QUALITY CHARACTERISTICS OF PHOSPHATE-FREE BEEF EMULSIONS MANUFACTURED WITH JERUSALEM ARTICHOKE POWDER

Meltem Serdaroğlu, Burcu Öztürk*, Berker Nacak, Buket Durdu, Hayrettin Yaşar and Şermin Göral

Ege University, Engineering Faculty, Food Engineering Department, 35100, Bornova, İzmir, Turkey

*Corresponding author email: burcu.ozturk@ege.edu.tr

Abstract – The aim of our study was to investigate the effects of Jerusalem artichoke powder (JAP) plus sodium carbonate utilization in model system beef emulsions (MSBE) as phosphate replacers. 4 treatment groups of MSBE were prepared as follows: C: meat emulsions formulated with 0.5% phosphate (control), J1: emulsions formulated with 3.8% JAP, J2: emulsions formulated with 5.7% JAP, and J3: emulsions formulated with 7.6% JAP. The lowest moisture and highest ash content was recorded C samples ($P<0.05$) and J3 samples had lower fat than C samples ($P<0.05$). No significant differences were recorded in protein content of the samples. The lowest pH value was recorded in C treatment ($P<0.05$). C samples had the lowest expressible fluid, while J2 samples had the lowest expressible fat ($P<0.05$). The lowest jelly and fat separation and the highest water-holding capacity results were recorded in C and J2 compared to J1 and J3 ($P<0.05$). No significant changes were recorded in the initial peroxide value of the treatments, while initial TBA value was higher in J3 ($P<0.05$). Generally peroxide values were decreased and TBA values remained stable during storage. Our results showed that 5.7% JAP+0.2% sodium carbonate utilization in phosphate-free beef emulsions had promising effects to supply equivalent quality parameters compared to phosphates in terms of emulsion stability and oxidation.

Key Words – phosphate-free, Jerusalem artichoke, model system beef emulsion.

I. INTRODUCTION

Phosphates are salts of phosphoric acid available in different chemical forms which are used to improve the quality of meat products and serve specifically as water binding and antioxidant agents [1, 2]. In recent years, however, due to the potential health risks there has been a tendency to decrease the usage of phosphates in meat product formulations [2, 3]. Since there is a challenge for meat industry to find ingredients that have equivalent functionality as phosphates, it is important to investigate the utilization opportunities of potential natural ingredients that enhance overall quality. Jerusalem artichoke (JA) (*Helianthus tuberosus*) is a natural raw material for the derivation of a number of functional food ingredients such as inulin [4, 5]. Since inulin is known as a valuable prebiotic dietary fiber enhancing technological properties of meat products [6], JA is a promising ingredient which could be utilized as inulin source in meat product formulations. Although a limited number of studies are available regarding phosphate replacement with different kind of ingredients [3, 7, 8, 9], no study has reported the effects of JAP on quality of phosphate-free beef emulsions. It was for this reason that we objected to determine the utilization opportunity of JAP in production of phosphate-free meat products.

II. MATERIALS AND METHODS

Jerusalem artichoke powder (JAP) was produced from fresh and non-damaged tubers. The tubers were obtained from a local producer in İzmir, washed with tap water, peeled and sliced. Slices were air-dried in an industrial drying oven at 55-65°C for 5-8 hours. The dried slices were ground and sieved through 0.5 mm. Model system beef emulsions (MSBE) were prepared based on the method described by Cofrades *et al.* [10]. The formulation of the treatments is presented in Table 1. Beef was trimmed of visible fat and connective tissue, and then lean and fat were separately minced through a 3 mm plate. Minced meat was homogenized with half of the sodium chloride (NaCl) for 1 min by using a kitchen-type mixer

(Tchibo, Germany). After that, beef fat, 0.5% sodium tripolyphosphate (STPP) (control) or JAP (3.8%, 5.7%, 7.6%) + 0.2% sodium carbonate (Na_2CO_3) blend, half of the ice and rest of NaCl were added and emulsified for 1 min. The other half of the ice was then added and mixing was continued for 2 min. MSBE samples were centrifuged at 4000 rpm for 1 min to eliminate any air bubbles. Samples were then heat-treated in 70°C water bath for 30 min, cooled to room temperature and stored at 4°C prior to analysis.

Table 1 Formulation of model system beef emulsion treatments

Ingredients	Treatment groups*			
	C	J1	J2	J3
Beef (g)	500.0	500.0	500.0	500.0
Beef Fat (g)	250.0	250.0	250.0	250.0
Ice (g)	150.0	400.5	424.92	449.4
NaCl (g)	15.0	15.0	15.0	15.0
STPP (g)	3.75	-	-	-
JAP (g)	-	28.5	42.75	57.0
Na_2CO_3 (g)	-	1.5	1.5	1.5

***C:** MSBE formulated with 0.5% STPP **J1:** MSBE formulated with 3.8% JAP, **J2:** MSBE formulated with 5.7% JAP, **J3:** MSBE formulated with 7.6% JAP.

Total moisture [11], ash [11] and fat [12] content of the samples were determined. Protein content of the samples was analysed by a Dumas Nitrogen/Protein analyzer (LECO, FP-528, USA). pH values were measured by using a pH-meter (WTW pH 330i/SET, Germany). Emulsion stability (ES) in terms of total expressible fluid (TEF) and total expressible fat (EFAT) [13], jelly and fat separation (JFS) [14] and water-holding capacity (WHC) [13] of samples were analyzed to characterize stability. Peroxide value [15] and thiobarbutiric acid (TBA) value [16] were determined in samples to evaluate lipid oxidation rate during storage. Data was statistically analysed using SPSS statistical package program (IBM, version 21.0, USA) by one-way and two-way ANOVA and Tukey Post-Hoc test to identify significant differences (P<0.05).

III. RESULTS AND DISCUSSION

Chemical composition of MSBE treatments is presented in Table 2. C samples had the lowest moisture content compared to samples formulated with JAP (P<0.05), which could be due to higher amounts of water used in the formulation. Although the amount of ice was calculated according to added JAP and the moisture content was fixed for the raw emulsion, final moisture content could have changed between samples due to the behavior of the emulsion structure during heat treatment. No significant differences were recorded in protein content of the samples. J3 treatment had lower fat content compared to C (P<0.05), which could be due to higher fat release from the sample during heat treatment. Control samples had higher ash content than other samples (P<0.05), which could be attributed to the differences in dry matter of samples. Hurtado *et al.* [8] reported that phosphate-free frankfurters with plasma proteins had similar moisture, but higher protein and lower fat than control samples. pH values of the samples changed between 6.01-6.52, where C samples had the lowest pH value than other samples (P<0.05), due to the effect of sodium carbonate used in these groups. Prabhu and Husak [9] stated that in natural products, sodium carbonate can be used to increase the meat pH.

Table 2 Chemical composition of MSBE samples

	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
C	62.08 ±0.62^{b}	12.95 ±0.50	23.16 ±1.26^{a}	2.20 ±0.02^{a}
J1	67.62 ±0.91^{a}	12.38 ±0.42	19.79 ±1.61^{ab}	1.84 ±0.06^{b}
J2	68.97 ±0.62^{a}	12.25 ±0.35	19.04 ±0.24^{ab}	1.73 ±0.05^{b}
J3	66.52 ±1.44^{a}	12.99 ±0.92	15.71 ±0.63^{b}	1.76 ±0.01^{b}

Data are presented as the mean values of 3 replications ± standard error. ab: Means with the different letter in the same column are significantly different (P<0.05).

The results of ES, JFS and WHC could be seen in Table 3. ES results showed that samples showed different characteristics in terms of TEF and EFAT. C samples had the lowest TEF, while J2 samples had the lowest EFAT (P<0.05). This result could be an indicator of good fat retention property of J2 samples containing 5.7% JAP, while higher TEF results of J1 and J3 could be attributed to higher moisture content of the samples leading release from the structure upon

cooking. The lowest JFS and the highest WHC were recorded in C and J2 compared to J1 and J3 (P<0.05). Similar values of C and J2 samples indicated that J2 was the most effective group showing equivalent stability properties to control samples with phosphate. Hurtado *et al.* [8] reported that phosphate-free frankfurters produced with plasma proteins had similar WHC to control samples, due to high hydrophilic character of plasma proteins. Prabhu and Husak [9] mentioned that potato starch can be used in combination with sodium carbonate as phosphate replacers to provide the improved WHC thereby resulting in improved cook yield and reduced purge in pork. Also, Dimitrakopoulou *et al.* [3] stated that salt level and processing conditions had an important effect on cooking losses in phosphate-free restructured pork products.

Table 3 ES, JFS and WHC of MSBE samples

	ES		JFS (%)	WHC (%)
	TEF (%)	EFAT(%)		
C	11.93 ±0.14^{b}	27.83 ±2.30^{a}	19.75 ±1.14^{b}	52.91 ±1.82^{a}
J1	17.79 ±0.42^{a}	26.87 ±1.92^{a}	29.74 ±0.94^{a}	35.31 ±1.69^{b}
J2	17.78 ±1.02^{a}	15.29 ±0.48^{b}	17.61 ±1.41^{b}	46.43 ±1.36^{a}
J3	19.77 ±0.99^{a}	25.46 ±0.75^{a}	33.24 ±0.75^{a}	27.85 ±2.26^{b}

Data are presented as the mean values of 3 replications ± standard error. ab: Means with the different letter in the same column are significantly different (P<0.05).

Peroxide and TBA values of the samples measured 28 days of storage are illustrated in Fig. 1 and 2, respectively. No significant changes were recorded in the initial peroxide value of the treatments, which were between 0.98-1.04 meq/kg. From 0 day until 14 days, the values remained stable between groups. On 14th day, C samples had lower peroxide value than J2 and J3 (P<0.05). At the end of the storage period, C samples had the lowest peroxide value compared to others (P<0.05), which could be due to accelerated degradation of peroxide compounds during chain reactions of oxidation. During the storage period, peroxide values recorded in treatment groups showed significant decrements (P<0.05). Final peroxide value of the samples measured on 28th day ranged between 0.20-0.55 meq/kg. Initial TBA values of the samples were recorded between 0.23-0.43 mg malonaldehyde/kg. C, J1 and J2 samples had similar initial TBA results, while J3 had higher TBA compared to C (P<0.05). On the other storage days, no significant differences were obtained in TBA values of the samples. During the storage period, TBA values of all the treatments generally remained stable except slight changes. Lipid oxidation rate in samples indicated that utilization of either 3.8% or 5.7% JAP showed favorable impact in terms of meeting antioxidative functions of phosphate. Afoakwah *et al.* [17] found that 9% freeze-dried and oven-dried JAP added sausages showed stronger antioxidant-stability compared to corn starch added sausages. Authors stated that the antioxidant property of the sausages may depend on the total phenolic concentration of the powders.

Fig. 1 Peroxide value of MSBE treatments during storage (meq O_2/kg)

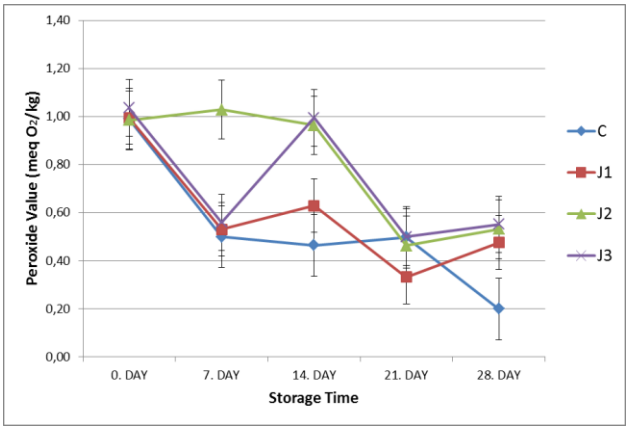
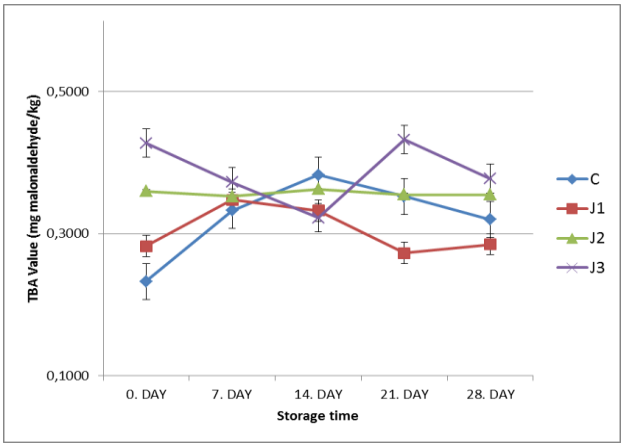


Fig. 2 TBA value of MSBE treatments during storage (mg malonaldehyde/kg)



IV. CONCLUSION

The results of our study showed that utilization of JAP provided advantages in production of phosphate-free beef emulsions in terms of emulsion stability and oxidative parameters. This study presents the first findings of utilization of JAP, a healthy and economical dietary fiber source for phosphate replacement in emulsified meat products. Further and comprehensive research will be needed to assess issues related to different quality parameters of various phosphate-free meat products.

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