that observed for moisture retention. The raise in fat retention may be related to the fact that the swelling of the fiber and starch in addition to the fat absorbed by the fiber can be interact with the protein of the crushed meat matrix to avoid migration of fat from the product (Alakali et al., 2010). Table (6) also shows that the addition of artichoke parts was decreased the cooking loss compared to control burger sample with values of 4.72 for control burger and 3.80, 3.52 and 2.86 % for burgers fortified with 2.5, 5 and 10 % receptacle, while the values decreased to 4.64, 4.53, 4.34 % for burgers fortified with 2.5, 5 and 10 %, bracts, respectively. This improvement in cooking loss was occurred by the addition of orange peel and marjoram leaves which is able to bind water and fat (Eldemery, 2010; Mahmoud et al., 2017; Badawy & Ali, 2018). Fibers decreased the cooking loss of burgers because of their high ability to retain moisture and fat in the medium (Besbes et al., 2008).The percentage of shrinkage was decreased with the artichoke level increased (Table 6).

Bracts part showed more decrease than receptacle part, where the control burger showed the highest shrinkage percent, 7.14 %, compared to 5.71, 3.57 and 2.85 % for burgers fortified with 2.5, 5 and 10 %receptacle, and to 4.28, 2.86 and 1.34 % for burgers fortified with 2.5, 5 and 10 %, bracts, respectively. The denaturation of protein meat, water evaporation and juices during cooking process is associated to the shrinkage (Alakali et al., 2010; Al-Juhaimi et al., 2016). The lower shrinkage observed in fish burgers fortified with artichoke parts compared to the unfortified burgers might be due to the stabilizing and binding characteristics of portions used, which retain the meat particles together and banned changes in the juice losses, moisture and accordingly the shape of the product as reported by Naveena et al., (2006) and Al-Juhaimi et al., (2016).

Influence of the artichoke parts level on sensory properties of cooked fish burgers

Results presented in Table (7) show the mean sensory scores of cooked fish burger samples prepared with different levels of artichoke parts. The addition of non-meat ingredient to fish usually decreases its quality and the main problem is to keep it at the level as close as possible to the full-meat product. Results indicated that there were no significant differences at $p \leq 0.05$ for color, odor, texture, flavor and overall acceptability between cooked burgers fortified by different levels of artichoke and the control burger. Fish burgers which were not fortified with dried artichoke or were fortified with 2.5 and 5% dried artichoke parts had better organoleptic properties compared to burgers fortified with 10%. Therefore, supplemented burger with Artichoke till 5 % could be recommended to be produced as burger with good quality acceptable sensory quality attributes.

Conclusions

The results of this study showed that powders of artichoke parts (receptacle and bracts) are important sources of minerals (K, Na. Mg and Ca), bioactive compounds (phenolic compounds), inulin and vitamin C. In addition, these powders have antioxidant potential being beneficial in a healthy diet for prevention of diseases caused by free radicals. Dried receptacle and bracts of artichoke can be used for food fortification and as functional food in fish products. Fortification with dried artichoke at levels 2.5, 5 and 10% caused good effects on all physicochemical properties and cooking properties of fish burgers at zero time. Fish burgers which were not fortified with dried artichoke or were fortified with 2.5 and 5% dried artichoke had better organoleptic properties compared to burgers fortified with 10%. Therefore, powders prepared from artichoke parts can be used as functional ingredients and can be used to fortify food products (fish, bakery and pastry products, especially) in order to increase the nutritional and their antioxidant potential, but also as sweetening agent for products for diabetics. The results indicated that used artichoke parts has high potential as a binder for use in burger production in addition to its health and nutritional benefits. Further studies are needed to characterize artichoke parts.

Conflict of Interest

The authors have declared no conflicts of interest for this article.

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