Volume 70(1). Published February, 01, 2020
www.jnsciences.org
E-ISSN 2286-5314

Effect of artichokes leaves powder on quality of dried sausages from culled ewes

TIBAOUI SOUHA[1, 2]. ESSID INES [2]. SMETI SAMIR[1]. ATTI NAZIHA[1]

[1]University of Carthage, INRA-Tunisia, Laboratoire de Productions Animales et Fourragères, rue HédiKarray, 2049 Ariana, Tunisia
[2] University of Carthage, INA-Tunisia, 43 Avenue Charles Nicole, Tunis, Tunisia

*Corresponding author: souhatibaoui@gmail.com

Abstract - The aim of this work was to study the effect of artichokes powder (AP) on microbiological, physicochemical and sensorial properties of ewe's meat dry sausages. Results showed that addition of AP (6%) significantly reduced ($p<0.05$) pH values and lipid oxidation (TABARS).The redness (a*), yellowness (b*) and lightness (L*) valuestended to be higher for Control than AP sausages. Addition of AP decreased ($p<0.05$) the growth of total viable counts during drying, without any significant effect on lactic bacteria.Yeast and mold count increased ($p<0.05$) due the AP use. The addition of AP has decreased ($p<0.05$) the scores of juiciness and increased those of hardness. No significant effect was recorded on the other sensory attributes.

Keywords: ewe's meat; sausage; artichokes; antioxidant; microbiological quality

1. Introduction

In recent years, consumers are becoming more health-conscious and tend to search nutritious foods in general and in particular healthier meat products.Hence, consumption of meatproducts is being linked to the increase of obesity, cancer, coronary heart disease(Lemos 2015) and diabet(McCune 2002).They are seeking for safe, nutritious, and healthy food.Moreover,various meat and meat product spoilage epidemics occur in different parts of the production chain, such as in the preparation, storage and distribution of products. For instance, dry sausages are susceptible to lipid oxidation that can deteriorate their sensorial properties, by generation of compounds such as dienals and aldehydes, which are associated with a rancid taste and odor (Krkić et al. 2013).The oxidation, can also affect the nutritional value of sausages by decomposition of vitamins and polyunsaturated fatty acid (Ansorena and Astiasarán2004). In addition to lipid oxidation and autolytic enzymatic spoilage, microbial deterioration also plays a major role in quality deterioration(Dave and Ghaly 2011).Therefore, the main challenge of meat industry is to find a natural equivalent of synthetic preservatives and antioxidants(Stefanello et al. 2015).Recently, special attention has been focused on the use of natural antioxidants, from inexpensive or residual sources from agriculture industries, in food such as grape seed extract (Brannan 2007), green tea extract(Bozkurt 2006), apple peel (Wolfe 2003), tomato powder (Kim 2011) and rosemary extract (O'Sullivan 2004). The use of globe artichokes residues (mostly external bracts and leaves) as sources of bioactive compounds has emerged due to its high content of flavones luteolin and caffeoylquinic acid (Romani et al. 2006,Pandino et al. 2013, Dabbou et al. 2015). The two main phenolic compounds are 5-O-caffeoylquinic acid and 1, 5-di-O-caffeoylquinic acid (Schütz et al. 2004, Yoo et al. 2012), which have a strong antioxidant capacity. Globe artichoke has been successfully used as an effective medicine due to its pharmacological properties such as its anti-oxidative, antimicrobial and anti-inflammatory activities (Rondanelli et al. 2011). Besides, artichokes powder has a useful function in dairy products (Penksza et al. 2013) and adding artichokes powder to meat product would supply the requisite quantities of natural antioxidants able to prevent tissue damage (Chen et al. 2013). Therefore, the objective of this study was to determine the effectiveness of artichokes leaves powder in dried sausages from culled ewes as measured by pH, microbiological analysis, TBARS values, color and sensory evaluation during 6 days of drying.

2. Materials and methods

All procedures involving animals meet ethical guidelines and adhere to Tunisian legal requirements (The Livestock Law No. 2005-95 of 18 October 2005).

2.1. Sausage Preparation

Artichokes leaves and rods were collected from the region of Jdaida (Tunisia), cleaned and dried for two weeks in open air then ground with a laboratory grinderto give a fine Artichoke powder (AP). Fresh fat-tail Barbarineewe'smeat was usedto prepare dried sausages. Animals were slaughtered with an average body weight of 45 Kg and aged 5 to 6 years. They were fed aoat-hay and concentrate.The carcasses' joints were dissected, and then the lean meatfrom the leg and fat from the tail were stored at -18°C. They were taking out of the refrigerator, 24 hours before the experiment. Lean meat and fat were mixed and minced using aMoulinex mincer (Moulinex Inc., Paris, France) then salt and paprikawere added to the mixture. Two batches were prepared; the first one, served as Control and the second one (experimental) was formulated with lean and 6% of AP (Table 1), this percentage was fixed based an experimental design that was used in order to obtain scientifically valid results. From each batch, 50 sausages were made by stuffing the mixture into a natural casing using aSirman sausage stuffer (Sirman Inc., Padova,Italy).Sausages were tied manually into 10-15 cm long and brought to dry in open air for 6 days (T= 25°C; HR =65%). Microbiological (lactic bacteria,total viable counts, total and fecal coliforms and yeast and mold) and physicochemical analyses (TBARS, pH, color parameters) weredone every day during drying in triplet.

Table 1 Sausages' ingredients

Ingredients (%)	Control	Experimental
Ewe's leg- lean	76.92	72.72
Ewe's fat	19.23	18.18
Paprika	2.88	2.72
Salt	0.96	0.90
Artichoke powder (AP)	0	5.45
Total	100	100

2.2. Total phenolic content determination (TPC)

The extraction and estimation of TPC was achieved following the procedures of Julkunen-Tiito (1985) with some modifications. About 0.2 g of fine ground sample was placed in a test tube. Five milliliters of Reagent 1 (Acetone: Water (1:1) + 5% Formic Acid) were added and the tubes were stirred in vortex for 10 min. Then, the tubes were put in a sonicator (Selecta Ultrason H-D), at 30°C and 40 KHz, for 20 min followed by centrifugation at 2264×g for 20 min at 4ºC and the supernatant was recovered and filtered and the extract obtained was used to determine TPC according to Folin–Ciocalteu method In a test tube, 100 µl of extractwere mixed with 500 µl of Folin–Ciocalteu reagent. After 2 min, 400 µL of sodium carbonate solution (7.5%) wereadded to the test tube and mixed. samples, were incubated for 10 minutes and then absorbance was measured at 760 nmagainst a standard curve of gallic acid using a spectrophotometer.The results were expressed as mg gallic acid equivalent/g AP

2.3. Chemical composition and Physical characteristics of sausages

The chemicalcomposition (dry matter content, fat content, mineral matter content and protein content) was determined on fresh sausages and after drying. Nitrogencontent was determined by Kjeldahl methodandconverted to protein using a factor of 6.25.Fat was analyzed using Randhallmethod with diethyl ether as the extraction agent. The pH was determined in a homogenized sample by a penetrating electrode connected to a portable pH-meter (HANNA, Romania)after calibration with two buffers (7.00 and 4.01) introducing a pH meter into the center of the sausage.The color changes during drying were monitored by evaluating L*, a*, b*, Hue and Chroma values. Colorimetric analysis on surface of sausages was performed using a spectrocolorimeter CM-2006 d (Konica Minolta Holdings, Inc, Osaka, Japan) standardized with a white plate (Y=92.6; x=0.3134; y=0.3195). L* (lightness), a* (redness) and b* (yellowness) values were measured on the outer surface of sausages from three randomly chosen spots. Hue angle (Tan -b /a) and chroma values $(a^2+b^2)^{1/2}$ were calculated.

2.4. Lipid oxidation analysis (TBARS)

The sausage's lipid oxidationwas determined by measuring thiobarbituricacid reacted substance (TBARS) according to the method of Witte et al. (1970) with modifications. 10 g of sausage were homogenized with 20 ml of 10% trichloroacetic acid using an Ultra-Turrax for 10seconds at 13,500 rpm.

After homogenization, the mixture wascentrifuged at 4000rpm and 4°C for 30 min. The supernatant was decanted through a paper filter. Then, 2 mlof the homogenate were placed in a test tube and mixed with 2 ml of thiobarbituric acid solution. The mixtures were incubated at 97°C in a water bath for 15 min to develop a pink absorbance. After cooling, the absorbance of sample was read against the appropriate blank at 532 nm by a Shimadzuspectrophotometer. A standard curve was prepared using 1, 1, 3, 3-tetramethoxypropane; the amount of TBARS was calculated from this curve and expressed as mg malondialdehyde (MDA) equivalents/kg sample. TBARS values were measured every day during the drying process.

2.5. Microbiological analysis

Microbiological parameters were measured every day duringdrying. Forthese analyses, sausage samples (10 g) were aseptically taken and homogenized using Clear Line stomacherblender bags (Clear Line., Paris,France) with 90 ml of peptone water. Serial 10-fold dilutions were prepared by diluting 1 ml in 9 ml of peptone water. Total Viable Counts (TVC) were counted on Plate CountAgar (PCA) and incubated at 30°C for 24 to 48h.Theyeasts andmoldswere enumerated on Sabouraud Dextrose Agar after incubation at25 °C for 2 to 3 days.The quantification of lactic acid bacteria (LAB) was determined by spread plating and counting on MRSagar at 30°Cfor 48h, while*Staphylococcus aureus* were enumerated on Baird Parker Medium followed by incubation at 37°Cfor 24h.Fecal and total coliforms were counted after incubation for 48h at 44°C and for 24h at 35°C, respectively on Desoxycholate agar.All analyses were performed in triplicate and the number of formed colonies was counted and reported as log10 of colony forming units/g (log CFU) for each sample.
Microbiological analysis of AP was also determined at the beginning of the experiment.

2.6. Sensory analysis

The sensory quality of sausage samples, from each batch, was evaluated by fifteen-member trained panelists from the laboratory staff. Descriptive analysis was carried out to evaluate the intensities of sensory characteristics. Sausages (day 0 samples) were cut into pieces (3-5cm), coded and served to each panelist randomly. Panelists were asked to evaluate them for color, odor, flavor, juiciness, firmness and overall acceptability using a nine-point hedonic scale (1, dislike extremely to 9, like extremely). For each session, panelists tested samples from all dietary treatments presented in a random order. Bread and water were provided for the trained panelists between samples to freshen the mouth.

2.7. Statistical analysis

Statistical analyses were performed with SAS, 9.1 (2004). Linear-Mixed-model analysis was conducted on the physicochemical and microbiological characteristics of the sausages during drying. The model includes the treatment (artichoke powder dose), the drying period and the interaction between them as fixed parameters and the samples as variables. Storage data of sensory analysis were analyzed using a one–way analysis of variance (ANOVA) with Duncan's multiple range test and the statistical significance was defined at $p<0.05$.

3. Results and discussion

3.1. Characterization of Artichoke powder (AP)

Total phenolic compounds (TPC)have been reported to be responsible for the antioxidant activitiesof globe artichoke as well as their by-products (Lombardo et al. 2013, Pandino et al. 2013).In this study, TPC content of AP sampleswas 23.6 mg/g dry matter.This result was supported by the result of Dabbou et al. (2015) who found that TPC contents in the bracts and leaves of two Tunisian Artichoke varieties «Violet d'Hyérs » and « Blanc d'Oran »were20.83 and 19.04 mg /g dry matter,respectively. The microbial analysis did not revealed the presence of coliforms in the AP used for this experiment but it contained a totalplate count of 2.27 log UFC/g and a number of 2.21 logUFC/g for yeast and mold

3.2. Sausage chemical composition

Table2shows themean values of drymatter, protein and fat content of fresh and dry sausages.The incorporation of AP and the drying period had a significant effect on sausages 'dry matter and protein content ($p<0.05$). During the drying process, dry matter content significantly increased, while protein content decreased for both types of sausages and reached 21% of DM in control samples and 25.3%of DM in AP sausages, at the end of thedrying process.This result is in agreement with the work of Kovacevic et al. (2010) on traditionally dried sausages.

Table 2 Sausages' chemical composition

		Day 0	Day 6	*SEM*	Statistiques	
					P **– Group**	***P*** **- Time**
Dry matter (DM)	**Exp**	45.3	88.14	21.42		
	C	37.9	73.18	17.64	0.01	0.001
Fat (%DM)	**Exp**	21.2	20.5	0.35		
	C	23.5	22.9	0.3	NS	NS
Protein (%DM)	**Exp**	21.3	21	0.15		
	C	27	25.3	0.85	0.01	NS

C, control; Exp, sausages added with 6% of AP
NS, non sigificant

3.3. Microbiological characteristics of sausages

The mean values of microbiological counts of sausages are presented in Table 3.The use of AP had a significant effect on the microbiological characteristics of sausages ($p<0.05$). However, interaction between drying time and AP incorporation did not show any significant effect on the total viable count ($p>0.05$). Fecal coliforms and the *Staphylococcus aureus*were not detected throughout the period of drying in both control and treated samples. It could be due to the hygienic practices followed during the preparation of sausages.

Table 3 Effect of artichokes powder (AP) on the microbial status (log CFU/g) of the sausages

		Days of drying						
test	**Sample**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
TVC	**C**	2.65 ^{ax}	3.5 ^{bx}	4.19 ^{bx}	4.56 ^{bx}	4.6 ^{bx}	5.09 ^{bcx}	5.14 ^{bcx}
	Exp	2.76 ^{ax}	2.92 ^{ay}	3.14 ^{ay}	3.21 ^{ay}	3.45 ^{aby}	3.43 ^{aby}	4.2 ^{by}
YM	**C**	3.42 ^{ax}	3.51 ^{ax}	3.62 ^{ax}	3.83 ^{abx}	4.26 ^{bx}	4.14^{bx}	4.05 ^{abx}
	Exp	2.48 ^{ay}	2.78 ^{by}	3.64 ^{cx}	4.53 ^{dy}	4.07 ^{dcx}	4.12 ^{dcx}	4.30 ^{dx}
LAB	**C**	1.98 ^{ax}	1.88 ^{ax}	2.78 ^{bx}	3.17 ^{cx}	3.40 ^{cx}	3.47 ^{cx}	3.59 ^{cx}
	Exp	1.43 ^{ay}	1.6 ^{ay}	2.41 ^{by}	3.36 ^{cx}	3.35 ^{cx}	3.49 ^{cx}	4.53 ^{cx}
TC	**C**	-	2.32 ^{ax}	2.52 ^{ax}	-	-	3.36 ^{bx}	4.4 ^{bx}
	Exp	-	3.15 ^{ay}	3.46 ^{ay}	-	-	3.31 ^{ay}	3.53 ^{ay}

CFU / g, colony units per gram; C, control; Exp, sausages added with 6% of AP; TPC, total plate count; YM, yeast and mold ; TC, total coliforms; LAB, lactic bacteria.

$^{a, b, c}$: For the same parameter, different letters within lines (different drying days) are significantly different ($P<0.05$); $^{x , y}$: different letters within columns are significantly different ($P<0.05$) between groups

3.3.1. Total viablecounts (TVC)

Total initial plate counts was 2.7log cfu/g for both batches without significant difference between groups, then it increased significantly to reach on the 6th day of drying 5.14 against4.2 log CFU/g for control and experimental group, respectively. These values were lower than 5.69 log CFU/g, the threshold established by the European legislation (Regulation EC 2073/2005). During all dryingperiod, the total plate countwas significantly higher for Control than AP sausages. These findings were consistent with another investigation conducted on AP inhibition potential on the growth of microorganisms in meat products (Gedorovica and Karklina 2013). In fact, the inhibition potential of AP could be due to its phenolic content which may block adherence and invasion pathogens in the products (Newlove et al. 2015). The result observed in this study was supported by the workof Newlove et al. (2015)on pork meat sausages added with AP.Yuan et al. (2012) had also reported the effect of polyphenols on microbial growth inhibition.

3.3.2. Yeats and mold count

Initial yeast and mold count was higher ($p<0.05$) for Control than AP sausages. This count augments during drying for both groups of sausages (Table 4). It had significantly ($p<0.05$) increasing trends when it reached 4.26 log cfu/g on the 4th day in control sausages, and 4.53 log cfu/g on the 3rd day in experimental groups containing AP.During the 2^{ed} and 3rd day of the drying, the overall mean values of yeast and mold count was significantly higher ($p<0.05$) for AP than Control sausages. This increase may be attributed to the use of AP which contained a number of 2.21 log cfu/g for yeast end mold.

3.3.3. Lactic bacteria count

Lactic bacteria count has significantly ($p<0.05$) increased throughout the drying processfrom 1.98 log cfu/g (day0) to 3.59 log cfu/g (day 6) and from 1.43 log cfu/ (day 0) to 4.53 log cfu/g (day 6) for control and experimental samples, respectively. During the first two days, lactic bacteria count was significantly ($p<0.05$) higher for control samples but from the 3rd day until the end of drying, it increased in the experimentalsamples and reached a final value higher than that of control group. This result proved that the use of AP did not have a negative effect on the development of lactic bacteria which contributed in the acidification of sausages by producing lactic acid.

3.3.4. Coliforms count

The total coliform counts significantly increased ($p<0.05$) during drying and reached, on the 6th day, 3.53log cfu/g for the experimental sausagesand 4.4 log cfu/g for the control group. For this group, the highest valueexceeds the standard log 3.69 cfu/ g.These high values might be due to the slaughter methods used, a bad pre-slaughter, carcass and meat handling, or to the equipment and facilities used (Jutzi 2004).In fact, in meat processing, contamination of the product can originate from the animal, from the environment or from the personnel involved in the operation. However, the experimental did not reach this threshold thanks to AP power.

3.4. pH and color parameters

Table 4illustrated the effect of AP on color properties, and pH valuesof sausages during drying. The pH values were significantly ($p<0.05$) higher for the control sausages compared to the sausages containing AP. No changes in overall pH were observed with the advancement of drying daysfor the control group. A gradual increase in pH values was recorded during the first two days for both samplesas a result of an increase in the number of spoilage organisms which cause a higher protein degradation and accumulation of metabolites of bacterial action on protein and amino acids might beresponsible for increasing the pH of the product (Jay1996, Feiner 2006).However, a significant decrease in pH wasrecorded after 3 days for the AP sausages. This decreased might be due to significant ($p<0.05$) increase in lactobacillus count during the drying process producing lactic acid by break down of carbohydrates (Biswas 2003). The result observed in this investigation was supported by the result of Papadima and Bloukas (1999) who also reported a decrease in pH of traditional Greek sausages during storage condition.

The color of sausages was animportant quality parameter, and thus color is of utmost reputation for sausages consumers. The color properties were affected ($p<0.05$) by the AP incorporation. The overall mean values of L* (lightness) was significantly ($p<0.05$) higher for control than AP samples. The use of salt and AP resulted in the dark color (lower L value). For both groups of sausages, there was a significant decrease of lightness throughout the whole drying period ($p<0.05$) which means that sausages were becoming darker. The redness (a*) and yellowness (b*) scores werehigher ($p<0.05$) for control than experimental samples.Both scores decreased ($p<0.05$) for both sausage's groups during the drying process. The color of AP due to the presence of polyphenolics compounds may be carried over to the final product. It was reported (Choi et al. 2009)that this situation can affect the L*, a* and b* values in sausages. In another study, Swatland and Barbut (1999) reported a reduction in L* value due to addition of salt in chicken patties.Besides, it has been further proved that salt greatly accelerate the meat discoloration process due to pro-oxidative activity which can be attributed to its ability to release iron from heme pigments (Rhee 2001). The high value of redness a* indicates the change in color from red to brown which could be due to the formation of metmyoglobin (Suresh 2011).The chroma value (color intensity) was higher ($p<0.05$) for control than experimental samples. Chroma values showed a decreasing trend across the drying process for both groups. In fact, chroma C* is related to the quality of pigments and high values indicate a more vivid color and lack of grayness (Smeti 2013), consequently, due to the incorporation of AP sausages became darker.

Table 4 Effect of artichokes powder (AP) on the pH and color properties of sausages

		Days of drying						
Index	**Sample**	**0**	**1**	**2**	**3**	**4**	**5**	**6**
pH	**Exp**	5.47^{ax}	5.50^{ax}	5.49^{ax}	5.38^{bx}	5.34^{bx}	5.38^{bx}	5.41^{bx}
	C	5.60^{ay}	5.62^{ay}	5.58^{ay}	5.57^{ay}	5.59^{ay}	5.52^{by}	5.58^{ay}
L*	**Exp**	34.96^{bx}	37.64^{ax}	30.12^{cx}	27.11^{cx}	17.38^{dx}	27.73^{cx}	29.15^{cx}
	C	49.71^{ay}	48.38^{ay}	38.43^{by}	26.08^{cx}	35.79^{by}	31.37^{bcy}	28.85^{bcx}
a*	**Exp**	2.88^{ax}	3.05^{ax}	1.95^{ax}	0.39^{bx}	. bx	1.24^{abx}	0.22^{bx}
	C	16.28^{ay}	17.15^{ay}	17.64^{ay}	12.21^{by}	17.46^{ay}	15.55^{aby}	13.43^{by}
b*	**Exp**	8.84^{ax}	7.77^{ax}	5.52^{bx}	3.54^{bx}	7.01^{abx}	6.56^{bx}	4.43^{bx}
	C	20.53^{ay}	21.29^{ay}	15.70^{by}	8.39^{cy}	13.32^{cby}	12.97^{cy}	10.42^{cby}
C	**Exp**	6.14^{ax}	8.46^{ax}	5.86^{ax}	3.57^{ax}	8.07^{ax}	6.53^{ax}	4.41^{ax}
	C	26.21^{ay}	27.35^{ay}	16.74^{by}	14.80^{by}	21.96^{aby}	20.30^{aby}	17^{by}
h	**Exp**	67.83^{ax}	68.51^{ax}	70.28^{ax}	83.41^{bx}	96.52^{cx}	77.56^{bx}	84.74^{bx}
	C	51.59^{ay}	51.05^{ay}	41.42^{by}	25.86^{cy}	37.32^{by}	39.86^{by}	37.79^{by}

C, control; Exp, sausages added with 6% of AP; L*, Lightness; a*, Redness; b*, Yellowness; C, chroma; h, hue,
$^{a, b, c}$: For the same parameter, different letters within lines are significantly different (P<0.05) in the time ; $^{x, y}$: different letters within columns are significantly different (P<0.05) between groups

3.5. Lipid oxidativestability

The control samples had significantly (p<0.05) higher TBARS valuesthan experimental ones (Figure1).The overall TBARS values significantly increased during the whole drying period and, up to 4 days of drying.They were still below the threshold of rancidity perception (0.6-2 mg/Kg)for both groups of sausage (Greene 1982). On day 5, these values reached 2.12 and 2.16 mg/kg for the experimental and control groups, respectively. This significant (p<0.05) increase in TBARS value during the drying period might be due to increased lipid oxidation and production of volatile metabolites in the presence of oxygen during aerobicdrying(Suresh 2011). Thus, it could be established that the addition of AP was able to enhance the oxidative stability of the sausages by reducing the autoxidation. In fact, phenoliccontained in the AP have the ability to prevent free radical-mediated oxidation.Besides, theyhave ideal structural chemistry for free radical scavenging-ability (Newlove et al. 2015).Gadekar et al. (2014), found a significant increase in TABRS values during refrigerated storageof cured,restructured goat meat product added with natural antioxidants (sodium ascorbate and alpha tocopherols acetate).Also, Bozkurt(2006) reported an increasing trend in TBARS values in Turkish dry-fermented sausages added with natural antioxidant (tea extract) andsynthetic antioxidants (buthylatedhydroxytoluene, BHT), and pointed out that themost effective antioxidant was found to be green tea extract.Antioxidant properties of AP incooked pork meat sausages have been reported by Newlove et al.(2015).Similarly, the totalphenolic content and radical scavenging activities of artichokes leaves were investigated byYuan et al.(2012) who concluded that the leaves of Jerusalem artichoke might be a potential source of natural antioxidants. Therefore, these natural antioxidants could be utilized to enhance quality and provide safer products.

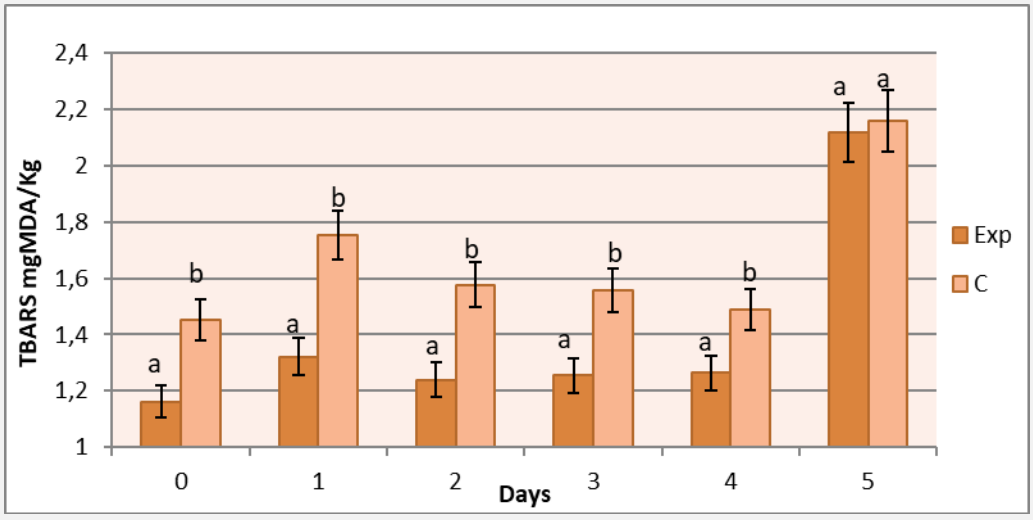

Fig. 1 Overall means of TBARS values during the drying process of sausages
C, control; Exp, sausages added with 6% of AP
$^{a, b,}$: different letters are significantly different (P<0.05)

3.6. Sensory attributes

The results of sensory acceptance test are shown in Table 5.The addition of AP significantly ($p<0.05$) decreased scores of juiciness. In fact, the juiciness score of control group was higher than that of experimental group as a result of slightly higher moisture content. However, the hardness score was significantly ($p<0.05$) higher for the samples added with AP than control samples due to the presence of AP. The other sensory characteristics (color, flavor and odor) were similar for both groups of sausages, which werejudged moderately dark (6.5-5.83). Eating quality is a combination of flavor, juiciness and tenderness and it is one of the key aspects that influence consumer's products buying decisions (Grunert et al. 2004).The addition of AP has negatively affected two of the main components of eating quality (juiciness and tenderness) which may explain the low acceptability scores of the experimental samples (3.92)

Table 5 Effect of artichoke powder (AP) on the sensorial properties of dry sausages

Characteristics	C	Exp	*p*-value
Color	6.5	5.83	0.503
Odor	5.75	6.5	0.297
Flavor	6.17	7.08	0.175
Firmness	3	5.83	0.001
juiciness	7.75	5.17	0.001
Overall acceptance	4.58	3.92	0.442

C, Control; Exp, sausages added with 6% of AP

4. Conclusion

Artichokes leaves powder was prepared and applied in dry sausages and its effect on the microbiological, physicochemical and sensory quality was investigated during the drying period.The results of our study indicated that the addition of AP significantly ($p<0.05$) reduced the pH and TBARS values. Sausages elaborated with AP presented the lowest total phenolic content, without any significant effect on lactic bacteria growth.The addition of AP has significantly ($p<0.05$) decreased the redness (a*), yellowness (b*) and lightness (L*) values, and the scores of juiciness but it increased those of hardness. No significant effect was recorded on the other sensory attributes.Therefore, control sausages showed better color and sensory quality. The results of this study pointed out that AP could be successfully added to dry sausage to function as antioxidant. As promising as these results are, additional research will be required to determine how this powder could be used as health promoting functional ingredients in meat and meat products.

Acknowledgements

The authors are grateful to ZinaTaghouti, technician in Animal Production laboratory in INRAT for her technical assistance, and to the technicians of the agro-food industry department in INAT

5. References

Ansorena D, Astiasarán I (2004) The use of lin seed oil improves nutritional quality of the lipid fraction of dry-fermented sausages. Food. Chem. 87: 69-74

BiswasK, KeshriR C, KumarJ(2003) Effect of enrobing and adding antioxidants on the quality of pork patties. J. Ani. Sci.16: 1374-1383

BozkurtH (2006) Utilization of natural antioxidants: Green tea extract and Thymbraspicata oil in Turkish dry-fermented sausage. Meat Sci. 73: 442-450

Brannan R G, Mah E (2007) Grape seed extract inhibits lipid oxidation in muscle from different species during refrigerated and frozen storage and oxidation catalyzed by peroxynitrite and iron/ascorbate in a pyrogallol red model system. Meat Sci. **77**: 540-546

ChenF, LongX, YuM, LiuZ, LiuL, ShaoH (2013) Phenolics and antifungal-activities analysis in industrial crop Jerusalem artichoke leaves. Ind crops.Prod. 47: 339-345

ChoiS, ChoiJ H, HanD J, KimH Y, LeeM A, KimH W, JeongJ Y , KimC J (2009) Characteristics of low fat meat emulsion–systems with pork fat replaced by vegetable oil and rice bran fiber. Meat sci. 82:266-271

Dabbou S, Pandino G, LombardoS, MauromicaleG, Chahdoura H, L Gasco, Helal A N (2015) In vitro antioxidant activities and phenolic content in crop residues of Tunisian globe artichoke. Scientia. Horti.190: 128-136

Dave D, Ghaly A E (2011) Meat spoilage mechanisms and preservation techniques: a critical review. American. J. Agri .Bio.Sci. 6: 486-510

FeinerG (2006) Meat Products Handbook : Practical Science and Technology, (Woodhead Publishing Limited and CRC Press LLC, Abington,

GadekarbY P, SharmaaB D, ShindebA K, VermacA K, MendirattaS K(2014) Effect of natural antioxidants on the quality of cured, restructured goat meat product during refrigerated storage (4 ± 1◦C). Small .Rum. Res.119**:**72-80

GedorovicaI, KarklinaD (2013) Sensory evaluation of meatballs with Jerusalem artichoke (Helianthus tuberosus L.). International. Schol. Sci. Res. Inno.75: 752-754

GreeneB A, CumuzeT H(1982) Relationship between TBA numbers and inexperienced panelist's assessments of oxidized flavor in cooked beef. J. Food. Sci.47:52-58

GrunertK G, BredahlL, BrunsøK(2004) Consumer perception of meat quality and implications for product development in the meat sector: a review. Meat Sci.66: 259–272

JayM (1996) Microorganisms in fresh ground meats: the relative safety of products with low versus high numbers. Meat Sci. 43: 59-66

Julkunen-Tiito R (1985) Phenolics constituents in the leaves of northern willows: methods for the analysis of certain phenolies. Journal of Agriculture and Food Chemistry,33, 213-217

JutziS (2004) Good practices for the meat industry, Vol 2, Food & Agriculture Organisation

Kim I S, JinS K, MandalK P, KangN S (2011) Quality of low-fat pork sausages with tomato powder as colour and functional additive during refrigerated storage. J. Food Food ScienceTechnology 48:591–597

KovačevićD, MastanjevićK, ŠubarićD, Jerković I Z (2010) Marijanović,Physico-chemical, colour and textural properties of Croatian traditional dry sausage (Slavonian Kulen). Meso.12: 270-275

Krkić N, B Šojić, Lazić V, Petrović L, Mandić A, Sedej I, Tomovic V (2013) Lipid oxidative changes in chitosan-oregano coated traditional dry fermented sausages Petrovska Klobasa. Meat Sci. 93:767-770

Lemos A L S C (2015) As tendências no uso de ingredientes e aditivos para productos cárneos. Revista Carne Tecnica. 22: 50–53

LombardoS, PandinoG, MauromicaleG (2013) Total polyphenol content and antioxidant activity among clones of two Sicilian globe artichoke landraces. Acta Horti.983: 95-101

McCune L M, JohnsT (2002) Antioxidant activity in medicinal plants associated with the symptoms of diabetes mellitus used by the Indigenous Peoples of the North American boreal forest. J. Ethnopharma. 82:197-205

NewloveA, Afoakwah, DongY, ZhaoY, XiongZ, OwusuJ, J WangJ, ZhangJ (2015) Characterization of Jerusalem artichoke (Helianthus tuberosus L.) powder and its application in emulsion-type sausage.LWT. Food. Sci. Technol. 64: 74-81

O'Sullivan C M, Lynch A M, Lynch P M, Buckley D J, Kerry J P (2004) Use of antioxidants in chicken nuggets manufactured with and without the use of salt and/or sodium tripolyphosphate : Effects on product quality and shelf-life stability. Inter. J. Poultry Sci. **57:** 377-381

Pandino G, S Lombardo, Maurimaucale G (2013) Globe artichoke leaves and floralstems as a source of bioactive compounds. Ind. Crops. Prod. 44: 326-333

PapadimaS N, BloukasJ G (1999) Effect of fat level and storage conditions on quality characteristics of traditional Greek sausages. *Meat.Sci.* 51,103-113

PenkszaP, Sarosi R, JuhaszR, Manninger-KoczanK, Szabo-NotinB, SzakacsL (2013) Jerusalem artichoke powder as a food additive in dairy products and fat replacers. Acta Alim. 42:53-62

RheeK S, ZiprinY A (2001) Pro-oxidative effects of NaCl in microbial growth controlled and uncontrolled beef and chiken. Meat. Sci.57:105-112

Romani A, PinelliP, CantiniC , CimatoA, HeimlerD (2006) Characterization of Violetto di Toscana, a typical Italian variety of artichoke (Cynara scolymus L.). Food Chem.95**:** 221-225

RondanelliM, GiacosaA, OrsiniF, OpizziA, VillaniS (2011) Appetite control and glycaemia reduction

in overweight subjects treated with a combination of two highly standardized extracts from Phaseolus vulgaris and Cynarascolymus. Phytoth .Res. 25: 1275-1282

Schütz K, KammererD, Carle R, Schieber A (2004) Identification and quantification of caffeoylquinic acids and flavonoids from artichoke (Cynara scolymus L.) heads, juice, and pomace by HPLC–DAD–ESI/MS. J. Agri .Food. Chem. 52: 4090-4096

SmetiS, AttiN, MahouachiM, MunozF (2013) Use of dietary rosemary (Rosmarinus officinalis L.) essential oils to increase the shelf life of Barbarine light lamb meat. Small Rum. Res.113: 340-345

StefanelloF L, CavalheiroC P, LudtkeF L , SilvaM S, FriesL L M, KubotaE H (2015) Efeito da adição de extrato de cogumelo do sol emlinguiçasuína e avaliação Daestabilidad e oxidativa e microbiológica do produto. Semina: Ciências Agrárias, Londrina . 36: 171-186

Suresh K, DevatkalK, NarsaiahA, BorahA(2011) The effect of salt, extract of kinnow and pomegranate fruit by-products on colour and oxidative stability of raw chicken patties during refrigerated storage. J. food Sci. Tech.48:472-477

SwatlandH J, BarbutS (1999) Sodium chloride levels in commented chiken muscle in relation to processing characteristics and Fresnel reflectance detected with a polarimetric probe. Meat Sci. 51:377-381

WitteV C, KrauseG F, Bailey M E (1970) A new extraction method for determining 2-thiobarbituric acid values of pork and beef during storage. Journal of food Science. 35: 582-585

Wolfe K, WuX Z, LiuR H (2003) Antioxidant activity of apple peels. J. Agri. Food.Chem.51**:** 609-614

Yoo K S , E J Lee, D Leskovar, B S Patil (2012) Development of an automated method for Folin–Ciocalteu. Total phenolic assay in artichoke extracts. J. Food. Sci.77: 1278 1283

YuanX, GaoM, XiaoH, Tan C, DuY (2012) Free radical scavenging activities and bioactive substances of Jerusalem artichoke (Helianthus tuberosus L.) leaves. Food Chem. 133: 10-14