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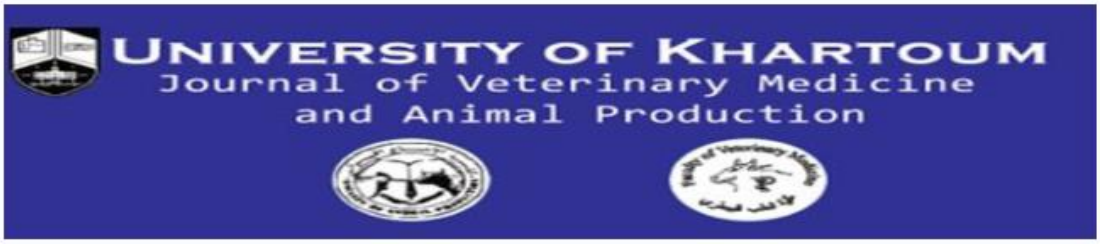

Quality and rehydration properties of dry camel meat as affected by coating level of Gum Arabic (*Acacia senegal*) powder and drying period

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Abstract

This study aimed to evaluate effect of Gum Arabic powder level (GAL) as a bio-edible coating and drying periods on quality and rehydration properties of dry camel meat. Camel meat was trimmed of fat, prepared into thin strips of 1x1x10 cm, and divided into three equal groups. The groups were GAL0%, GAL5% and GAL10% coated with 0% (control), 5% or 10%Gum Arabic powder. Each group was divided into 3 sub-groups and subjected to three drying periods (DP) 0 hours (fresh), 48 or 96 hours. After drying to the specified period, water activity, pH, peroxide value, total bacterial count (cfu/g), rehydration capacity and sensory evaluations were determined for each treatment. The results revealed a significant interaction between the GAL and the DP in the water activity, total bacterial count (cfu/g) and odor scores. Increasing both GAL and DP resulted in a significant increase in the odor scores and significant decrease in water activity and total bacterial count (cfu/g). Increasing the GAL resulted in a significant increase in sensory scores, pH, peroxide value, and total bacterial count. The GAL10% dried for 96hrs had the highest odor scores (4.8). The rehydration percentage in boiled water (100ºC) was significantly lower than that in tab water. The rehydration of dry meat inform of powder was about 3 times higher than that of strip form in all treatments. It can be concluded that the Gum Arabic powder as natural edible coating for dehydrated camel meat improved its appearance, odor and color. Water temperature and physical from of dried meat (strip or powder) can affect the rehydration ability of dried camel meat.

Key words: *Dry camel meat, Gum Arabic, coating, rehydration*

المستخلص

هدفت هذه الدراسة إلى تقييم تأثير مستوى مسحوق الصمغ العربي (GAL)، كغلاف حيوي صالح للأكل وفترات التجفيف على جودة وخصائص أعادة الرطوبة للحم الإبل المجفف. تم ازالة الدهن من اللحم وتحضيرهفي شكل شرائح رقيقة بحجم 1 × 1 × 10 سم ، ومقسمة إلى 3 مجموعات متساوية. كانت المجموعات 0٪ GAL، 5٪GAL و10٪GALغُلفت ب 0٪ (تحكم) ، 5٪ أو 10٪ مسحوق الصمغ العربي. تم تقسيم كل مجموعة إلى

3 مجموعات فرعية وأُخضعت لثلاث فترات تجفيف مختلفة (DP) (0 ساعة (طازج) ، 48 ساعة أو 96 ساعة. بعد التجفيف الى الفترة المحددة ، تم تحديد النشاط المائي ، ودرجة الحموضة وقيمة البيروكسيد والعدد البكتيري الإجمالي (cfu /g) وسعة إعادة الرطوبة والتقييم الحسيى لكل معاملات. أظهرت النتائج وجود تفاعل معنوي بين GAL و DP في النشاط المائي ، وعدد البكتيريا الكلي (cfu / g) درجات الرائحة. أدت زيادة كل من GAL و DP إلى زيادة معنوية في درجات الرائحة وانخفاض كبير في نشاط الماء وإجمالي عدد البكتيريا (cfu g /). أدت زيادة GAL إلى زيادة ملحوظة في درجات التقييم الحسي ، ودرجة الحموضة ، وقيمة البيروكسيد ، وإجمالي عدد البكتيريا. كانت نسبة GAL10٪ المجففة لمدة 96 ساعة أعلى معنوياً في درجات الرائحة (4.8). كانت نسبة إعادة الرطوبة في الماء المغلي (100 درجة مئوية) أقل معنويا من تلك الموجودة في ماء في درجة حرارة الغرفة. كانت إعادة الرطوبة للحوم الجافة على شكل مسحوق حوالي 3 مرات أعلى من تلك التي على شكل قطع طويلة في جميع المعاملات. يمكن ان يستخلص من الدراسةان مسحوق الصمغ العربي كغلاف طبيعي صالح للأكل للحم الإبل المجفف يحسن من مظهر ورائح ولون المنتج. تؤثر تقنية المعالجة درجة حرارة الماء والتجفيف على قابلية اعادة الرطوبة لحم الابل المجفف.

الكلمات المفتاحية: للحم الإبل المجفف، الصمغ العربي، كغلاف حيوي، أعادة الرطوبة

Introduction

During meat processing and storage, many chemical and physical factors can be influenced by the water activity and moisture content level. Chemical changes that are enhanced by water activity include enzymatic reactions Non enzymatic browning, and microbial growth. Bacterial growth is affected at fairly high water activity levels. (Yousif, 2011). Meat and meat products are excellent growth media for a variety of micro flora (bacteria, yeasts and molds) and has a short shelf-life unless preservation methods are used (Jay *et al.,* 2005: Olaoye and Onilude, 2010). Sun drying of lean meat was the most efficient method of meat preservation. The changes in quality can be manifested by deterioration in flavor, color, texture, and nutritive value, and the production of toxic compounds (Scollan *et al*., 2006; Mohamed *et al*., 2008). Due to the consumer awareness of chemical preservatives, extensive studies are being made on natural preservatives for preservation of meat and meat products. Increasing the demand of high quality, safety and extended shelf life of meat and meat products, numerous preservation technologies were done or proposed (Zhou et *al.,* 2010). Nowadays, extensive research is toward of bio edible coating or film to delay or prevent spoilage of most perishable food. These coatings acts as an envelope to prevents the exchange of transfer of gasses (O2 and CO2) (Bourtoom, 2008) and acts like a barrier for aromatic compounds, thus preventing quality changes in food (Miller and Krochta, 1997). Gum Arabic is a mixture of polysaccharides and glycoprotein obtained from Acacia senegal and Acacia seyal. Polysaccharide encapsulate aroma compounds and entrap active ingredients, thereby enhancing safety, nutritional and sensory attributes (Flaguera *et al*., 2011). This study aimed to evaluate effect of Gum Arabic powder as a bio-edible coating and drying periods on quality and rehydration properties of dry camel meat.

Materials and methods

Sample preparation:

Ten kg of camel meat from round cut and the Gum Arabic purchased from local markets were used in this study. The meat was transported in a clean ice box to the Meat laboratory, Department of Meat production, Faculty of Animal Production, University of Khartoum. Gum Arabic (Acacia senegal) was cleaned and blended to smooth powder. The meat was trimmed of fat, connective tissues,

sliced into strips of 1x1x10 cm, and then divided into 3 groups according to the Gum Arabic powder level (GAL) coating. The groups were GAL0%, GAL5% and GAL10% coating with 0% (control), 5% or 10% Gum Arabic powder. Each group was divided into 3 sub-groups and subjected to three drying periods under sunrays (DP) 0 hours (fresh), 48 hrs or 96 hours. The meat strips were suspended from one end using cotton thread in a metal frame sun dryer, covered all around with wire net mish, under direct sunrays until specified drying periods. Samples form treatment groups were taken for analyses.

Parameters Investigated:

pH

One gm. of each sample was blended with 9 ml distilled water in a blender for 30 second and pH was measured by a digital pH meter (Hm – 5 –S: TOA Elective Industrial Co ltd – Tokyo Japan) Standardized at pH 4 and 7.

Water activity (a_w):

Water activity was measured by using water activity meter, the sample was placed inside closed small container. Through evaporation equilibrium of humidity in the small airspace above the product and the humidity of the sample is build-up and this is directly measured by means of a hygrometer built into the lid of the instrument.

Oxidative rancidity: -

The measurement of peroxide value (hydroperoxides production), as the main indicator of oxidation compounds was determined by the method described by Estévez *et al*. (2009).

Milli equivalents of peroxide per $1.000g = \frac{(\text{ml of thio}) \times (N) \times (1000)}{\text{wt.(g) of sample}}$

Total count of bacteria:

It was carried out by using the plate count method as described by Harrigan (1998). A colony counter was used to count the viable bacterial colonies. The result was expressed as colony forming unites (cfu) per gram.

Sensory evaluation

Sensory evaluation, color, smell and acceptability was done by semi-trained panelists using a 5–point descriptive hedonic scale (5 = excellent and 1 = poor) as described by Ihenkoronye and Ngoddy (1985)

Rehydration**:**

Rehydration was carried out by two methods using tap water (29.8◦C) or boiled (100^0C) water to determine the rehydration capacity (RC) in powder or dried strip forms (broken to small pieces). 5 grams samples in each form was mixed with 10ml of tap or boiling water in a test tube and allowed hanging for 1/2 an hour before removing the remaining water. The increase in weight of the sample was considered as the rehydration capacity .as follows:

$$RC\ \% = \frac{(\text{Wt. of rehydrated meat sample} - \text{w.t of dried meat sample}) \times 100}{\text{wt. of dried meat sample}}$$

Statistical Analysis

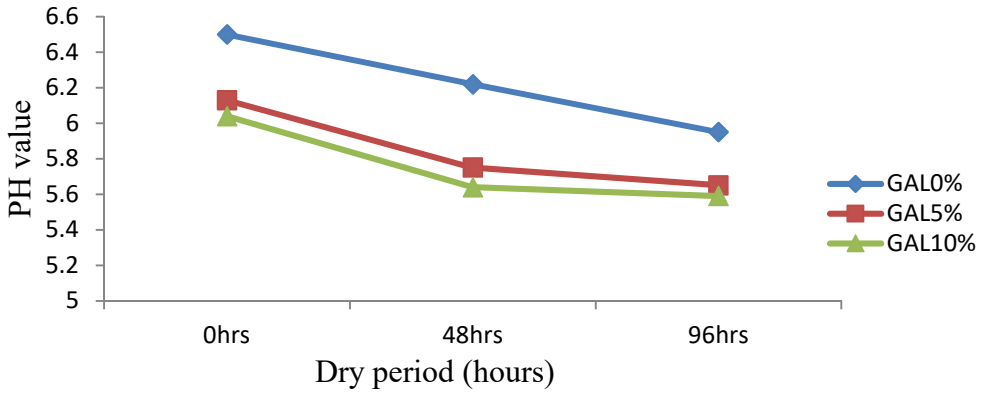
The data obtained were analyzed statistically by ANOVA as 3×3 factorial arrangement and means were tested for significance by Duncan multiple range test using SPSS. 11.5. The difference between treatments for each variable was considered statistically significant at $P<0.05$.

Results

pH

As seen in Figure (1), the pH value decreased with increasing the GAL, but this reduction was not significant ($P>0.05$) between the GAL5% and GAL 10%. The control (GAL0%) had a significantly ($P<0.05$) highest pH value among the treatments. Increasing the DP hours resulted in a significantly ($P<0.05$) reduction of the pH but this decrease was not significant ($P>0.05$)

between the 0hrs and the 48hrs although the 0hr had the highest pH. The 96 hrs drying period had a significantly (P<0.05) lowest pH but was not significantly different compared to 48 hrs treatment.



Figue 1: pH of dry camel meat as affected by added gum arabic powder level(GAL%) and drying period (hours)

Water activity (a_w)

As seen in Table (1) there is a significant interaction between the added Gum Arabic powder coating level and the drying period resulted in a significant (P<0.001) decrease of the water activity with increasing both of the added GAL coating and drying period. GAL0% and GAL5% treatments were not significantly different. The GAL10% treatment presented the lowest water activity with increasing the DP among all the treatments. GAL0% and GAL5% treatments showed equal water activity at days 48 and 96 storage period.

Total bacterial count

As seen in table (1) there is a significant interaction between the added GAL and the drying period resulted in a significant (P<0.001) reduction in the total bacterial count (cfu/g) with increasing both of the GAL and the DP. The GAL10% treatment had a significantly (P<0.001) lowestbacterial count while the control has a significantly (P<0.001) highest bacterial count among all the treatments. The dry period 96 days present the lowest bacterial count in all the treatments.

Table (1): Effect of Gum Arabic coating level and drying period in water activity and total bacterial count of dehydrated camel meat

Dependable variables	GAL (%)	DP (hours) 0	48	96	SE	Main effects DP	GAL	Interaction DP X GAL
Water activity (a_w)	0	0.81^{a}	0.43^{c}	0.40^{d}	0.16	***	NS	***
	5	0.80^{a}	0.43^{c}	0.40^{d}				
	10	0.74^{b}	0.42^{c}	0.40^{d}				
Total bacterial count (cfu/g)	0	4.93^{a}	4.60^{b}	3.82^{d}	0.07	***	***	***
	5	4.48^{b}	3.63^{e}	3.31^{f}				
	10	3.70^{c}	3.52^{g}	2.62^{h}				

GAL: Gum Arabic powder level; DP: drying period; GAL x DP: Interaction
SE: standard error; NS: not significant; *** P≤0.001,
^{abc}Means within the same row or column having different superscripts are significantly different

Peroxide value:
Figure (2) presented the peroxide value, which was used as an indicator of oxidative rancidity of the dry camel meat coated with different levels of Gum Arabic powder and dried for varying periods. There was no significant (P>0.05) interaction between the GAL and DP. The peroxide value increased significantly (P<0.01) with increasing the drying period, GAL0% at (0hrs) had the lowest value and at 96hrs DP had the highest value among the treatments. The peroxide value increased rapidly with increasing the DP up 48hours and then slowed with increasing the DP to 96hrs. Increasing the GAL coating percentage resulted in a significant (P<0.01) reduction of the peroxide value. The GAL10% had the lowest value compared with the control (GAL0%) which had the highest value.

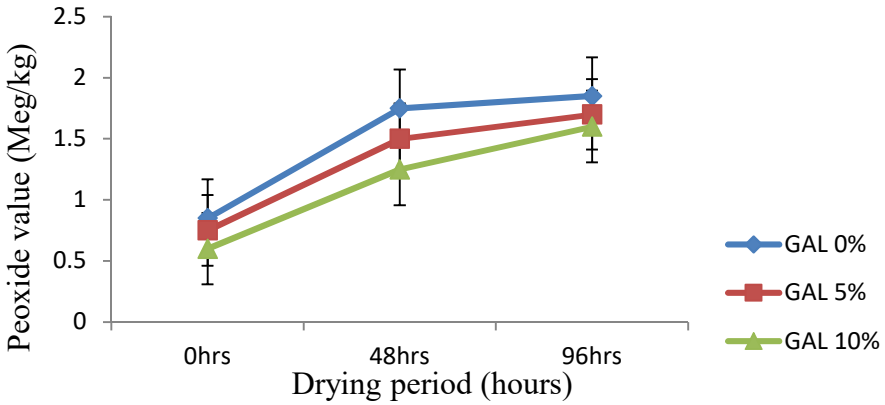


Figure 2: Effect of added Gum Arabic powder and drying period on the peroxide value of dry camel meat

Sensory evaluation:
The interaction between the GAL and the DP was only significant (P<0.05) on the odor scores**.** Increasing both of GAL and DP resulted in a significant (P<0.05) increase of the odor scores. The GAL 10% in all the DP gave a significantly (P<0.01) highest odor scores compared to other treatments. The control and the GAL5%had same odor scores at DP 48 and 96hrs (figure 3).

The main effect of GAL and DP for sensory evaluation of color and acceptability of dry camel meat processed with different GAL and DP was shown in Table (2). Increasing the GAL resulted in a significantly (P<0.001) increase of the panel scores for color and acceptability. GAL 10% received the highest scores (P<0.001). the control (GAL 0%) received the lowest scores (P<0.001) among the treatments. Increasing the DP resulted in a significant (P<0.05) increase of the panel scores for color.

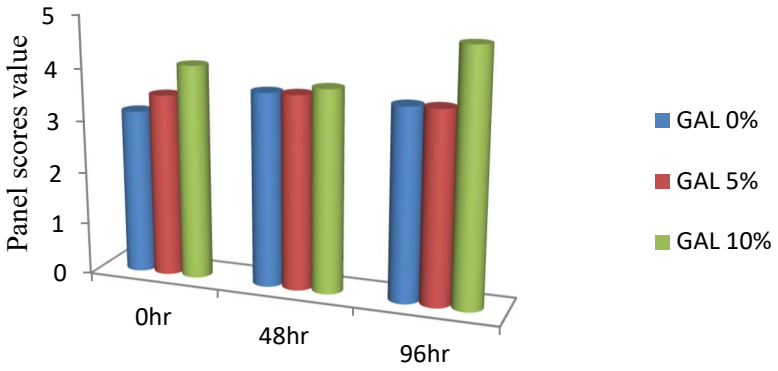


Figure3: Sensory odor scores of camel meat as affected by drying period (hrs) and added GAL%

Table (2): Main effect of Gum Arabic coating level and drying period on color and Overall acceptability of dehydrated camel meat

Main effects	Parameter	color	Overall acceptability
Gum Arabic added level (%)	0	3.57[a]	3.31[a]
	5	4.05[b]	3.80[b]
	10	4.60[c]	4.50[c]
	SE±	012	0.12
	LS	***	***
Drying period (hours)	0	3.98[a]	3.70 [a]
	48	3.85[a]	3.90 [a]
	96	4.38[b]	4.01 [a]
	SE±	0.12	0.12
	LS	**	NS

[abc]Means within the same column having different superscripts are significantly different. SE: standard error; LS: Least significant difference NS: not significant P>0.05; *** P<0.001; ** P<0. 01

Effect of GAL and DP on rehydration of strip and powder forms of dry camel meat

Table (3) shows a significant (P<0.01) interaction between the GAL and DP in the rehydration percentage. The water temperature (29.8C and 100C) and physical processing form (powder and strip) had a significant (P<0.05) effect on the rehydration percentage. Strip form rehydrated in boiled or tap water gave the lowest rehydration percentage compared with the powder form irrespective of GAL and DP treatments of the dry camel meat. Increasing the GAL and the DP together resulted in a reduction of the rehydration percentage of the powder form treated with tap water or boiled water. This reduction was only significant (P<0.01) between samples treated with boiled water. The GAL 10%dried for 96hrs and treated with boiled water had a highly significant (P<0.001) lowest rehydration percentage among all treatments. Increasing the GAL for 48hrs DP of the strip form at both temperature treatments resulted in a significant (P<0.01) increase of the rehydration

percentage. where the control had a significantly (P<0.01) lowest rehydration percentage, but when the DP increased to 96 hrs the same samples showed a significant (P<0.01) reduction of the rehydration percentage and the control gave the highest rehydration% among the treatment groups.

Table (3): Effect of processing technology, water temperature, Gum Arabic powder coating level and drying period on the rehydration percentage of dry camel meat

Drying period (hours)	Gum Arabic level (%)	Powder		Strips	
		Tap water 29.8˚C	Boil water 100◦C	Tap water 29.8˚C	Boil water 100˚C
48	0	242.46[a]	231.45[b]	77.35[c]	76.17[c]
	5	235.40 [a]	230.01[b]	87.74[b]	85.49[b]
	10	225.13 [a]	223.17 [b]	84.99[b]	84.97[b]
96	0	241.20 [a]	237.31[a]	97.25[a]	97.32[a]
	5	234.49 [a]	230.00 [b]	90.12[b]	73.45[c]
	10	222.11 [a]	205.30[c]	69.04[d]	66.89[d]
	SE±	3.61	2.65	1.51	1.08
	LS	NS	***	**	**

[abc]Means within the same column and row having different superscripts are significantly different. SE±: standard error; NS: not significant; *** P<0.001; ** P<0. 01

Discussion

Interaction Effect of the added gum Arabic powder coating level and drying period on the quality of dry camel meat

Increasing both Gum Arabic powder coating level and the drying period resulted in a significant reduction of the water activity which was reflected in a significant reduction of the total bacterial count (cfu/g) and a significant increase of the odor scores of the dry camel meat. The 10% GAL in dried camel meat for 96hrs present the lowest water activity ($_a$w), total bacterial count and better odor scores among all the treatments. The gum Arabic coating had a high absorption characteristic and the thin layer of coating formed on the samples surfaces together with the low water activity makes it difficult for the bacterial to grow with increasing the sun drying period .The improved odor could be attributed on one hand to the fact that the degradation of the proteins to the different amino acids as a result of rapid ripening processes occur during meat dehydration was trapped by the gum coating and on the other hand due to the reduction of the total bacterial load caused by the GAL resulting in decrease of the meat putrefaction and thus not affecting the odor. The results agreed with Deng, *et al* (2014) who found that air drying of squid fillet caused more damage to squid myosin structure than heat pump drying, while freeze drying effectively retained the myosin integrity. These results agreed with Zukál and Incze, (2010) who stated that lowering the water activity to ≤0.8 ensure that all spoilage and pathogenic microorganisms are controlled. Dirar (1992) reported that the traditional Sudanese preparation method of the sun dried Sharmout, using a constant temperature of 30 – 32°c, resulted in dropping of microbial

count of the thin meat slices from an initial load of about 100,000 cells per gram to about 1000 cells per gram within one week and to about 100 cells per gram in two weeks. when water content and water activity of foods are reduced to low levels, the microbiological growth and other deteriorative reactions are also reduced, thus promoting longer shelf life (Ibarz and Barbosa-Cánovas, 2003). The results were in line with Asgar *et.al* (2010) who stated that Gum Arabic used as a novel edible coating for enhancing shelf-life. Madhumita R. and Ramalingam C., (2013) reported the efficacy of gum arabic along with garlic, cinnamon extracts as a potent natural antibacterial agent which can be used for preservation and increasing shelf life of meat and fish products. The results were in line with Yousif, (2011) who found that Sun drying when coupled with gum Arabic coating had no effect on quality attributes, which can be considered as a simple and effective method for farmers and rural families to preserve their product for better in come by preventing postharvest losses during storage.

Main effect of gum Arabic powder coating level and drying period

pH:

Increasing the GAL coating and the DP hours as main effects resulted in a significant reduction in the pH value (pH is acidic) but this reduction in value was not significant between the 5% and 10% GAL. The 96hrs drying period had a significantly lowest pH but was not significantly ($P>0.05$) different from the 48hrs.This could be attributed to the fact that Gum Arabic have a weak acid property (pH 4.5). This acidity was reflected in the reduction of the total bacterial count and thus enhances the preservation action of the GA as antimicrobial agent. The results agreed with Badreldin *et al*., (2008) and Abdul-Hadi *et al*., (2010) in that Gum Arabic is a branched-chain, complex polysaccharide, either neutral or slightly acidic. Asma and Nour, (2013). reported that beef burger treated with 1% Gum Arabic powder gave a significantly low pH value (5.03) compared with the 0.5% treatment (5.43) and the 0% control (5.71). Yousif, (2011) who stated that sun drying when coupled with gum Arabic coating had no effect on quality attributes of tomato, which can be considered as a simple and effective method. for rural families to preserve their product s.

Oxidative rancidity:

The increase of rancidity with increasing the drying period may be due to fact that the meat used for drying is derived from unchilled carcasses and rapid ripening processes occur during the first stage of drying as the meat temperature continues to remain relatively high. This also may be due to reaction between the fats and oxygen to form peroxides that break down into short-chain compounds such as aldehydes, ketones, acids, and alcohols where the sun light and heat catalyze this reaction. The results agreed with Velasco and Williams, (2011) who found that shelf life and meat quality can be improved by using natural antioxidants in some stages of meat production to reduce microbial growth and lipid oxidation during storage. The reduction of the peroxide value with increasing the GAL could be due to the presence of phenolic compounds in the Gum Arabic, which was proved to be effective antioxidant. The results are in line with Ali *et al* (2009) who reported that Arabic Gum has antioxidant properties. Asma and Nour (2013) who found that increasing the added level of Gum Arabic from 0% control, to 1% in beef burger

resulted in a significantly lower oxidative rancidity.

Sensory evaluations:
Increasing the DP resulted in a significant ($P<0.05$) increase of the panel scores for color There was no significant difference between all the DP treatments on overall acceptability although the 96hrs DP received the highest scores. The improved sensory scores due to the increase of the GAL coating could be attributed to the fact that the thin layer of gum Arabic coating form a glazing appearance of the dried camel meat rendering it in a bright glazing red colour also the coating act as a barrier against fat oxidation. The results agreed with Asma and Nour (2013) who found that sensory evaluation scores were not significantly different among the treatments except that the 1% gum Arabic treatment showed the higher ($P\leq0.05$) juiciness scores. Eltrefi, (2003) reported that the color rating was significantly increasing in meat dehydrated from 3 days to 5 days. Helander *et al*., (1995) reported that polysaccharides matrix is able to encapsulate aroma compounds in-order to maintain the organoleptic quality in food systems.

Effect of GAL of powder coating and DPIn rehydration of strip and powder dry camel meat

Processing technology (powder/strip) and the water temperature had a highly significant effect of the rehydration %. The strip form gave low rehydration % compared with the powder form which gave high rehydration % irrespective of GAL, DP and water temperature. Increasing both of the GAL and DP resulted in a significant reduction of the rehydration% of powdered camel dry meat but the samples treated with boiled water showed a significant reduction of the rehydration % compared with tap water in all the treatments. Increasing both GAL and DP resulted in significant increasing of the rehydration% except for the 10%sample dehydrated for 96hur which showed the lowest rehydration % in tap water and boiled water in all the treatment the powder and strip forms. These findings could be attributed to increase surface area as well as the size of the particle of the powdered dry camel meat. Increasing the GAL powder coating to 10% change the composition of the rehydration and the viscosity of the medium also the hardening of the meat due to prolong time of drying under the high sun temperature which lead to the protein change. The results agreed with Eltrefi, (2003) who found that the rehydration % of sun dried beef meat was significantly affected by the drying period where the samples dried for three days had a high rehydration % (211.38) compared with those dried for five days (207.56). Vega-Gálvez *et al*. (2011) found that drying temperature effect was noticeable on drying rate and on color indexes, rehydration capacity, and texture of dried squid. High drying temperatures showed a negative effect on the rehydration index. Rehydration capacity of dried meat is influenced by both the drying method and the water temperature, the rehydration in higher temperature water is considerably lower than with cold water, especially for freeze dried samples (Tribuzi and Laurindo, 2014).

Conclusion

Coating of dehydrated camel meat with Gum Arabic powder forms a thin transparent layer on the product surface, which improves its appearance and act as a preservative of odor and color. Increasing GAL and DP of the dehydrated camel meat resulted in a decrease of the water activity, which

was reflected in reduction of the total bacterial count and thus increased shelf life of the product. Gum Arabic coating % as main effect had a significant reduction of the oxidative rancidity (peroxide value), and hence its keeping quality The dry camel meat coated with 10% gum Arabic powder had highest sensory scores for color, odor and acceptability. Increasing the GAL and DP resulted in a significant reduction of the rehydration percentage of dry camel meat in powder form. Water temperature and methods of processing and preparation had impact on rehydration percentage.

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