



Full Length Research Paper

# The effect of cooking on the chemical Composition of Artichoke (*Cynara scolymus L.*)

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## Abstract

Artichoke is considered a healthy food due to its nutritional and chemical composition. Artichoke contains proteins, minerals, low amount of lipids, dietary fibers and high proportion of phenolic compounds. The aim of this study is to investigate the effect of cooking on the chemical composition and antioxidant activity of artichoke. The cooking process has a positive effect on the moisture (1.3 fold), total protein content (1.1 fold), total phenolic content (1.7 fold) and antioxidant activity (1.5 fold). On the other hand the cooking process has a negative effect on the ash and minerals (1.04 fold), crude fiber (1.07 fold), total carbohydrate (1.06 fold), total lipids (1.5 fold) and vitamins content. We can conclude that the use of fresh or light cooked artichoke preferred than cooked artichoke to avoid losing of its nutritional value during cooking process.

**Key words:** Artichoke, Cooking process, Chemical composition, phenolic content, Antioxidant activity.

## INTRODUCTION

Artichoke, *Cynara cardunculus L. subsp. scolymus (L.)* Hayek, (formerly *Cynara scolymus L.*) is an ancient herbaceous perennial plant, originating from the Mediterranean area, which today is widely cultivated all over the world. The botanical name is derived in part from the tradition of fertilizing the plant with ashes (Latin: cinis, cineris), and partly from the Greek skolymos, meaning "thistle" from the spines found on the bracts (they are not leaves) that enclose the flower heads forming the edible portion of the plant (Oliaro, 1969). Globe artichoke contributes significantly to the Mediterranean agricultural economy, with an annual production of about 770,000 tones (t) (>60% of total global production) from over 80 kha of cultivated land. Italy is the leading world producer (about 474,000 t), followed by Spain (215,000 t), France (55,000 t) and Greece (25,000 t). Globe artichoke is also cultivated in the Near East (Turkey and Iran), North Africa (Egypt, Morocco, Algeria, Tunisia), South America (Argentina, Chile and Peru), and the United States, and its cultivation is spreading in China (65,000 t in 2007) (FAO, 2007; Bianco, 2005). Artichoke is widely cultivated

for its large immature inflorescences, called capitula or heads, with edible fleshy leaves (bracts) and receptacle, which represent an important component of the Mediterranean diet and is a rich source of bioactive phenolic compounds, and also inulin, fibers and minerals (Orlovskaya *et al.* 2007). In addition, the leaves, also rich in phenolic compounds (Fратиanni *et al.* 2007), are used as herbal medicine and have been recognized since ancient times for their beneficial and therapeutic effects (Adzet *et al.* 1987). Globe artichoke is healthy addition to any eating plan due to containing antioxidants, and phytonutrients, which are thought to protect cells against the attack by free radicals (Metwally *et al.* 2011). Artichoke contains proteins, minerals, low amount of lipids, dietary fibers and high proportion of phenolics (Liorach *et al.* 2002; Frатиanni *et al.* 2007). Artichoke extract is low in fat and calories, so it is an excellent choice for traditional weight loss diets. The two major phytonutrients found in artichokes are Cynarin and Silymarin. These are of particular interest for their ability to lower cholesterol, protect and

support liver function, increase bile production and prevent gallstones (Ceccarelli et al. 2010). Standardized supplements of artichoke extract with stated minimum amounts of active ingredients are available in tablets, capsules, gels and liquids. Studies indicate that artichoke leaf extract can reduce the symptoms of irritable bowel syndrome (IBS) and functional dyspepsia, activity that may be related to improved fat digestion (Bundy et al. 2004). Artichoke is very beneficial to the liver and studies have found they may even regenerate liver tissue. Artichokes have long been used in folk and alternative medicine as a treatment for liver ailments and the scientific studies are now proving them to be correct (Mtwally et al. 2001).

There are many ways to cook an artichoke, such as steaming or braising, so that the entire thing, stem and all, can be consumed. However, even eating just the meat of the leaves and the heart will provide benefits. Boiling is one of several cooking methods used to prepare artichoke for human consumption. Many investigations reported different changes in artichoke chemical composition after boiling process. Lutz et al. (2011) studied the effect of cooking on the chemical composition of artichoke and reported that, ash content; carbohydrate content and dietary fiber were decreased after boiling. On the other hand, lipid and protein contents were increased. Boiling decreased the dietary fiber content (by 3.2% in artichoke samples). The loss may be related with the thermal degradation of polysaccharides, as well as the solubilization of constituents that leak into the water (Svanberg et al. 1997). Boiling may alter the properties of fiber, and changes in total fiber content as well as in extractability have been reported, leading to redistribution between the relative amounts of soluble and insoluble fractions (Puupponen-Pimiä et al. 2003). The major phenolic compounds present in artichoke were increased after cooking. The anti-oxidant capacity of cooked artichoke enormously increased after cooking particularly after steaming up to 15 fold and boiling up to 8 fold. The observed cooking effect on the artichoke antioxidant profile is probably due to matrix softening and increased extractability of compound (Rosalia Ferracane et al. 2008). Furthermore, cooking might increase the digestibility of artichoke proteins with which calcium is bound, thus increasing the release of the minerals from any protein complexes. On the other hand, boiling might lead to an increase in mineral loss into the water. Dugo et al. (2005) reported that boiling processing caused a significant decrease of manganese levels in artichokes. During boiling of Jerusalem artichoke tubers aldehydes and alkanes are formed by thermally induced lipid oxidation. These are only produced in quantifiable amount in the second harvest, which suggests that the content of lipids in the tubers was higher in the second than in the first harvest (Bach, 2012). Boiling was found

to greatly destroy the amount of vitamin C concentration in all cooked vegetables. In artichoke, boiling seriously destroyed vitamin C by percentages ranging from 23.9% to 94% due to its instability at high temperatures and its water-soluble nature that causes it to leech into cooking water, which is generally discarded after cooking (Bach, 2012). Agbemaflé et al. (2012) reported that the effect of boiling on vitamin C as well as several compounds is time dependent since his study revealed that as the boiling time increased the concentration of vitamin C in the vegetables decreased. Therefore, it is suggested that boiling of vegetables should be done within the shortest possible time to retain most of these nutrients. Boiling method was an effective method to reduce 7-56% tannin content in vegetables. Conventional boiling method appeared to be more effective in destroying tannin. Tannic acid and phenolic compounds in vegetables showed heavy loss during prolonged cooking time, whereas in other processes, such as blanching or stir-frying, percent tannin loss is lower; this would explain why tannic acid is not easily destroyed or eliminated in a short time period of a heating process (Racchi et al. 2002 and Zhang and Hamazu, 2004). It is might need a longer heating time of cooking or being largely leached into the cooking water in order to reduce tannin content (Lutz and Przytulski, 1994). Boiling of several vegetables would attribute to the suppression of oxidation by antioxidants due to thermal inactivation of oxidative enzymes (Yamaguchi et al. 2001). In addition the boiling process may destruct the cell wall and subcellular compartments thus release of potent radical scavenging antioxidants. Polyphenol oxidase activity (PPO activity) in extracts of whole Jerusalem artichoke tubers after 2 min boiling has been investigated with different results. Tchoné et al. (2005) found the activity to decrease to 1% of its original value, whereas Takeuchi and Nagashima (2011); found the activity to decrease to only 50% of its original value. The total content of volatile compounds such as  $\beta$ -bisabolene and  $\alpha$ -pinene decreases with increasing boiling time, with as much as 95% of the total volatile compounds being lost because of evaporation during baking and leaching out to the cooking water during boiling. Therefore, the overall flavor has been shown to decrease with increasing boiling time (De Belie et al. 2002).

The aim of this study is to investigate the effect of cooking process on the chemical composition and antioxidant activity of artichoke.

## MATERIALS AND METHODS

Artichoke (*Cynara scolymus* L.) Samples were collected from Agricultural Research Centers, Cairo, Egypt. Artichoke edible heads were washed with tap water to

**Table 1.** Chemical analysis of fresh and cooked artichoke

Chemical analysis	Fresh artichoke(%)	Cooked artichoke(%)
Moisture	75.80	97.40
Ash	7.21	6.91
Crud fiber	63.76mg/g	59.53 mg/g
Total Protein	13.84	15.31
Total Carbohydrate	76.34	72.23
Total Lipids	1.56	1.03

remove the dust followed by distilled water and prepared to direct analysis as fresh and cooked samples.

### Cooking of artichoke

Artichoke heads were cooked in boiling water with a hot plate according Robert et. al. (2012), Lutz et. al. (2010) and Weenanen et al. (2008) with modifications. About 500 ml of distilled water was poured into a boiling container and put on a hot plate. As the water in the container began to boil at 100° C, the sample (100 g) was poured into the boiling water and let to boil for 20 min. After cooking the samples were cooled and dried in an oven at 50° C and stored at 4° C until analysis.

### Aproximate analysis

Aproximate analysis contents were carried out according AOAC (2006). Moisture content was determined by air-oven drying at 105 °C overnight. The total protein content was determined by Kjeldahl method (% protein= N x 6.25). Lipid content was determined by Soxhlet apparatus; using hexane as an organic solvent at 80 °C for 6 h. Crud fiber was determined by dilute acid and alkaline hydrolysis. Carbohydrate content was determined by differences of total contents (fibre, protein, fat and ash) from 100.

### Determination of minerals

Five grams of dried powdered sample was dissolved in 6 M HCl solution and the resulting solution was made up to 20 ml and used to determine of minerals. Sodium and Potassium were determined by flame photometer (Marshall, 1995) while calcium, magnesium, iron and zinc were determined by atomic absorption (David, 1958).

### Determination of vitamins content

Vitamins content was determined using HPLC according to Moreno and Salvado, (2000).

### Determination of phenolic compounds

Total phenolic content of the artichoke samples was determined using Folin-Ciocalteu assay (AOCS, 1990). A

0.5 ml extract was added to 2.5 ml of Folin-Ciocalteu reagent followed by addition of 2 ml sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>) (75 g/l). The sample was then incubated for 5 min at 50° C. the absorbance was then measured at 760 nm. The phenolic content was expressed as mg gallic acid equivalents per gram of extract (mg GAE/g).

### Determination of anti-oxidant activity

The free radical scavenging activity of the sample was measured in artichoke samples according to the method of Brand-Williams et al. (1995). The extract was dissolved in 1 ml methanol and the solution added to 1 ml of α, α-diphenyl-β-picrylhydrazyl (DPPH) solution at room temperature. The absorbance was then measured at 515 nm. The antioxidant activity was expressed as percentage of reduction of initial DPPH absorption by test samples as follows:

DPPH scavenging effect % = [(A<sub>0</sub>-A<sub>t</sub>)/ A<sub>0</sub>] X 100

A<sub>0</sub> is the absorbance of control at zero time

A<sub>t</sub> is the absorbance of the antioxidant at 15 min.

The IC<sub>50</sub> is defined as the concentration of antioxidant necessary to decrease the initial DPPH concentration by 50 %. The IC<sub>50</sub> of the sample was derived from the % scavenging activity against concentration plot and is expressed as mg/ml.

## RESULTS AND DISCUSSION

### Aproximate analysis

#### Moisture content

The results showed that, moisture content of mature artichoke was increased after cooking up to 1.3 fold from 75.80% to 97.40% as shown in Table 1. The increasing of the moisture content after cooking is referred to water absorption during boiling process. This result agreed with the findings of Lutz et al. (2011).

#### Ash and minerals

Cooking of artichoke in boiling water for 20 min caused decreasing of ash content from 7.21 to 6.91 mg/100g as shown in Table 1. Minerals (Na, Ca, Mg, Mn, K, Fe and Zn) level was decreased after cooking as shown in Table 2. It is may be referred to leaching of minerals in boiling

**Table 2.** Effect of cooking on mineral content

Element	Raw (mg/100g)	Cooked (mg/100g)
<b>Na</b>	92.53	74.56
<b>K</b>	364.30	283.20
<b>Mg</b>	59.07	28.75
<b>Fe</b>	1.23	0.63
<b>Mn</b>	0.23	0.094
<b>Ca</b>	43.31	24.25
<b>Zn</b>	0.46	0.35

**Table 3.** Effect of cooking on vitamin content in artichoke

	Raw (mg/100g)	Cooked (mg/100g)
<b>Vitamin C</b>	15.42	13.20
<b>Vitamin A</b>	0.043	0.028
<b>Thiamine (B1)</b>	0.49	0.34
<b>Riboflavin (B2)</b>	0.51	0.38
<b>Cyanicobalamine (B12)</b>	1.27	0.94
<b>Folic Acid</b>	0.39	0.25

water. These findings were agreed with Lutz et al. (2011) who studied the effect of cooking on the minerals and revealed that the boiling process has the negative effect on the minerals content in of artichoke. In same time the obtained results agreed with the results of Mepba et al. (2007) who's revealed that the cooking process caused reduction in K, Na, Ca, Zn, Fe and P content.

### Crude fiber

Crud fiber of artichoke was decreased from 63.76mg/g to 59.53 mg/g after cooking as shown in Table 1. The decreasing of crud fiber after cooking may be due to the thermal degradation of polysaccharides during cooking process. These results agree with findings of Mepba et al. (2007) who reported that the processing treatment caused decreasing of crud fiber in some Nigerian edible leafy vegetables.

### Total Protein

Our results showed a positive effect for cooking on protein content of artichoke. The protein content increased after boiling from 13.84 % to 15.31 % (Table 1). This result agreed with Lutz et al. (2011) who reported that, total protein was increased after cooking process in mature and baby artichoke. On the other hand, our findings disagreed with Pereira Lima et al. (2009) who reported a decrease of the protein content in some cooked vegetables.

### Carbohydrate

The cooking of artichoke caused lightly decreased of the carbohydrate content from 76.34 % to 72.23 as shown in Table 1. It is may be due to the thermal degradation and

extraction of carbohydrate in boiling water. These findings agreed with Gao-feng Yuan et al. (2009) who reported decreasing the soluble sugars in broccoli after cooking.

### Total lipid

The boiling of artichoke caused limited decreases in total lipid from 1.56% to 1.03 % as shown in Table 1. These findings agreed with Mondy and Mueller (1977) who's studied the effect of cooking on the lipid composition of potatoes and revealed that the crude lipid content of potatoes was lowered by all methods of cooking; and disagreed with Lutz et al. (2011) who revealed that the boiling of artichoke has a positive effect on lipid content.

### Vitamins

The boiling of artichoke showed negative effect on its vitamin content (Table 3). The vitamins (C, A, B1, B2, B12 and folic acid) were studied and the results revealed that these vitamins content decreased during boiling process for 20 min as shown in Table 3. It is may be due to extraction of vitamins in boiling water. These findings were agreed with Duroy et al. (2010) who showed that significant loses of vitamin C during cooking process of potatoes.

### Total phenolic content and antioxidant activity

The cooking process in boiling water for 20 min increased the total phenolic content in the obtained extract from cooked samples (from 6.21 in fresh samples to 10.23 mg/100g of cooked samples). This result was agreed with (Wang et al 2003); (Lutz et al. 2011), who's revealed that, the total phenolic compounds were highest in boiling artichoke in distilled water. Increasing of total

**Table 4.** The effect of cooking on total phenolic content and antioxidant activity

	Row	Cooked
Total phenolic content	6.21	10.23
Antioxidant activity	40.08	60.24

phenolic content may be due to inactivating polyphenoloxidase that catalyze the oxidation of phenolics to quinones that subsequently induce the formation of secondary products. Polyphenoloxidase may reduce total phenolic in fresh materials and boiling may be inactivate this enzyme and caused preservation the phenolic content and increase the total phenolic content in the cooked artichoke. This study revealed that, the boiling of artichoke materials caused increasing of antioxidant capacity as shown in (table 4). Many of researches revealed that, a strong linear relationship between total phenolics and antiradical capacity. Based on these findings, the increasing of phenolic content in cooked artichoke materials caused increasing of antioxidant capacity. These findings agreed with (Lutz et al. 2011) who's approved that the antioxidant activity of mature artichoke was improved by thermal treatment, and (Duroy et al. 2010) who's approved that the cooking increased the antioxidant activity of different species of potato.

The obtained results in this study confirmed that the cooking process in boiling water has negative effect on some important components like lipid, Vitamins, elements, fibers and carbohydrate contents. On the other hand, the cooking process has a positive effect on the Moisture, protein and total phenolic contents. Also the cooking process caused the increasing of anti oxidant activity due to the relationship between the total phenolics and antioxidant activity. The final conclusion from this study is the cooking process induces the loss of the most of nutrients and bioactive compounds that are non-heat-stable. So we can conclude that, eating of fresh artichoke more healthy for human than cooked.

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