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Evaluation of Some Vegetal Colloids on the Quality Attributes of Beef Sausage

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Abstract: Colloids are of vital role for improving the quality of foods including that of psyllium, locust bean and pectin which is found in orange peel albedo. These colloids are also of value for clinical nutrition. The last opinion could be confirmed by the chemical analysis which revealed that locust bean seeds had higher total phenolic compounds (485.28 mg/100 g) while psyllium seeds (297.54 mg/100 g) and orange peel albedo (246.11 mg/100 g) showed nearly the same level. Major phenolic compound was pyrogallol for locust bean, being cholchecein for other two colloids sources. Total flavonoid compounds were higher for psyllium seeds (536.46 mg/100 g) and locust bean seed (275.76 mg/100 g), being less for orange peel albedo (113.65 mg/100 g); major flavonoid in all sources was the hesperidin. The best eating qualities recoded for psyllium sausage followed by locust bean sausage. Generally, all three colloids sources improved the eating quality of beef sausage. Plasticity confirmed the results of sensory evaluation where the best sample was that of psyllium sausage. Higher pH value after 6 months storage at-18ºC was in line with the best Water Holding Capacity (WHC) and plasticity levels recorded for psyllium sausage. Color intensity and TBA value were best for locust been followed by psyllium treatments. The lowest color intensity was in line with the highest TBA value. The keeping quality was better when adding the tested colloids; TVN, TBA value, Total Bacterial Count (TBC), Yeast and Mold (Y and M) count was lowest for psyllium followed by locust bean treatment. Other colloids showed the same trend but at lower degree.

Keywords: Beef sausage, colloids, frozen storage, locust bean seeds, orange peel albedo, psyllium seeds, quality attributes

INTRODUCTION

There are few of processed foods that do not contain one or more hydrocolloids in the formulation. Hydrocolloids are generally polysaccharide extracts, obtained from plants, which have a great affinity for water at relatively low concentrations with production of high viscosity system. Hydrocolloids are broadly used in food systems for various purposes, for example as thickeners, gelling agents, texture modifiers and stabilizers. Large, linear and flexible polysaccharides increase viscosity even at low concentrations. This property allows hydrocolloids to be the major ingredient in liquid and semisolid type foods. Recently there has been an increase in the demand of hydrocolloids (Williams and Phillips, 2000; Nishinari, 2008).

Pectin a polysaccharide derived from plant material, mainly citrus fruit peel, apple peel or sugar beets. Pectin is widely used to impart formulation, thickening and physical stability to wide range of foods as confectioneries and is mostly used in fruit-based products including jams, jellies, fruit drinking and also dairy products as yoghurt (Nassinovitch, 1997; Ramírez *et al*., 2011). It should be noted that orange peel albedo (*citrus sinensis*) which is a good source of pectin was not used as it is in foods. At the same time according to El-Naqib (2010) orange albedo powder when fed to hepatointoxicated/diabetic rats lowered serum glucose and improved the liver and kidneys functions.

Psyllium is an annual plant from the *Plantago* genus (Craeyveld *et al*., 2009). Around 200 species of this genus broadly distributed all over the moderate regions of the world (Guo *et al*., 2009). Psyllium is also called Isabgol meaning ‘‘horse ear’’ in Indian, which describes the shape of the seed. The psyllium seed husk which is a well-known source for the production of psyllium hydrocolloid (Craeyveld *et al*., 2009) is widely utilized in pharmaceutical and food industries (Singh, 2007; Yu *et al*., 2003). The psyllium is utilized in pharmaceutical industries as a medicinally bioactive polysaccharide and used for the medical treatment of constipation, colon cancer, diarrhea, high cholesterol, diabetes and inflammation bowel diseases–ulcerative colitis (Singh, 2007). Additionally, it is also used in food industries as constituting the gel and enhancing the consistency and stability (Bemiller and Whister, 1996). In this concermn, Abou- Moussa (2009) found that

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addition of *Plantage psyllium* seed improved the water holding capacity and plasticity of raw and roasted beefburgers, the sensory characteristics were also enhanced.

The carob tree (*Ceratonia siliqua* L.), also called algarroba, locust bean and St. John's bread, is a leguminous evergreen tree which grows throughout the Mediterranean region, mainly in Spain, Italy, Portugal and Morocco. The fruit pod (containing sweet pulp) gives, after removal of the seeds, the carob powder (Yousif and Alghzawi, 2000). The seeds, covered with a tight-fitting brown coat, contain a white and translucent endosperm (containing galactomannans), also called Carob gum, Locust Bean Gum (LBG) or E411 (Dakia *et al.*, 2007). The seed coat contains antioxidants (Batista *et al*., 1996) Seed of carob after decortications may be split and milled then used or extracted with hot water to obtain the Locust Bean Gum (LBG). The most familiar use of carob bean gum (LBG) is for food. Dairy products, sauces and dressing contain LBG. Meat products, breads and breakfast cereals may contain it, as well LBG can be used to replace fat and lower cholesterol and it has even been associated with decreased diarrhea in infant, children and adults (El-Hajaji *et al.*, 2010; Milani and Maleki, 2012).). The aim of current research was to evaluate the effect of some vegetal colloids extracts such as psyllium seeds, locust bean seeds and orange albedo compared with pure pectin extract on quality attributes of beef sausage during frozen storage at-18 ºC for 6 months.

MATERIALS AND METHODS

Lean beef and fat tissues: Fresh lean beef from boneless round and fat tissues (sheep tail) were purchased from the private sector shop in the local market at Giza, Egypt.

Pure pectin: It was obtained from El-Gomhouria Co. for Trading pharmaceutical, Chemicals and Medical Equipments, Cairo, Egypt. It was used at 5% solution by dissolving in hot water at 80ºC up to completely dissolving and allowed to cool to room temperature and kept overnight in refrigerator (5±1ºC).

Carob seeds or locust bean seeds: (*Ceratonia siliqua*) purchased from a spices shop at Giza, Egypt. Seeds were milled and extracted with hot distilled water (5 g: 95 mL) for 2 h at 80ºC under constant stirring and allowed to cool to room temperature and kept overnight in refrigerator (5±1ºC).

Orange fruit: (*Citrus sinensis*) peeled and inner white part separated, washed, dried, milled into powder form and then extracted with hot distilled water (5 g: 95 mL) at 80 ºC for 2 h under constant stirring and allowed to cool to room temperature and kept overnight in refrigerator (5±1ºC).

Psyllium seeds: (*Plantago psyllium*) purchased from a spices shop at AL-Azhar, Cairo, Egypt. Seeds were milled into powder and then dispersed in distilled water (5 g: 95 ml) at 80 for 2hr under constant stirring; the dispersion became a homogenous gel and then cooled to room temperature. The dispersion was then kept overnight in refrigerator (5±1ºC)

All above extracts added during formulation of raw sausage mixture by replacement of added water used in control sample with these extracts by the same percent.

Other ingredients: Other ingredients such as defatted soy flour were obtained from Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Also, food grade sodium tripolyphosphate and sodium nitrite (El-Gomhoriya Company for Drugs, Chemical and Medical equipments, Cairo, Egypt). Salt, dried garlic and spices were obtained from local market at Giza, Egypt. The spices were powdered in a laboratory mill and a mixture of the powdered spices was prepared as follows: 7.27% laurel leaf powder; 4.37% cardamom; 5.22% nutmeg; 13.12% Arab yeast, 12.44% cinnamon, 9.58% clove, 7.50% thyme, 27.75% cubeb and 12.75% white pepper.

Preparation of beef sausage: Five main formulas of beef sausages were prepared in this study. The first formula was prepared with water according to the traditional formula, to serve as the control sausage sample and consisted of the following ingredients: lean beef (60%), fat tissue (17.0%), water (15.0%), defatted soy flour (4.90%) dried garlic (0.20%), tripolyphosphate (0.30%), sodium chloride (1.50%), nitrite (0.01%) and spices (1.09%). Other four formulas were prepared by using the same ingredients with the replacement of added water by psyllium extract, locust bean extract, orange albedo extract and pure pectin, respectively. Sausages were prepared as described by Heinz and Hautzinger (2007) and stuffed into a nature casings which were hand linked at about 15 cm intervals. Sausages were aerobically packaged in a foam plate, wrapped with polyethylene film and stored at -18°C for 6 months. Samples were taken for analysis every month periodically.

ANALYTICAL METHODS

Chemical and physicochemical: Phenolic compounds of psyllium seeds, locust bean seeds and orange peel albedo were fractioned and determined by HPLC according to the methods of Goupy *et al.* (1999), while flavonoid compounds fractioned and quantified by HPLC according to the method of Mattila *et al*. (2000).

Total Volatile Nitrogen (TVN) and Thiobarbituric Acid value (TBA) of sausage samples were determined using the method published by Kirk and Sawyer (1991). The pH value was measured by a pH m (Jenway, 3510, UK) on suspension resulting from blending 10 gm sample with 100 mL deionized water for 2 min (Fernández-López *et al*., 2006). Color of beef sausage formulas was determined by measuring the absorbance at 542 nm according to Husaini *et al.* (1950).

Texture Profile Analysis (TPA) was determined by a universal testing machine (Cometech, Btype, Taiwan) .provided with software. An Aluminum 25 mm diameter cylindrical probe was used in a ‘‘Texture Profile Analysis’’ (TPA) double compression test to penetrate to 50% depth, at 1 mm/s speed test. Hardness (N), gumminess, chewiness, adhesiveness, cohesiveness and springiness were calculated from the TPA graphic. Hardness = maximum force required to compress the sample; Cohesiveness = extent to which sample could be deformed prior to rupture; Springiness = ability of sample to recover to its original shape after the deforming force was removed; Gumminess = force to disintegrate a semisolid meat sample for swallowing (hardness×Cohesiveness); and Chewiness = work to masticate the sample for swallowing (springiness×gumminess) were determined as described by Bourne (2003).

Physical properties: Water Holding Capacity (WHC) and plasticity were measured according to the filter-press method of Soloviev (1966). The cooking loss of prepared sausages were determined and calculated as described by AMSA (1995). This measurement was carried out after cooking in hot water at 85ºC the boiling in water for 15 min.

Microbiological methods: According to the procedures described by Difico-Manual (1984), total bacterial count and yeast and mold counts of beef sausage were determined by using nutrient agar and potato dextrose agar media respectively. Incubations were carried out at 37ºC/48 h for total bacterial count and 25 ºC/5 day for yeasts and molds counts.

Organoleptic evaluation: Organoleptic evaluation of beef sausage was carried out according to Watts *et al*. (1989) by aid of ten members of the Meat and Fish Res. Dep., Food Technology Research Institute. Judging scale for each factor was as follows: excellent (8-9), Very good (7-<8), Good (6-<7), Fair (5-< 6), Poor (4-<5) and Rejected (<4).

Statistical analysis: Data were subjected to Analysis of Variance (ANOVA). Means comparison was performed using Duncan’s test at the 5% level of probability as reported by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Phenolic and flavonoids compounds: From results of Table 1, it could be noticed that, the major phenolic compound in psyllium and orange peel albedo was the cholchecien (234.01 and 229.68 mg/100 g respectively) which was pyrogallol for locust bean (388.95 mg/100g), the latter contained also significant amount of chochecein (88.46 mg/100 g) and tangible amount of catechol and coumaria (2.85 and 1.79 mg/100 g respectively) while psyllium had significant amount of catechol and pyrogallol (37.67 and 12.01 mg/100g respectively) and tangible amount of coumarin, cafien, syringic acid and cinnamic acid (2.73, 1.90, 1.60 and 1.49 mg/100 g respectively) . It could be observed that total phenolic compounds was higher for locust bean (485.28 mg/100 g), followed by psyllium (297.54 mg/100 g) and orange peel albedo (246.11 mg/100 g).

The same table revealed that the major flavonoid was hesperidin for these studied sources, being highest for psyllium extract (442.40 mg/100 g) and locust bean extract (265.18 mg/100 g) while was lower for orange peel albedo extract (65.14 mg/100 g). For psyllium total quercitrn, hespertin, rosmarinic acid and rutin were 90.88 mg/100 g which was 41.66 mg/100 g for locust bean extract and 39.80 mg/100 g for orange peel albedo. Total flavonoids were highest for psyllium (536.46 mg/100 g) and locust bean (275.76 mg/100 g) and lower for orange peel albedo (113.65 mg/100 g).

It evident Table 1, that total phenolic and flavonoids compounds was higher for psyllium followed both locust bean and orange peel albedo. This result may of value when using these sources in clinical nutrition.

Table 1: Phenolic and flavonoid compounds (mg/100 g) of some colloid extracts prepared in this study

Items	Psyllium	Locust bean	Orange peel albedo
Phenolic compounds			
Protocatechuic acid	0.67	0. 68	4.67
Catechol	37.67	2.85	4.16
Cafien	1.90	0.37	1.26
Syringic acid	1.60	0.14	2.73
Ferulic acid	5.32	0.54	1.82
Cholchecien	234.01	88.47	229.68
Pyrogallol	12.07	388.95	ND
Coumarin	2.73	1.79	ND
Cinnamic acid	1.49	0.90	ND
Caffeic acid	ND	0.59	ND
P-Benzoic acid	0.08	ND	1.79
Total	297.54	485.28	246.11
Flavonoid compounds			
Hesperidin	442.40	265.18	65.14
Rosmarinic acid	4.55	19.31	25.96
Rutin	0.82	18.28	5.62
Hespertin	26.74	0.69	5.03
Quercitrin	58.77	3.38	3.19
Quercetin	0.23	0.07	1.33
Kamferol	2.61	0.59	ND
Luteolin	0.34	0.31	2.69
Apigenin	ND	0.17	4.69
Total	536.46	275.76	113.65

ND: not detected

Table 2: Texture profile analysis of different cooked sausage treatments as affected by type of colloids

Texture profile	Treatments				
	Control	Psyllium	Locust bean	Orange peel albedo	Pectin
Hardness N	20.79±1.78[a]	15.10±1.24[c]	17.06±1.36[b]	18.24±1.43[b]	17.85±1.18[b]
Cohesiveness	0.48±0.07[c]	0.80±0.1[a]	0.71±0.09[ab]	0.55±0.06[bc]	0.63±0.05[abc]
Gumminess (g)	9.97±1.0[b]	12.08±1.17[a]	12.11±1.13[a]	10.03±0.43[b]	11.24±0.87[ab]
Chewiness (g×mm)	5.48±0.48[b]	8.09±1.0[a]	7.63±0.92[a]	5.62±0.63[b]	6.29±0.42[b]
Springiness (mm)	0.55±0.06[a]	0.67±0.07[a]	0.63±0.08[a]	0.56±0.06[a]	0.56±0.06[a]

Values are mean and SD (n = 3); where: Mean values in the same row with the same letter are not significantly different at 0.05 level

Table 3: Physical and physiochemical properties of different sausage as affected by type of colloid at zero time

Items	Treatments				
	Control	Psyllium	Locust bean	Orange albedo	Pectin
WHC	1.8±0.08[a]	0.4±0.01[c]	0.65±006[c]	1.35±0.07[b]	1.1± 0.05[b]
Plasticity	3.2±0.2[d]	4.5±0.2[a]	4.1±0.1[ab]	3.5±0.31[cd]	3.7±0.30[bc]
Cooking loss	22.75±0.75[a]	12.27±0.27[e]	13.7±0.7[d]	17.9±0.8[b]	15.73±0.73[c]
Cooking yield	77.25 ±0.75[e]	87.73±0.27[a]	86.30±0.7[b]	82.10 ±0.80[d]	84.27 ±0.73[c]
Color intensity	0.435±0.01[a]	0.527±0.02[a]	0.548±0.03[a]	0.456±0.03[a]	0.442±0.02[a]
pH value	6.21±0.11[a]	6.16±0.13[a]	6.19±0.12[a]	6.18±0.10[a]	6.20±0.11[a]

Values are mean and SD (n = 3); where: Mean values in the same row with the same letter are not significantly different at 0.05 levels

Texture Profile Analysis (TPA) of cooked sausage as affected by type of colloid: Data illustrated in Table 2, revealed that texture indices were at different levels for the variable colloid sources. Hardness of sausage treatments was significantly decreased by replacement of added water with different colloids which decreased from 20.79 for control to 15.10, 17.06, 17.85 and 18.84 for psyllium, locust bean, pectin and orange peel albedo respectively. No significant differences in hardness were recorded between sausage treatments prepared with locust bean, orange peel albedo and pectin. Cohesiveness values ranged from 0.48 to 0.80 showed less variation between different sausage treatments. The highest cohesiveness value was recorded for psyllium sausage followed by locust bean sausage and pectin sausage with non significant differences between them. Also, no significant differences in cohesiveness were observed between control sample and sausages prepared with orange peel albedo and pectin. Gumminess and chewiness of different sausage treatments ranged from 9.97 to 12.08 g and 5.48 to 8.09 respectively showed significant differences between control sample and both psyllium and locust bean sausage. On the other hand springiness value ranged from 0.55 to 0.67 showed no significant differences between all treatments. These results were in line with the results of sensory evaluation which obtained by panelists. The values of texture profile analysis are similar to that reported by some researchers on different cooked sausages (Kerr *et al.*, 2005; Garcia *et al.*, 2006; Herrero *et al.*, 2008).

Physical and physiochemical properties:

Water Holding Capacity (WHC) and plasticity: From Table 3, it could be noticed that water holding capacity and plasticity of different sausage treatments were significantly ($p<0.05$) affected by the type of colloids immediately after processing. The highest or best water holding capacity (i.e., lowest value) and plasticity was recorded for sausage made with psyllium extract (0.40 and 4.50cm^2/0.3 g, respectively) followed by locust bean sausage (0.65 and 4.10 cm^2/0.3 g, respectively) with non significant differences between them ($p>0.05$). Also, no significant differences in WHC and plasticity were found between orange peel albedo sausage and pectin sausage. On the other hand, control sample had significantly lower WHC and plasticity when compared with other sausage treatments. These results are in agreement with that reported by Abou-Moussa (2009) found that addition of *Plantage psyllium* seed improved the water holding capacity and plasticity of raw and roasted beefburgers.

During frozen storage, the water holding capacity and plasticity were decreased (i.e., separated free water increased) with advancement of storage time for all treatments (Fig. 1 and 2). The loss of WHC and plasticity during storage may be attributed to protein denaturation and loss of protein solubility. The rate of decrease in WHC and plasticity was lower for sausage treatments prepared with different type of colloid especially psyllium and locust bean when compared with control. This may be due to these colloids are polysaccharides which have a great affinity for water at relatively low concentrations with production of high viscosity system (Nishinari, 2008).

Cooking loss and cooking yield: Significant differences ($p<0.05$) in cooking loss and cooking yield were observed between all sausage treatments at zero time (Table 3). Cooking loss was significantly decreased by replacement of added water with different colloids. Cooking loss decreased from 22.75% for control to 12.27% for psyllium, 13.70% for locust bean, 15.73% for pectin and 17.19 % for orange peel albedo. From Fig. 3, it could be noticed that cooking loss of all treatments increased as the period of storage increased. This may be due to decreased water holding capacity.

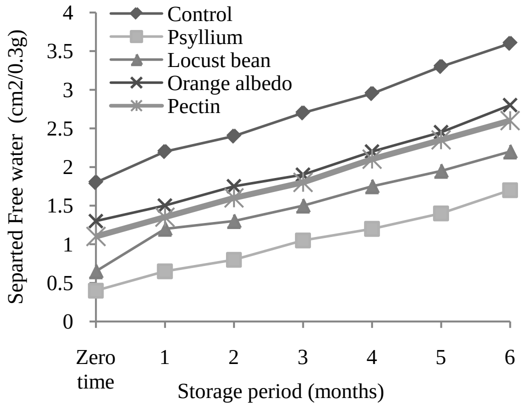

Fig. 1: Water holding capacity (cm^2/0.3 g) of different sausage treatments as affected by type of colloids during frozen storage

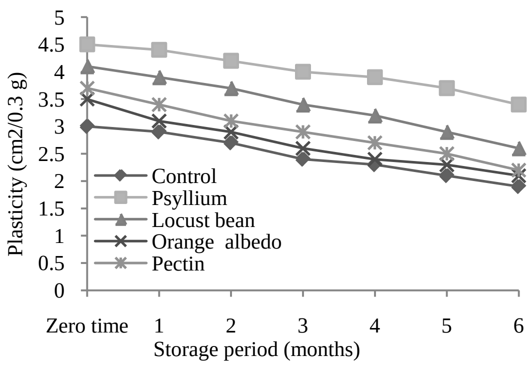

Fig. 2: Plasticity (cm2/0.3 g) of different sausage treatments as affected by type of colloid during frozen storage period

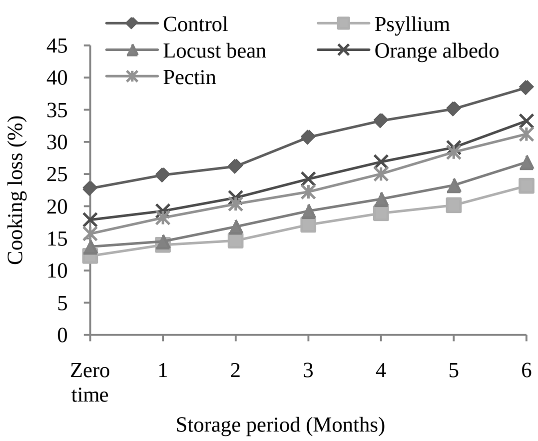

Fig. 3: Cooking loss of different sausage treatments as affected by type of colloid during frozen storage

The lowest increment of cooking loss during storage was recorded for psyllium. The highest cooking loss in control sample after 6 months of frozen storage was in line with the lowest WHC and pH values (Fig. 1 and 5).

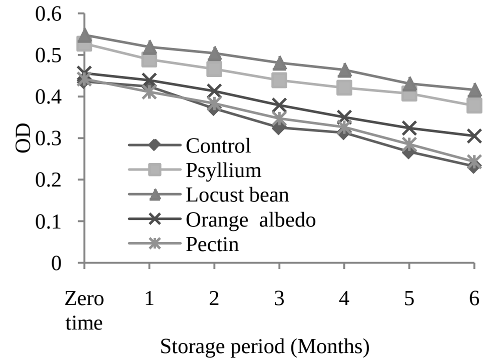

Fig. 4: Color intensity of different sausage treatments as affected by type of colloid during frozen storage

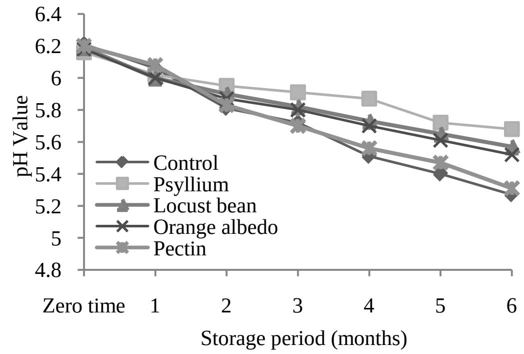

Fig. 5: pH values of different sausage treatments as affeccted by type of colloid during frozen storage period

Color intensity: Data presented in Table 3, showed that color intensity slightly improved due to adding of the colloids sources in sausages, provided that best color recorded for locust bean, followed by psyllium treatments. It showed be mentioned that lowest color intensity was found for pectin sausage was also better than that of control. Generally, no significant differences were recorded in color intensity between treatments at zero time. Also, from Fig. 4, it could be observed that, by advancement of frozen storage time, the color intensity was decreased for all treatment. This decrease in color intensity may be due to oxidation of oxymyoglobin to metmyoglobin beside lipid oxidation as reported by Osheba (2003). It seems possible that color intensity is affected by antioxidant efficiency; it was better for locust bean and psyllium sausages than other treatments during frozen storage. This may be due to locust bean and psyllium had higher photochemical compounds such as phenolic and flavonoids compounds which have antioxidants. The lowest color intensity of control sample was parallel to the highest TBA value.

pH value: pH values of different sausage treatments ranged from 6.16 to 6.21 showed no significant differences between all treatments at zero time. Also, differences between all treatments were actually slight at any time of frozen storage (Table 3 and Fig. 5). By advancement of storage period, the pH values were

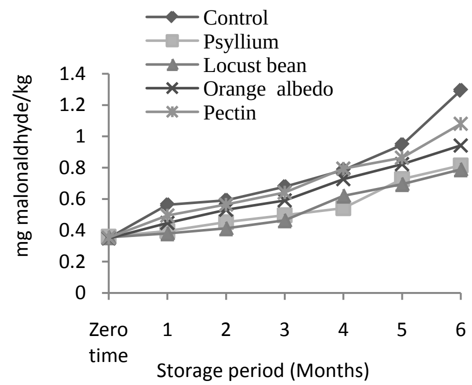

Fig. 6: Thiobarbituric acid of different sausage treatments as affected by type of colloid during frozen storage

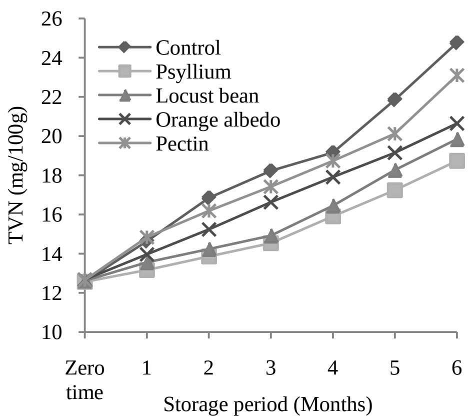

Fig. 7: Total volatile nitrogen (mg/100g) of different sausage treatments as affected by type of colloid during frozen storage

slightly decreased for all treatments. This may be due to the breakdown of glycogen to produce lactic acid and consequently decreased pH value (Darwish *et al*., 2012). The highest pH value after 6 months of frozen storage (5.68) was in line with the best WHC (1.7cm^2/0.3 g) value (Fig. 1) and the highest plasticity (3.40 cm^2/0.3 g) for psyllium sausage (Fig. 2).

Chemical properties:

Thiobarbituric Acid (TBA): Figure 6, show thiobarbituric acid (mg malonaldhyde/kg) of different sausage treatments as affected by type of colloids during frozen storage at -18ºC up to 6 months. From these results it could be noticed that, TBA values of different sausage treatments ranged from 0.349 to 0.361 mg malonaldhyde/kg showed no variations at zero time. These values were gradually increased with advancement of frozen storage period. This increase in TBA value during storage could be indicating continuous oxidation of lipids and consequently the production of oxidative by products (Brewer *et al*., 1992). The highest increment of TBA value was recorded for control sample which reached 0.947 and 1.194 mg malonaldhyde/kg after 5 and 6 months of frozen storage respectively being exceeded the maximal permissible limit of 0.9 mg malonaldhyde/kg for TBA in frozen sausage (Egyptian Standards, 2005). On the other hand, the lowest increment of TBA values was observed for locust bean sausage followed by psyllium sausage with slight differences between them. This may be due to the locust bean and psyllium extract contain many phenolic and flavonoids compounds (Table 1) which have antioxidant activity. TBA values of locust bean and psyllium sausages reached 0.789 and 0.815 mg malonaldhyde/kg respectively after 6 months of frozen storage being not exceeded the maximal permissible limit. TBA values of sausage prepared with orange peel albedo and pectin exceeded the maximal permissible limit of TBA with only 0.042 and 0.18 mg malonaldhyde/kg respectively after 6 months of frozen storage.

Total Volatile Nitrogen (TVN): Total volatile nitrogen of different sausage treatments did not affected by the type of colloids immediately after processing which ranged from 12.50 to 12.68 mg/100g as shown in Fig. 7. Total volatile nitrogen of all treatments progressively increased as the time of frozen storage increase. After 5 months of storage, TVN of all treatments were in the range of permissible level reported by Egyptian Standards (2005) being not more than 20 mg/100 g with exception of the control sample and pectin sausage. The increase of TVN in these treatments than allowance was 1.32 and 0.85 mg only respectively. Meanwhile, after 6 months of storage TVN of all treatments was higher than permissible level of TVN, except the treatments prepared with psyllium (18.73 mg/100g) and locust bean (19.84 mg/100g). Generally, at any time of frozen storage, psyllium sausage had the lowest TVN followed by locust bean sausage. This indicates the effectiveness of psyllium and locust bean extracts for inhibiting many types of microorganisms which caused protein hydrolysis, this may be due to these colloids contain many phenolic and flavonoids compounds (Table 1) which have antimicrobial.

Microbial load: Total bacterial count and yeast and mold counts of different sausage treatments as affected by type of colloids during frozen storage at-18ºC for 6 months are presented in Table 4 and 5. At zero time, it was noticed that total bacterial count of different sausage treatments ranged from 2.87×10^4 to 4.32×10^4 cfu/g. The counts in sausage treatments which prepared with colloids were lower than control sample, this reflex the inhibitory effect of these colloids. Yeast and mold not detected in psyllium and locust bean sausages at zero time and during frozen storage, meanwhile they appeared in other treatments with low numbers at zero time and gradually increased with increasing storage

Table 4: Total bacterial count (cfu/g) of different sausage treatments as affected by type of colloids during frozen storage up to 6

	Treatments				
Storage period (months)	Control	Psyllium	Locust bean	Orange peel albedo	Pectin
Zero time	4.32×10^{4}	2.45×10^{4}	2.87×10^{4}	3.78×10^{4}	4.18×10^{4}
1	4.02×10^{4}	1.96×104	2.41×10^{4}	3.21×10^{4}	3.81×10^{4}
2	4.13×10^{4}	1.51×10^{4}	2.16×10^{4}	2.82×10^{4}	3.25×10^{4}
3	4.71×10^{4}	1.36×10^{4}	2.72×10^{4}	3.11×10^{4}	4.32×10^{4}
4	9.52×10^{4}	2.71×10^{4}	3.81×10^{4}	4.93×10^{4}	6.75×10^{4}
5	7.81×10^{5}	6.27×10^{4}	9.05×10^{4}	1.02×10^{5}	6.11×10^{5}
6	1.65×10^{6}	4.31×10^{5}	5.85×10^{5}	7.18×10^{5}	1.13×10^{6}

Table 5: Yeast and mold counts (cfu/g) of different sausage treatments as affected by type of colloids during frozen storage up to 6 months

	Treatments				
Storage period (months)	Control	Psyllium	Locust bean	Orange peel albedo	Pectin
Zero time	8.00×10^{1}	ND	ND	3.00×10^{1}	7.00×10^{1}
1	7.00×10^{1}	ND	ND	3.00×10^{1}	6.50×10^{1}
2	5.00×10^{1}	ND	ND	5.00×10^{1}	5.00×10^{1}
3	1.20×10^{2}	ND	ND	6.00×10^{1}	8.00×10^{1}
4	6.40×10^{2}	ND	ND	8.00×10^{1}	1.00×10^{2}
5	7.60×10^{2}	ND	ND	1.30×10^{2}	2.50×10^{2}
6	9.10×10^{2}	ND	ND	1.90×10^{2}	4.10×10^{2}

ND: Not detected

Table 6: Organoleptic evaluation of different sausage treatments as affected by type of colloid

	Treatments				
Properties	Control	Psyllium	Locust bean	Orange peel albedo	Pectin
Texture	7.50 ± 0.57^{c}	8.80 ± 0.44^{a}	8.70 ± 0.41^{a}	7.90 ± 0.35^{bc}	8.20 ± 0.57^{b}
Odor	8.10 ± 0.35^{a}	8.00 ± 0.41^{a}	8.00 ± 0.57^{a}	8.10 ± 0.67^{a}	8.00 ± 0.54^{a}
Taste	8.20 ± 0.22^{a}	8.20 ± 0.50^{a}	8.10 ± 0.27^{a}	8.00 ± 0.41^{a}	8.10 ± 0.44^{a}
Color	7.60 ± 0.41^{bc}	8.20 ± 0.27^{a}	8.2 ± 0.28^{ab}	7.60 ± 0.22^{bc}	7.50 ± 0.41^{c}
Overall acceptability	7.85 ± 0.27^{a}	8.30 ± 0.36^{a}	8.20 ± 0.25^{a}	7.90 ± 0.33^{a}	7.95 ± 0.22^{a}

Values are mean and SD (n = 10); where: Mean values in the same row with the same letter are not significantly different at 0.05 level

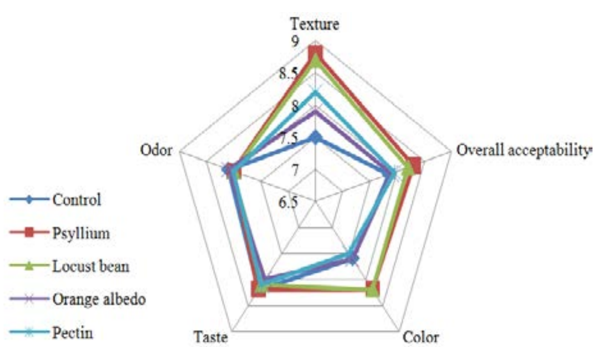

Fig. 8: Organoleptic evalution of sausage as affected by type colloid

period. Total bacterial count of all sausage treatments was also increased by increasing storage time. Total bacterial count of control sample and pectin sausage reached 1.65×10^{6} and 1.13×10^{6} cfu/g, respectively after 6 months of storage. It exceed the maximal permissible limit of 10^{6} cfu/g for total bacterial count in frozen sausage (Egyptian Standards, 2005) while total bacterial count of other sausage treatments reached to 4.31×10^{5} for psyllium, 5.85×10^{5} for locust bean and 7.18×10^{5} cfu/g for orange peel albedo was not exceeded the maximal permissible limit at the end of frozen storage.

Organoleptic evaluation: The organoleptic evaluation of different sausage treatments as affected by type of colloid was tabulated in Table 6 and graphically in Fig. 8. From statistical analysis of these data it could be noticed that there were significant differences ($p<0.05$) in texture and color scores between different sausage treatments, but other sensory properties i.e., taste, odor and overall acceptability showed no significant differences ($p>0.05$).

Texture score of control sample (7.5) was significantly lower when compared with other sausage treatments, except orange peel albedo sausage which had no significant differences with control. The highest texture (more tender) and color scores were recorded for psyllium sausage followed by locust bean sausage with non significant differences between them. Also, no significant differences in the same parameters were recorded between orange albedo sausage and pectin sausage.

Moreover, no significant differences ($p>0.05$) in taste, odor and overall acceptability scores were recorded between all sausage treatments. Generally, results indicated that psyllium sausage was the best one considering texture, odor, taste, color and overall acceptability, followed by locust bean sausage, pectin sausage, orange peel albedo sausage and control sample. It concluded also that all three colloid sources slightly improved the beef sausage quality specially the psyllium. In this concern, Abou-Moussa (2009) found that addition of *Plantage psyllium* seed enhanced the sensory characteristics of beefburgers.

It seems better to judge based on organoleptic test, which indicated that the best treatment was that of psyllium. This was also found for plasticity values (Table 3 and Fig. 2) which were best for psyllium fresh and stored sausage.

Finally from all obtained results, it could be noticed that, the used colloids sources improved the quality attributes of beef sausage and extend the shelf life.

CONCLUSION

Finally, any of the used colloid sources may be recommended during processing of beef sausage to improve the quality attributes of the end product especially psyllium and locust bean. This practice may result in certain therapeutic effect due to pronounced polyphenol and flavonoids levels.

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