Utilization of mucilage extracted from taro tubers (*Colocasia esculenta*) in canned beef

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ABSTRACT

The commercial gelatin is not accepted from some Muslim community because it might be extracted from pig. This issue led to searching for alternative gelatin sources. This study aims to investigate the possibility of utilization of natural binders extracted from plant sources such as mucilage extracted from taro (*Colocasia esculenta*) as an alternative gelatin in different concentrations (1, 2 and 3%) in canned beef products. In this study we evaluated the physical properties, minerals (K, P, Na, Ca, Zn, Pb and Cd), antioxidant activity and total phenolic for taro mucilage. Chemical quality characteristics, texture profile, microbiology analysis and sensory evaluation were evaluated in the canned beef products. The comparison study between taro mucilage treatments and commercial gelatin showed the taro mucilage (TM_2) had a higher value of emulsion capacity (35.71 g water/g sample) and oil absorption (2.84 g oil/g sample) than gelatin (14.28 g water/g sample), (0.8 g oil/g sample); respectively. Water absorption values were higher in the commercial gelatin (37.80g water/g sample), compared to the taro mucilage treatments (TM_1, TM_2 and TM_3) that were 23.48, 24.28 and23.20g water/g sample, respectively. Viscosity value was higher in taro mucilage treatment (TM_2) (625cp) compared to the other all treatment. The total phenolic content in taro mucilage was 32.2mg gallic acid/g). In conclusion, adding hydrocolloid material (taro mucilage) to canned meat improved the stability of the samples during storage at room temperature for six months. On the other side, this material improved the texture profile, and organoleptic properties of canned beef.

Keywords: Taro mucilage; Texture profile; Quality attributes; Meat products.

INTRODUCTION

Canned beef is referred to \a meat product in closed sterilized cans (USDA, 2003) as reported by Hamasalim (2012). Hydrocolloids are a large group of food additives with international applications in the food manufacture also are high-molecular-weight biopolymers and obtained by extraction from plants and sea plants (Dickinson, 2003). Binder materials are divided into two main types: natural binders and artificial binders. A commonly used artificial binding agent is CMC (Carboxy Methyl Cellulose) is very costs, it is considered non economical (Syamsu, 2007). Taro Mucilage has unique rheological properties and gives much potential for use as a food binder and stabilizer, in addition to producing gelling properties and increases viscosity (Njintang *et al*., 2011; Kaushal *et al*., 2013).

Haug and Draget (2009) reported that for Muslims, the religion is the reason for not accepting gelatin from pig sources and beef gelatin is accepted if it has been slaughtered according to religious basics and requirements. The aim of this study to use natural binders from plant sources in canned meat, where there are few studies on the use of gelatin alternatives from plant sources in canned meat, so it was determine the optimal conditions for mucilage extracted from taro. Descriptive tests were determined to identify the most important functional groups and physical tests in taro mucilage. Also, the effect of the taro mucilage on the chemical quality attributes, texture and microbiological quality of canned meat product during storage at room temperature for six months.

MATERIALS AND METHODS

Materials

Taro (*Colocasia esculenta*) was purchased from local market, Tanta City, El-Gharbia Government, Egypt.

Raw beef meat and beef fat used in this study was purchased from butcher's shop, Tanta City, El-Gharbia Government, Egypt.

Salt, sugar, garlic powder and black pepper were purchased from local market, Tanta City, El-Gharbia Government, Egypt.

Chemical compounds, like sodium nitrite were purchased from Al-Gomhoria Company, Tanta City, El-Gharbia government, Egypt.

Tin cans were purchased from Kaha Company for Preserved Food, Kaha city, El-Qalyubiyah Government, Egypt. It's

approximetly dimensions are 53 cm3 and have a capacity of 160 g.

Extraction of taro mucilage

Taro mucilage was extracted according to the method described by Arora *et al*. (2011) with some modifications. Fresh taro corms were washed with tap water, peeled and sliced. The cubic pieces soaked in 1:3 and 1:5 (W/V) of distilled water. Heating at 50 ˚C for 2 h, and soaked in 1:7(W/V) of distilled water. Let to stand for half an hour followed by heating at 80 ˚C for 2h.

The extract (Taro mucilage) was filtered through muslin cloth to obtain mucilage. Three volumes of ethyl alcohol 95% were added to one volume of the supernatant to precipitate mucilage. The mixture was centrifuged (K2015R, T10A, United Kingdom) by 4000 rpm at 4˚C for 10min. The mucilage was dried in an electric oven (XBC605, UNOX, Italy) at 40°C. The dried sample was ground to fine powder in an electric grinder using a disc mill (Moulinex, made in France), sieved through 50 mesh and stored at 5±2°C for further use.

Preparation of canned beef

Canned beef was preparation according to EOS (2013), at Kaha Company for preserved food, Kaha city, El- Qalyubiyah government, Egypt. Raw beef meat was washed, cut and then chopped. The fat percentage was adjusted to be 20% in the final product. Chopped meat was mixed with salt, sugar, garlic powder, black pepper and sodium nitrite 2.5, 1.5, 1.5, 0.5 and 0.02%, respectively, by processor (Moulinex, made in France). Gelatin added by 3% to the control canned beef. Taro mucilage was added by replacement of gelatin in proportions at ratio (gelatin: taro mucilage 3:0, 2:1, 1:2, and 0:3% respectively). The mixture was packaged in tin cans .After packaging, the exhausting (preheating at 77°C) and double seaming were made and sterilization at 121°C for 20min, and cooling for 15 min. Following that, the cans incubation at 55˚C for 10 day. Finally, the samples were stored at ambient temperature and analyzed periodically every two months for six months (zero time, two, four and six months).

Analytical methods

Physical characteristics

Swelling index

Swelling index procedure was determined according to the method recommended by Pharmacopoeia (2008).

Water absorption

Water absorption was carried out in comply with the Chau and Cheung (1998), as reported by Thanatcha and Pranee (2011). The samples were weighed (0.25 g), added with 25 ml distilled water, and mixed by magnetic stirrer for 15 min, and then centrifuged (K2015R, T10A, United Kingdom) at 3500 rpm for 30 min.

Oil absorption

Oil absorption of the tested samples was estimated according to Raghavendra *et al.* (2006).

Emulsion capacity (EC)

Emulsion capacity of the tested samples was determined as described by Obatolu *et al*. (2001). The samples were weighed (1.0 g), dissolved in 50 ml distilled water, and added 50 ml refined oil (corn oil). Then, homogenizing for 1 min and centrifuged (K2015R, T10A, United Kingdom) at 1500 rpm for 5 min. (Thanatcha and Pranee, 2011). Finally, measured the height of emulsified layer compared with the height of whole layer.

Minerals content of taro mucilage and commercial gelatin

Dried sample (0.5g) was digested using the hydrochloric acid as described by (Jones *et al*. 1991).

Total Phenolic Content of Taro Mucilage:

Phenolic compounds were determined based on a method described by Singleton *et al*. (1999), as reported by Mohamed *et al*. (2010).

Antioxidant activity of taro mucilage

Determination of radical DPPH scavenging activity

The free radical scavenging activity of tested samples was measured according to the DPPH method as reported by Nanjo *et al.* (1996).

Determination of ABTS scavenging activity

The ABTS assay of tested samples was measured according to the method of Re *et al.* (1999).

Texture profile of canned beef

Texture Profile Analysis (TPA) of all tested samples were determined according to the method of Bourne (2003).

Microbiological examination of canned beef

Samples preparation

Samples were prepared using the recommended methods for the microbiological

examination of foods published by American Public Health Association (A.P.H.A., 1976).

Total viable bacterial counts

Total viable bacterial count of the tested samples were determined by transferring appropriate dilution into a sterile plates and pouring with Nutrient Agar Medium (Difco, 1984).

Total coliform bacterial counts

Total coliform count of tested samples was determined on Macconkey Agar Media according to the method of Oxoid (1992).

Proteolytic bacterial counts

Proteolytic bacterial count of the tested samples was determined according to Hamasalim (2012).

Lipolytic bacterial counts

Lipolytic bacterial count of the tested samples was determined according to Hamasalim (2012).

Total spore forming bacterial counts

Enumeration is carried out for bacteria belonging to species of *Clostridium* and *Bacillus*, were determined according to Hamasalim (2012).

Mould and Yeast Counts

Moulds and yeasts count of the tested samples was determined according to Difco (1984).

Sensory Evaluation of Canned beef

Sensory evaluation of canned meat samples was carried out by10 panelists from Food Science and Technology Depatment, Faculty of Home Economics, Al-Azhar University, Tanta, Egypt (Smith *et al.,* 1973).

RESULTS AND DISCUSSION

Physical characteristics of taro mucilage and commercial gelatin

Water absorption for taro mucilage treatments has been shown in Table (1) which observed that the value of TM_2 (24.28 g water/g dry sample) was higher than TM_1 and TM_3, which were 23.48 and 23.20 g water/ g dry sample weight while, commercial gelatin (CG) was found to be 37.80 g water/g dry sample weight; respectively.

Also, data in Table (1) showed that the values of water absorption were higher in commercial gelatin than mucilage extracted from taro. These results were higher than value of water absorption for Jujube mucilage powder which was 11.77g water/ g dry sample weight. While these results were lower in water absorption for *Ocimum canum S*. seed, which was 157.09 g water/ g dry sample weight (Thanatcha and Pranee, 2011).

Hong and Ibrahim (2012) cites by Naqvi *et al*. (2010) indicated that high concentration of hydroxyl groups in polysaccharide had high potential for water binding and was capable of absorbing significant amounts of water. From the same Table the swelling index values of taro mucilage treatments are showed that the TM_2 sample had the higher value (340%) than TM_1 and TM_3, which were recorded 322 and 317%, respectively. While commercial gelatin (CG) swelling index value was 380 %.

In addition the values of swelling index were higher in commercial gelatin than from taro mucilage. Our results were agreement with Assi *et al*. (2017) who found that the mucilages extracted from fruit of *B. manni* (Sran) and leaves of *C.oiltorius* (Kpllala), fruit of *I. Gabonensis* (Kplé) and *A. esculentus* (Okra) provided hydration capacities ranging from 257.39 to 519.52%.

The emulsion capacity value in mucilage extract (TM_2) which was recorded 35.71 %.was higher than that found in the other tested samples, while the lowest value was found in mucilage extract (TM_3), which was recorded 27.14%,compared with the emulsion capacity value for commercial gelatin (CG) which was14.28%.

From previous results taro mucilage has the highest values in emulsion capacity, compare with commercial gelatin. Our results are partially agree with (Thanatcha and Pranee, 2011) who found that the EC. for Jujuba mucilage powder was 52.22%. Andrade *et al*. (2015) reported that the chemical composition provides that the emulsifying power of the TM (Taro mucilage) can occur due to the presence of carbohydrates (hydrophilic part) together with the small protein fraction, also its conformation and the presence of amino acids with hydrophobic radicals. The lipid fraction may help in emulsification, however its content is low, and the gums usually do not contain lipids.

The oil absorption amounts for taro mucilage treatments and commercial gelatin also showed in the same Table (1), it present that the highest value of oil absorption for taro mucilage treatments was detected in TM_2(2.84 g oil/g dry sample), respectively and the lowest value was TM_3 (2.24g oil/g dry sample). While,

oil absorption values for gelatin (CG) was (0.8 g oil/g dry samples**).** Thebaudin *et al*. (1997) reported that oil absorption is the ability of absorption on sample surface. Mucilage had high oil absorption value since many nonpolar mucilage molecules can trap large amounts of oil particles.

From tabulated data taro mucilage has the highest values of oil absorption compared with the commercial gelatin sample.

Minerals composition of taro mucilage and commercial gelatin

Some important minerals of taro mucilage and commercial gelatin were determined and presented in Table (2).

Table (2) illustrated that taro mucilage (TM) content of calcium, magnesium and sodium were 84.30, 54.10 and 46.12mg/ 100g, respectively. While commercial gelatin was contained 602.50, 128.27 and 127.70 mg/100g for Ca, Na and Mg, respectively. The mucilage usually appears as calcium salts which have a significant effect on the capacity to hold water and other biophysical properties (Matsuhiro *et al*., 2006).

Also data in the same Table (2) are showed that K, P and Mn recorded 15.62, 2.10 and 0.065 mg/100g in commercial gelatin sample (CG), while they were presented 36.50, 0.112 and 1.63mg/100g in taro mucilage sample; respectively.

This characteristic of minerals may be used to overcome the deficits of certain minerals such as Mg, Ca and Zn whose deficiency causes anemia and threatens the vital prognosis of the mother and child as indicated by Avallone *et al*. (2003). Data presented in the same Table show that the concentrations of zinc, cadmium and lead achieve lower value compared to the other above mentioned minerals.

Metal ions are bound by several ionic or covalent attachments, with the metal ion occupying a central position in the structure. For example, high divalent cations such as Ca may form bridges between neighboring carbohydrate molecules resulting in gel formation as reported by John (1999). Also, according to Sagou (2008) sodium will increase viscosity as reported by Assi *et al*. (2017).

(GMIA, 2012) Gelatin Manufacturers Institute of America indicated that content of gelatin minerals sodium (Na), phosphour, calcium (Ca), potassium (K), lead (Pb) and zinc (Zn) were 500, 1, 90, 125, 0.002 and 1.5 ppm, respectively.

Antioxidant activity and total phenolic content of taro mucilage

The antioxidant activity of taro mucilage treatment was determined on the basis of the DPPH and ABTS radical scavenging activity.

The obtained results are showed in Fig (2) the taro mucilage has an antioxidant activity, which was 3.368 mg AAE/g, by DPPH radical scavenging**.** In regards to the ABTS radical scavenging activity, it was 9.063 mg TE/g of taro mucilage(TM). Total phenolic content in taro mucilage was 32.2mg as Gallic acid/g. From figure data, the antioxidant activity and total phenolic contents don't measure in commercial gelatin; this is may be due to the gelatin has higher percentage of protein.

The DPPH and ABTS radical scavenging activities were examined to evaluate the ability of the polysaccharide fractions to provide hydrogen to a free radical. This activity may be due to the amount of phenolic compounds found in raw materials (Skyberg *et al*., 2012).

Kim *et al*. (2019) measured anti-oxidant activity in steamed and un- steamed taro corm extracts by DPPH which was recorded 34.82 and 24.37% respectively, while the value of ABTS activity was 56.34 and 42.33% of steamed and un- steamed taro corm extracts respectively. Also, they found that total phenolic content in steamed and un- steamed taro corm extracts was 42.77 and 32.32 mg GAE/g on dry weight; respectively. Nguimbou *et al*. (2012) found that total phenolic content in taro mucilage ranged from 28.0 to 35.4 mg ferulic acid equivalent/g. Polyphenols are bioactive substances widely distributed in natural products (Duthie *et al*., 2000).

Chemical quality attributes of canned meat supplements with different levels of taro mucilage (TM) as compared by commercial gelatin (CG).

Data in Table (3) cleared that free fatty acid (FFA) value in control sample was 0.065, while canned meat samples treated with taro mucilage showed the lowest value compared to samples containing gelatin, this is may be due to taro mucilage has an antioxidant activity as shown in Fig (1). From tabulated data, the peroxide value (PV) and thiobarbtioric acid (TBA) for control sample of canned meat was 0.52 meq.O_2/Kg and 0.271 mg malonaldhyde/kg, respectively. While sample treated with taro mucilage (T_3) (canned beef contained 3% taro mucilage) has the lowest value for PV and TBA which were 0.24 meq.O_2/Kg and 0.142 mg malonaldhyde/kg

respectively at zero time, compared to control sample. When the canned meat samples were stored for six months at ambient temperature, the samples treated with high percentage of taro mucilage recorded a slight increase in the of FFA, PV and TBA values which ranged from 0.033 to 0.042%, 0.24 to 0.32 meq.O_2 / Kg and 0.142 to 0.159 mg malonaldhyde/kg, respectively compared to the control sample.

From the same table, the value of TVB-N for canned meat samples containing high percentage of taro mucilage (T_3) decreased significantly (3.26mg/100g) compared to control sample (3.72 mg/100g) at zero time. The increase in TVN value is also noticed in samples stored at room temperature for six months. The pH values has been observed in the same Table (3), which found that the samples containing taro mucilage are nearly to the pH value of canned meat sample. On the other hand, during storage, a slight decrease in the pH values of all parameters observe due to the effect of nonsignificant increase in the acidity values.

From these results (Table3), it could be found that the samples containing a high percentage of taro mucilage (T3) (canned beef contained 3% taro mucilage) have been recorded the least values of all previous parameters even after two months during the storage periods. Our results were in the line with those reported by Hamasalim (2012) which determined FFA, PV and TBA for corned beef and found the initial values were ranged from 0.03 to 0.065% FFA, 0.60 to 0.92 meq O2/kg fat PV and 1.35 mg malonaldehyde/kg fat.

Furthermore, it was observed that the sample was agreement with results obtained by Ebeed *et al*. (2015) which was 2mg TBA. They evaluated the total volatile nitrogen in canned meat with a mean value 10.88 mg/100g. In addition, measured the pH value of canned beef samples and found that the mean value was 6.11.

Texture profile of canned meat supplemented with different levels of taro mucilage (TM) as compared by commercial gelatin (CG)

Texture profile analysis (TPA) is a very useful technique for researching food products, in which tenderness and elasticity (resilience) are the main texture properties of a food and related to quality (Psimouli and Oreopoulou, 2013).

The texture profile of tested canned meat samples were shown in Table (4), which involves hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness for canned meat which supplemented with taro mucilage, storage for six months even after two months at ambient temperature.

The hardness (N) value of control sample was 51.90 N which increased in the samples treated with taro mucilage, which recorded 62.68, 56.26 and 53.92 N of treatments of T_1, T_2 and T_3, respectively. Also, from the same Table (4) cohesiveness value was higher in T_1 (0.76) and T_2 (0.70) than the control sample (0.67). On the other hand, springiness (mm) value for samples containing taro mucilage(TM) was nearly to the control sample (1.81mm), which was ranged from 1.43 to1.70 mm at zero time (Table 4). The same behavior was also observed in gumminess and chewiness properties of the tested samples even two months during the storage period (six months).

Also, Table (4) cleared that the texture profile of all tested samples was slightly decreased during storage period (six months) at ambient temperature, expect the two parameters (springiness and resilience). The addition of natural binder, antioxidant compounds can prevent the development of protein oxidation and maintain the textural properties of the canned meat at room temperature during storage period (six months) (Table4).

Microbiological examination of canned meat supplemented with different levels of taro mucilage (TM) as compared by commercial gelatin (CG)

The most important sources of microbial contamination of meat are endogenous sources, as the microbial load of meat is may be attributable to its high water activity, high protein content and approximately neutral pH (Yousuf *et al.,* 2008 and Kumar *et al*., 2014).

The illustrated data in Table (5) showed that the mean value of total bacterial count of canned meat samples in control sample was 4.33×10^1 at zero time, while the total bacterial count of the samples treated with taro mucilage T_1, T_2 and T_3 was 3.66, 3.42 and 3×10^1; respectively. For the mould and yeast, total coliform bacterial counts, proteolytic bacterial counts and lipolytic bacterial of canned meat samples. Table (5) shows that there were no growth have been detected for all samples. Also, results given in Table (5) cleared that the total spore forming bacterial count (*Clostridium* and *Bacillus*) of the examined canned meat samples was not been detected of all samples.

The cause of reduced bacterial numbers may be due to the preparation of tested samples and

heat treatment, which add some preservatives, especially nitrates, which play an important role in reducing the growth and inhibition of anaerobic bacteria, particularly *Clostridium*. Scientifically, the canning process took place, handling and transport are correctly carried out there was no contamination as reported by Al-obaidi (2005). These results are relatively lower than that reported by Ebeed *et al. (*2015) reported that the level observed in canned beef with a mean value 2.96×10^{-2}.

Mohammed (2013) indicated that no significant difference was found in total aerobic bacteria, coliform bacteria, proteolytic bacteria, lipolytic bacteria, *Bacillus* and *Clostridium*, and he found that there were no growth have been indicated in canned chicken meat.

Sensory evaluation of canned meat supplements with different levels of taro mucilage (TM) as compared by commercial gelatin (CG)

The sensory panelists were recorded comparable color, flavor, texture, juiciness and palatability scores for canned meat which supplemented with taro mucilage which storage at room temperature for six months (Table 6). From tabulated data, score of color was 9.00 for control sample. While sample treated with taro mucilage T_2 and T_3 was recorded 8.90, which were slightly decrease compared to control sample at zero time. Table (6) cleared that score of color decreased in control sample during storage period compared to samples treated with taro mucilage. Furthermore, the highest color value was recorded in canned meat sample treated with taro mucilage during storage period (six months) at ambient temperature compared to control sample.

Color is one of the most important meat quality measures for consumers and can be changed and corrected with the use of additives and colorings (Skiepko *et al.,* 2016).

Table (6) illustrated that the mean score of flavor was higher in sample treated with taro mucilage T_1 (9.00) than control sample (8.90).From the same Table mean flavor scores followed a declining trend after four and six months compared to zero time and after two months. Flavor has been reported to be highly correlated to overall palatability, once tenderness is consider acceptable (Lucherk *et al*., 2016). Table (6) cleared that the control sample recorded the highest scores (8.90) for juiciness compared to the sample treated with taro mucilage T_1, T_2 and T_3 which was recorded 8.80, 8.70 and 8.50; respectively, at zero time.

As tabulated data it could be noticed that slightly decline in the sensory properties (juiciness) during storage period (six months) at ambient temperature, which scored from 9.00 – 8.00. Juiciness is a sensory attribute which determined by consumer or trained sensory panels. Unlike other parameters of texture (e.g., tenderness), juiciness remains a uniquely subjective property of meat. In consumer grading systems, juiciness is estimated to contribute to 10% of the variation in overall acceptability of meat by a consumer (Watson *et al*., 2008).

The data in Table (6) showed that the mean texture scores followed a declining trend after six months compared to zero time. Also, the mean value of texture has been recorded the highest scores of T_1 (8.90), and control sample (9.00) compared to the rest of treatments. The results in Table (6) are illustrated that the treatments control sample (8.95), and T_1 (8.90) recorded the best palatability by panelist at zero time. On the other hand, there was decline in the sensory properties (palatability) scores in tested samples during storage period (six months) at room temperature, which ranged from 8.95 to 7.80. Palatability is defined as the overall eating experience surrounding a food product; in beef products, this usually focuses on tenderness, juiciness, and flavor, in addition to their interaction (Drey and O'Quinn, 2017).

CONCLUSION

The mucilage extracted from *Colocasia esculenta* will be useful as emulsifying agent in canned meat product contain high percentage of fat for improvement the texture profile and sensory properties. Addition of natural binder materials can prevent the development of protein oxidation of the canned meat at ambient temperature during storage period

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Table 1. Physical characteristics of taro mucilage and commercial gelatin.

Parameter / Samples	**Water Absorption (g water/g)**	**Swelling Index (%)**	**Emulsion Capacity (%)**	**Oil Absorption (g oil/g)**
		Taro Mucilage (TM)		
TM_1	$23.48^{bc}\pm0.7$	$322^{c}\pm2.9$	$28.57^{b}\pm0.05$	$2.82^{a}\pm0.03$
TM_2	$24.28^{b}\pm0.1$	$340^{b}\pm1.72$	$35.71^{a}\pm0.04$	$2.84^{a}\pm0.08$
TM_3	$23.20^{c}\pm0.3$	$317^{d}\pm1.19$	$27.14^{c}\pm0.02$	$2.24^{b}\pm0.01$
		Commercial Gelatin (CG)		
CG	$37.80^{a}\pm0.4$	$380^{a}\pm1.41$	$14.28^{d}\pm0.03$	$0.8^{c}\pm0.05$

TM_1= Taro mucilage extraction ratio (1:3).TM_2= Taro mucilage extraction ratio (1:5). TM_3= Taro mucilage extraction ratio (1:7). CG= Commercial gelatin. Reported values are the mean ±SD of three replicates. Means in the same column followed by different lower case letters are significantly different ($p \leq 0.05$).

Table 2. Minerals Composition (mg/100g) of Taro Mucilage and Commercial Gelatin

Elements sample	Taro Mucilage (TM)	Commercial Gelatin (CG)
	(a) Macro Elements	
Na	46.12	128.27
Ca	84.30	602.50
Mg	54.10	127.70
K	36.50	15.62
P	0.112	2.10
	(b) Micro Elements	
Mn	1.63	0.065
Zn	2.53	15.12
Cd	ND	ND
Pb	ND	ND

ND: not detected.

Table 3. Chemical quality attributes of canned meat supplemented with different levels of taro mucilage (TM) as compared to commercial gelatin (CG) during storage at ambient temperature for six months.

Parameter / Samples	Free Fatty Acid (FFA%)	Acid Value (AV)	Peoxide Value (P.V) (meq.O^2/Kg)	Thiobarbtioric Acid (TBA) (mg malonaldhyde/k)	Total volatile nitrogen (TVN mg/100g)	pH
			Zero Time			
Control (Gelatin 3%)	$0.065^{aA}\pm0.04$	$0.129^{aA}\pm0.02$	$0.52^{aB}\pm0.03$	$0.271^{aA}\pm0.07$	$3.72^{aA}\pm0.05$	$6.47^{aA}\pm0.6$
T_1	$0.042^{aA}\pm0.02$	$0.084^{aA}\pm0.01$	$0.39^{bA}\pm0.08$	$0.183^{abA}\pm0.03$	$3.54^{bB}\pm0.04$	$6.52^{aA}\pm0.7$
T_2	$0.038^{aA}\pm0.03$	$0.075^{aA}\pm0.05$	$0.32^{bcA}\pm0.09$	$0.154^{bA}\pm0.06$	$3.36^{cB}\pm0.08$	$6.53^{aA}\pm0.2$
T_3	$0.033^{aA}\pm0.03$	$0.065^{aA}\pm0.04$	$0.24^{cA}\pm0.06$	$0.142^{bA}\pm0.01$	$3.26^{dA}\pm0.07$	$6.55^{aA}\pm0.4$
			Two Month			
Control (Gelatin 3%)	$0.067^{aA}\pm0.05$	$0.133^{aA}\pm0.03$	$0.54^{aAB}\pm0.06$	$0.273^{aA}\pm0.08$	$3.75^{aA}\pm0.09$	$6.43^{aA}\pm0.4$
T_1	$0.043^{aA}\pm0.03$	$0.085^{aA}\pm0.06$	$0.40^{bA}\pm0.03$	$0.184^{abA}\pm0.05$	$3.58^{bB}\pm0.07$	$6.50^{aA}\pm0.6$
T_2	$0.039^{aA}\pm0.01$	$0.077^{aA}\pm0.05$	$0.32^{cA}\pm0.04$	$0.155^{abA}\pm0.07$	$3.39^{cAB}\pm0.02$	$6.52^{aA}\pm0.8$
T_3	$0.035^{aA}\pm0.02$	$0.069^{aA}\pm0.01$	$0.30^{cA}\pm0.01$	$0.144^{bA}\pm0.03$	$3.24^{dA}\pm0.06$	$6.53^{aA}\pm0.5$
			Four Month			
Control (Gelatin 3%)	$0.069^{aA}\pm0.05$	$0.137^{aA}\pm0.08$	$0.57^{aAB}\pm0.07$	$0.277^{aA}\pm0.03$	$3.79^{aAB}\pm0.06$	$6.40^{a}\pm.02$
T_1	$0.046^{aA}\pm0.04$	$0.091^{aA}\pm0.03$	$0.45^{abA}\pm0.09$	$0.188^{abA}\pm0.05$	$3.63^{bAB}\pm0.02$	$6.47^{aA}\pm0.7$
T_2	$0.043^{aA}\pm0.01$	$0.085^{aA}\pm0.04$	$0.36^{bcA}\pm0.03$	$0.161^{bA}\pm0.06$	$3.44^{cAB}\pm0.05$	$6.48^{aA}\pm0.9$
T_3	$0.039^{aA}\pm0.08$	$0.077^{aA}\pm0.02$	$0.27^{cA}\pm0.05$	$0.150^{bA}\pm0.08$	$3.28^{dA}\pm0.03$	$6.50^{aA}\pm0.1$
			Six Month			
Control (Gelatin 3%)	$0.073^{aA}\pm0.05$	$0.145^{aA}\pm0.06$	$0.63^{aA}\pm0.03$	$0.285^{aA}\pm0.07$	$3.84^{aA}\pm0.02$	$6.37^{aA}\pm0.1$
T_1	$0.051^{aA}\pm0.02$	$0.101^{aA}\pm0.03$	$0.51^{bA}\pm0.08$	$0.196^{bA}\pm0.04$	$3.69^{bA}\pm0.06$	$6.43^{aA}\pm0.3$
T_2	$0.048^{aA}\pm0..03$	$0.095^{aA}\pm0.01$	$0.40^{cA}\pm0.05$	$0.167^{bA}\pm0.01$	$3.50^{cA}\pm0.07$	$6.45^{aA}\pm0.6$
T_3	$0.042^{aA}\pm0.04$	$0.083^{aA}\pm0.05$	$0.32^{cA}\pm0.07$	$0.159^{bA}\pm0.03$	$3.34^{dA}\pm0.05$	$6.46^{aA}\pm0.8$

Where: T_1= canned beef supported by 1% taro mucilage. T_2= canned beef supported by 2% taro mucilage. T_3= canned beef supported by 3% taro mucilage. Reported values are the mean ±SD of three replicates. Means in the same column followed by different lower and capital case letters are significantly different ($p \leq 0.05$).

Table 4. Texture profile of canned beef supplemented with different levels of taro mucilage (TM), as compared to commercial gelatin (CG), storage at ambient temperature for six months.

Parameter / Samples	Hardness (N)	Adhesiveness (N)	Cohesiveness	Springiness (mm)	Resilience	Gumminess (N)	Chewiness (MJ)
Zero Time							
Control Gelatin 3%	51.90	0.10	0.67	1.81	0.20	34.77	62.93
T_1	62.68	0.28	0.76	1.43	0.15	47.63	68.11
T_2	56.26	0.18	0.70	1.67	0.16	39.38	65.76
T_3	53.92	0.17	0.67	1.70	0.20	36.12	61.40
Two Months							
Control Gelatin 3%	50.74	0.10	0.65	1.86	0.21	32.98	61.34
T_1	62.18	0.20	0.73	1.50	0.16	45.39	68.09
T_2	55.46	0.17	0.68	1.71	0.18	37.71	64.48
T_3	51.92	0.16	0.66	1.79	0.20	34.26	61.32
Four Months							
Control Gelatin 3%	47.94	0.09	0.63	1.97	0.23	30.20	59.49
T_1	58.20	0.18	0.71	1.54	0.19	41.32	63.64
T_2	52.05	0.13	0.68	1.74	0.20	35.39	61.57
T_3	48.11	0.12	0.65	1.81	0.23	31.27	56.59
Six Months							
Control Gelatin 3%	43.92	0.07	0.59	1.98	0.26	25.91	51.30
T_1	54.87	0.16	0.66	1.55	0.22	36.21	56.12
T_2	48.19	0.11	0.63	1.78	0.23	30.35	54.02
T_3	42.93	0.10	0.60	1.83	0.25	25.75	47.12

Where: T_1= canned beef supported by 1% taro mucilage. T_2= canned beef supported by 2% taro mucilage. T_3= canned beef supported by 3% taro mucilage.

Table 5. Microbiological analysis of canned beef supplemented with different levels of taro mucilage (TM), as compared to commercial gelatin (CG)

Parameter / Samples	Total Viable bacterial count	Mould and Yeast	Total Colifrom Bacterial Count	Proteolytic Bacteria Count	Lipolytic Bacterial Count	Total Spore Forming Bacterial Bacillus (sp.)	Total Spore Forming Bacterial Clostridum (sp.)
Control (Gelatin 3%)	4.33×10^{-1}	N.D	N.D	N.D	N.D	N.D	N.D
T_1	3.66×10^{-1}	N.D	N.D	N.D	N.D	N.D	N.D
T_2	3.42×10^{-1}	N.D	N.D	N.D	N.D	N.D	N.D
T_3	3×10^{-1}	N.D	N.D	N.D	N.D	N.D	N.D

Where: T_1= canned beef supported by 1% taro mucilage. T_2= canned beef supported by 2% taro mucilage. T_3= canned beef supported by 3% taro mucilage.

Table 6. Sensory evaluation of canned beef supplemented with different levels of taro mucilage (TM) as compared to commercial gelatin (CG) during storage at room temperature for six months.

Parameter	Color	Flavor	Juiciness	Texture	Palatability
Samples			**Zero Time**		
Control (Gelatin 3%)	9.00^{aA}±0.5	8.90^{aA}±0.2	8.90^{aA}±0.8	9.00^{aA}±0.1	8.95^{aA}±0.6
T₁	9.00^{aA}±0.3	9.00^{aA}±0.9	8.80^{aA}±0.4	8.90^{aA}±0.5	8.90^{aA}±0.9
T₂	8.90^{aA}±0.7	8.80^{aA}±0.1	8.70^{aA}±0.6	8.70^{aA}±0.3	8.70^{aA}±0.4
T₃	8.90^{aA}±0.6	8.50^{adA}±0.3	8.50^{aA}±0.1	8.50^{aA}±0.7	8.50^{aA}±0.2
			Two Month		
Control (Gelatin 3%)	8.70^{aA}±0.4	8.80^{aA}±0.8	8.80^{aA}±0.7	8.90^{aA}±0.2	8.92^{aA}±0.1
T₁	8.80^{aA}±0.9	8.90^{aA}±0.7	8.80^{aA}±0.2	8.80^{aA}±0.8	8.90^{aA}±0.3
T₂	8.80^{aA}±0.1	8.70^{aA}±0.3	8.60^{aA}±0.9	8.60^{aA}±0.5	8.62^{aA}±0.7
T₃	8.90^{aA}±0.5	8.30^{aA}±0.6	8.50^{aA}±0.3	8.50^{aA}±0.1	8.47^{aA}±0.4
			Four Month		
Control (Gelatin 3%)	7.80^{aB}±0.3	8.70^{aA}±0.9	8.70^{aA}±0.4	8.70^{aA}±0.6	8.82^{aA}±0.5
T₁	8.60^{aA}±0.8	8.70^{aA}±0.1	8.60^{aA}±0.6	8.70^{aA}±0.9	8.80^{aA}±0.2
T₂	8.70^{aA}±0.5	8.50^{abA}±0.3	8.50^{aA}±0.9	8.30^{aAB}±0.2	8.50^{aA}±0.7
T₃	8.80^{aA}±0.2	8.00^{abA}±0.6	8.30^{aA}±0.1	8.00^{aA}±0.1	8.35^{aA}±0.8
			Six Month		
Control (Gelatin 3%)	7.20^{bB}±0.6	8.50^{aA}±0.4	8.50^{aA}±0.7	8.40^{aA}±0.3	8.74^{aA}±0.1
T₁	8.30^{aA}±0.1	8.40^{aA}±0.8	8.30^{aA}±0.2	8.30^{aA}±0.7	8.65^{aA}±0.6
T₂	8.50^{aA}±0.3	8.20^{aA}±0.6	8.20^{aA}±0.1	7.90^{aB}±0.2	8.22^{aA}±0.5
T₃	8.70^{aA}±0.5	7.90^{aA}±0.2	8.00^{aA}±0.9	7.70^{aA}±0.4	7.95^{aA}±0.3

Note: T_1= canned beef supported by 1% taro mucilage. T_2= canned beef supported by 2% taro mucilage. T_3= canned beef supported by 3% taro mucilage. Reported values are the mean ±SD of three replicates. Means in the same column followed by different lower and capital case letters are significantly different ($p \leq 0.05$).

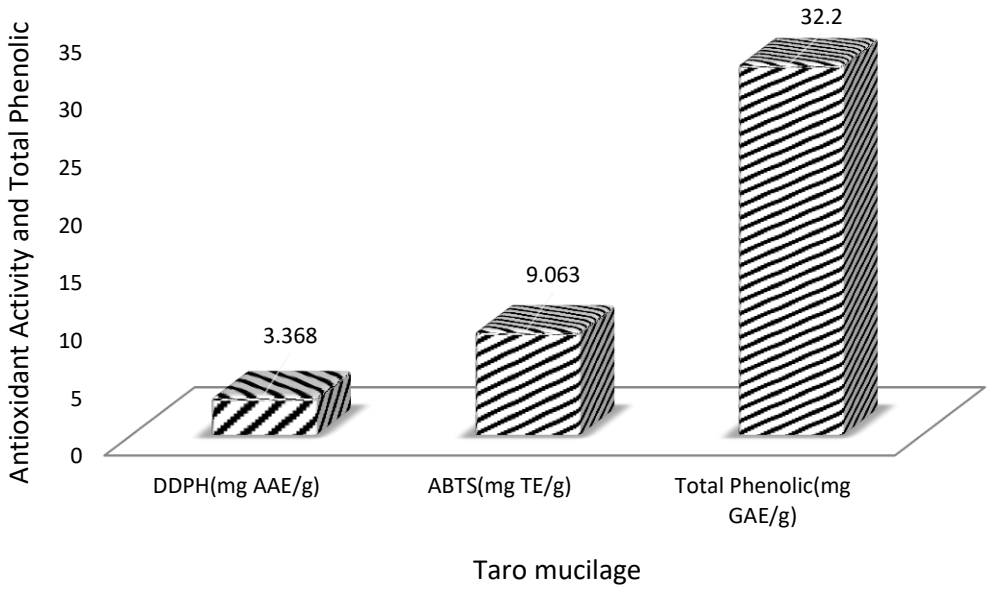

Figure 1. Antioxidant activity and total phenolic content of taro mucilage.

استخدام الموسيلاج المستخلص من درنات القلقاس (*Colocasia esculenta*) في اللحم البقري المعلب

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الملخص العربي

بعض الدول الاسلامية ترفض الجيلاتين التجاري لأن بعض الدول تقوم بتصنيعه من الخنازير مما أدى إلي البحث عن بدائل للجيلاتين من مصادر نباتية. لذلك في هذه الدراسة تم استخدام المواد الطبيعية المستخلصة من مصادر نباتية مثل (الميوسيلاج المستخلص من القلقاس) واستبدال الجيلاتين التجاري مع ميوسيلاج القلقاس بنسب (1 و2 و3%) في تجهيز اللحم البقري المعلب. في هذه الدراسة تم تقدير الخصائص الفيزيائية، المعادن (الكالسيوم- الصوديوم- الفوسفور- البوتاسيوم- الكادميوم- الزنك-الرصاص) وكذلك تقدير المركبات الفينولية الكلية والنشاط المضاد للأكسدة للميوسيلاج المستخلص من القلقاس. أما بالنسبة لمنتج اللحم البقري المعلب تم تقدير صفات الجودة الكيميائية و الصفات الميكروبيولوجية وكذلك الخصائص الحسية لكل عينات اللحم المعلب. في هذه الدراسة أيضا تم مقارنة مستخلصات ميوسيلاج القلقاس والجيلاتين التجاري ووجد أن ميوسيلاج القلقاس (TM_2) يعطي قدرة أعلى لتكوين المستحلب (35,71جم ماء/جم عينة) وأيضا القدرة على امتصاص الزيت (2,84جم زيت/جم عينة) مقارنة بالجيلاتين التجاري (14,28جم ماء/جم عينة) و(0,8جم زيت/جم عينة) على التوالي. بينما أظهر الجيلاتين قدرة أعلى على امتصاص الماء (37,80جم ماء/جم عينة) مقارنة بميوسيلاج القلقاس. محتوي ميوسيلاج القلقاس من الفينولات الكلية هو 32,2ملجم حمض جاليك/جم عينة. أوضحت النتائج أن إضافة المادة الغروية (ميوسيلاج القلقاس) إلى اللحوم المعلبة أدى إلى تحسين درجة ثبات العينات أثناء التخزين في درجة حرارة الغرفة لمدة ستة أشهر. من جانب أخر أدت هذه المادة إلى تحسين صفات القوام والخصائص الحسية في عينات اللحم البقري المعلب.

الكلمات الاسترشادية: ميوسيلاج القلقاس، صفات القوام، خصائص الجودة، منتجات اللحوم.