Effects of Replacing Pectin with Date Pits Powder in Strawberry Jam Formulation

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ABSTRACT

The importance of date (*Phoenix dactylifera*) pits as an agricultural waste arise from its large dietary fiber contents despite its limited usage in food processing. For this reason, replacing pectin in jam production with date pits powder (DPP) has been considered as a promising research area. This study aimed at evaluating the effects of pectin replacement in a strawberry jam with Khalas palm dates pits powder (DPP) as a novel source of dietary fiber. The examined treatments were replacing 25% of pectin by DPP (0.1%DPP and 0.3% pectin), 50% (0.2%DPP and 0.2% pectin), 75% (0.3 %DPP and 0.1% pectin), and 100% (0.4% %DPP and 0.0% pectin) compared with control treatment at 0.0% DPP and 0.4% pectin. Prepared strawberry jam samples were evaluated monthly for chemical, textural and sensory for six months storage duration. The results indicated that all treatments of pectin replacement have a positive relationship with color parameters. A slight increase in acidity, dry matter contents, Bostwick (consistency indicator) during storage period was also noticed. Replacement treatments at 50% and 75% varied and showed an increase in viscosity, hardness, cohesiveness, and adhesiveness for the strawberry jam samples during the storage period. There were no significant differences (p>0.05) in the sensory scores for color, taste, and texture. Overall acceptability increased steadily up to the 6th month of storage. The use of DPP as a novel source of dietary fiber may be an alternative to pectin in jam production.

Key Words: Date pits, Dietary fiber, Pectin alternative, Strawberry jam, Textural properties

INTRODUCTION

Gelling agents were used in jam products to ensure there is thickness consistency hence firm enough to suspend the fruit puree-sugar in a steady position (Draye and Van Cutsem, 2017). According to Hammod *et al*. (2018), pectin was the primary gelling agent used in some industry. In addition, it is also used to provide the required thickness and firmness for making jams and jellies (Bergholt 2010). However, Munami (2016) reported that pectin, as a gelling agent, exists in different colors and concentrations hence leading to the production of non-uniform jams and jellies. A study by Nostral (2014) found that pectin gelling agents could be classified into two broad classes, which include low methoxyl (LM) pectin (<50% methylation) and high methoxyl (HM) pectin (>50% of methylation). The two forms of pectin coexistence makes it difficult to separate by available techniques, hence making it unsuitable gelling agent for some food products. This stimulated the need to find alternative gelling agents that have minimal variations and compatible with most jams and jellies products. The new gelling agent would improve the organoleptic properties such as color, texture, taste, and shape; hence improving the ability to attract more consumers. The new gelling formulation shall also enhance the stability and shelf life of the jam s and jellies (Javanmard *et al*., 2012 and Aldhaheri *et al*., 2014).

Studies have shown that DPP contain large quantities of fibers that have some health benefits to human beings. In addition, they can provide thickness and firmness required in jam and jellies formulations (Ghazanfari *et al*., 2006 and Mirghani *et al*., 2012a). DPP composition entails 1%-2% ash, 5%-7% proteins, 5%–10% moisture, 7%–10% oil, 10%–20% crude fiber, and 55%–65% carbohydrates on dry mater basis. Studies of Wahini (2016) stated that fibers content in the DPP ranged between 57.0 and 57.5% and DPP contains hemicelluloses at 17.5%, lignin at 11%, cellulose at 42.5%, and ash at 4%. Moreover, the DPP' seeds are good source of natural antioxidants (Messaoudi *et al*., 2013), thus making them potential preservatives that will improve the stability and shelf life of the jams and jellies. DPP are stable and compatible with most food products under most environmental conditions. According to Ciurzyńska *et al.* (2015), DPP have low energy content and considered an ideal food ingredient with a variety of essential nutrients and possible health benefits.

Aldhaheri *et al*. (2014) reported that DPP fibers exhibit unique antioxidant properties. DPP also have higher concentration of acid detergent fibers compared to neutral detergent fibers and higher amounts of lignin that make the DPP resistance to oxidizing agents (Liu *et al*., 2013). The components of the DPP determine its potential uses in food properties and the need to perform studies to assess its qualities that could make it the best gelling agent as compared to the pectin gelling agent for jams' formulation.

DPP have well-balanced solubility and other physicochemical properties that put them at a better position to replace the pectin gelling agent in jam formulation. DPP can improve the shape, thickness, and firmness for jams and jellies (Ghazanfari *et al*., 2006). No researches were reported on replacing pectin in a jam by DPP, so the purpose of this research is to determine the effectiveness of DPP as the replacement of pectin gelling agent in strawberry jam's formulation.

MATERIAL AND METHODS

Date Pits Powder

Local khalas DPP in (Al-ahsa, Saudi Arabia) was prepared according to Suresh *et al.* (2013). DPP were washed, oven dried at 50°C for 48 hours then crushed and milled using grinding mill (Guangzhou Mingyue – China). The prepared pits powder according to Habib and Ibrahim (2009) contained 7.5, 10.5, 5.7, 1.05, and 78.3% (g/100 g) moisture, fat, protein, ash, and fiber, respectively.

Ingredients and Experimental Design

Jam ingredients and formulation (Table 1) was used for the production of strawberry jam with different percentage of DPP. All components were obtained locally for strawberry jam preparations.

Table 1. Formulation of strawberry jam treatments with different percentage of DPP.

Strawberry jam formulation	Control (0.0%)		1 (0.1%)		2 (0.2%)		3 (0.3%)		4 (0.4%)	
% of replacement	0		25%		50%		75%		100%	
Items	g	%	g	%	g	%	g	%	g	%
Sugar	1025	63.1	1025	63.1	1025	63.1	1025	63.1	1025	63.1
Frozen Strawberry 7% TS	585.9	36.06	585.9	36.06	585.9	36.06	585.9	36.06	585.9	36.06
Pectin	6.298	0.388	4.716	0.29	3.149	0.194	1.582	0.097	0	0
DPP	0	0	1.582	0.097	3.149	0.194	4.716	0.29	6.298	0.388
Citric acid	7.323	0.451	7.323	0.451	7.323	0.451	7.323	0.451	7.323	0.451
Strawberry Flavor	0.146	0.009	0.146	0.009	0.146	0.009	0.146	0.009	0.146	0.009
*Water	-24.86	-1.53	-23.28	-1.433	-21.71	-1.336	-20.15	-1.24	-18.57	-1.143
**Total 67% TS	1625	100	1625	100	1625	100	1625	100	1625	100

*The added water was withdrawn by vacuum during evaporation.

** Trail batch of the preparations (1.625 kg of final product).

Preparation of Jam

Local market strawberries were kept at –20°C before use. Frozen strawberries (pH 3.65 ± 0.01 with soluble solids content of 6.1 ± 0.1.), crystallized sucrose, and water were mixed. The mixture was allowed to boil for 10 min, after which, citric acid and pectin (Grindsted MM Pectin, Danisco Ingredients, Brabrand, Denmark) were added according to Holzwarth *et al*. (2013). Strawberry jams were cooked until the final product contained 67% of soluble solids (determined by refractometer). The jam was cooled at room temperature for 60 min before filling and sealing in 0.5 L glass jars. The jam samples were stored for six months at 5°C.

Color and Chemical Analysis

Hunter-Lab color (measurement *L* a* b** which *L** for the lightness, *a** and *b** for the green–red and blue–yellow color components) was used to determine the color of jam samples (CIE 2004 and Renuka *et al*., 2010). Color measurement in *L*a*b** units measured in glass sample cup of Hunter Lab (color flex®) instrument (Reston, VA, USA) according to Hunter and Richard (1987).

The pH of the jam medium was measured using an Orion pH meter (501, USA). The acidity of the citric and solubility of the solids (°Brix) was determined using Abbe Refractometer Model 10494 according to determined according to AOAC (2000).

Physical Analysis

The consistency of jam treatments was measured in triplicate by Bostwick consistometer at 25°C as (mm/g) according to Bourne (1982). Viscosity (centipoise) was detected by Brookfield methods (DV3+pro, USA) with 50 and 100 rpm speed. Brookfield Rheometer, type 10K USA measured hardness or firmness and adhesiveness of jam samples.

Statistical Analysis

The date was analyzed using SPSS software. Analysis of variance was assessed by ANOVA test and expressed at $p<0.05$ statistical significance level. Means comparison was assessed using to Duncan multiple range test.

Sensory Evaluation

According to Ranganna (2008), sensory evaluation scoring type was carried out to assign separation, texture, color, flavor, and overall acceptability. There were twenty points for each attribute acceptance except overall acceptability, which has 100 points.

RESULTS AND DISCUSSION

Color Measurements

Figure1 and table 2 illustrate color appearance and measurements (The average *L**, *a**, *b**) values of strawberry jam with the addition of DPP. Table 2 revealed that the increase in DPP concentration from 0.1% to 0.3% (0.1% and 0.3% represent 25% and 75% replacement of pectin) in jams increased *a** values (redness) during the six months of study. Comparable data were reported by Phimpharian *et al*. (2011) where positive relationship between fiber adding and *a** value was noticed. The redness factor was due to the anthocyanins contents according to Emerton (2008) in addition to water binding materials acted as co-pigment as stated by Lewis *et al*., 1995, that led to the increase jam red color (*a** values). DPP addition level increased the lightness, *L** at the beginning of storage then decreased later for all treatments at the end of storage. The addition of DPP increased the reflectance and consequently the lightness of the jam samples as a result of its characteristic color (Igual *et al*., 2014). For that reason, the addition of DPP turned the strawberry jam a bit dark (Fig. 1) although no red colorings were added. The change in color values may be due to non-enzymatic browning reactions. Damiani *et al*. (2012) noticed a decrease in color of the jam during a year of storage. In addition, Besbes *et al*. (2009) reported the same in their two months' study. These differences in color could be due to pectin's characteristics, particularly with other gelling agent or fiber. Anthocyanin contents strongly depend on pectin variety for electrostatic interactions of carboxylic groups (Hubbermann *et al*., 2006 and Holzwarth *et al*., 2013).

The past results of Grigelmo-Miguel and Martin-Belloso (1999) indicated an inverse relationship between dietary fiber after increasing the redness, yellowness, and lightness. The darkness may be due to non-enzymatic (Maillard) browning. Krokida and Maroulis (2000) indicated that water removal prevents enzymatic browning causing color stability.

Figure 1. Appearance strawberry jams with DPP.

Table 2: Color Measurements of strawberry Jam with addition of DPP.

Storage Time (months)	Replacement (%)	*L**	*a**	*b**	*a/b*
0	0	11.23^{i} ± 0.01	4.16^{q} ± 0.01	3.03^{s} ± 0.01	1.37^{a} ± 0.01
	25	11.42^{e} ± 0.02	4.22^{op} ± 0.01	3.08^{r} ± 0.02	1.37^{a} ± 0.01
	50	11.54^{d} ± 0.02	4.22^{nop} ± 0.01	3.09^{r} ± 0.02	1.37^{a} ± 0.01
	75	11.64^{b} ± 0.02	4.25^{mno} ± 0.03	3.11^{q} ± 0.02	1.36^{a} ± 0.01
	100	11.68^{a} ± 0.01	4.25^{mn} ± 0.03	3.12^{q} ± 0.01	1.36^{a} ± 0.01
1	0	11.11^{k} ± 0.01	4.21^{p} ± 0.00	3.07^{r} ± 0.01	1.37^{a} ± 0.00
	25	11.32^{g} ± 0.02	4.26^{lm} ± 0.01	3.13^{pq} ± 0.02	1.36^{a} ± 0.01
	50	11.42^{e} ± 0.02	4.28^{lm} ± 0.01	3.13^{pq} ± 0.02	1.37^{a} ± 0.01
	75	11.52^{d} ± 0.02	4.27^{lm} ± 0.03	3.14^{op} ± 0.02	1.36^{a} ± 0.01
	100	11.57^{c} ± 0.01	4.29^{kl} ± 0.01	3.16^{no} ± 0.01	1.36^{a} ± 0.00
2	0	10.98^{m} ± 0.01	4.29^{kl} ± 0.01	3.12^{pq} ± 0.01	1.38^{a} ± 0.00
	25	11.19^{j} ± 0.02	4.33^{ij} ± 0.01	3.17 ^{n}± 0.02	1.37^{a} ± 0.01
	50	11.27^{h} ± 0.03	4.33^{ij} ± 0.02	3.18^{mn} ± 0.01	1.36^{a} ± 0.01
	75	11.39^{f} ± 0.01	4.33^{ij} ± 0.02	3.18^{mn} ± 0.01	1.36^{a} ± 0.01
	100	11.44^{e} ± 0.01	4.37^{gh} ± 0.02	3.21^{lm} ± 0.02	1.36^{a} ± 0.01
3	0	10.87^{op} ± 0.01	4.32^{jk} ± 0.01	3.22^{l} ± 0.00	1.34^{b} ± 0.00
	25	11.07^{l} ± 0.02	4.37^{gh} ± 0.02	3.27^{k} ± 0.02	1.34^{b} ± 0.00
	50	11.18^{j}± 0.01	4.36^{hj} ± 0.03	3.28^{jk} ± 0.01	1.33^{bc} ± 0.01
	75	11.27^{h} ± 0.02	4.36^{hj} ± 0.04	3.30^{jk} ± 0.02	1.32^{c} ± 0.02
	100	11.33^{g} ± 0.01	4.40^{efg} ± 0.01	3.31^{j} ± 0.02	1.33^{bc} ± 0.01
4	0	10.65^{t} ± 0.01	4.38^{fgh} ± 0.01	3.56^{i} ± 0.01	1.23^{d} ± 0.00
	25	10.85^{op} ± 0.01	4.42^{de} ± 0.01	3.62^{h} ± 0.01	1.22^{d} ± 0.01
	50	10.96^{n} ± 0.02	4.44^{cd} ± 0.00	3.63^{h} ± 0.01	1.22^{d} ± 0.00
	75	11.06^{l}± 0.02	4.46^{c} ± 0.02	3.65^{gh} ± 0.03	1.22^{d} ± 0.01
	100	11.12^{hk} ± 0.03	4.46^{c} ± 0.02	3.66^{g} ± 0.03	1.22^{d} ± 0.01
5	0	10.43^{w} ± 0.02	4.41^{ef} ± 0.01	3.78^{f} ± 0.01	1.17^{e}± 0.00
	25	10.63^{t} ± 0.02	4.46^{c} ± 0.01	3.82^{e} ± 0.01	1.17^{e} ± 0.00
	50	10.74^{r} ± 0.02	4.47^{bc} ± 0.01	3.83^{e} ± 0.02	1.17^{e} ± 0.01
	75	10.84^{q} ± 0.02	4.46^{c} ± 0.04	3.84^{de} ± 0.02	1.16^{e} ± 0.00
	100	10.88^{o} ± 0.02	4.50^{b} ± 0.01	3.86^{D} ± 0.01	1.16^{e} ± 0.00
6	0	10.28^{x} ± 0.01	4.47^{bc} ± 0.01	3.95^{c} ± 0.01	1.13^{f} ± 0.00
	25	10.49^{v} ± 0.01	4.53^{a} ± 0.01	3.98^{bc} ± 0.03	1.14^{f} ± 0.01
	50	10.58^{u} ± 0.01	4.54^{a} ± 0.02	4.00^{b} ± 0.02	1.14^{f} ± 0.01
	75	10.69^{s} ± 0.02	4.53^{a} ± 0.02	4.01^{ab} ± 0.02	1.13^{f} ± 0.01
	100	10.74^{r} ± 0.01	4.55^{a} ± 0.01	4.04^{a} ± 0.06	1.13^{f} ± 0.02

Mean ± SD Within columns, means followed by the same letter are not significantly different according to Duncan's (0.05).

Chemical Parameters

Addition of DPP to strawberry jams decreased the pH of the final products in all treatments. The pH results of the jam formulations used as a control ranged from 2.90 ± 0.01 to 2.79 ± 0.01 at the end of storage. Regarding DPP addition, there was a subsequent decrease in pH value (Table 3). The present results of pH matched Hussain and Shakir (2010) and Abid *et al*. (2018) findings. Low pH is required for food products like Jams to prevent bacterial contamination and growth. The pH of the jam also affects the viscosity of the final product. Gel firmness depends on pH and the range of pH to support the formation of gel varies from 3 to 3.5. The pH of the jam also affects the viscosity of the final product. Gel firmness depends upon pH, and the range of pH to form gel varies from 3 to 3.5. The value of thickness was not entirely predictable since it also depends on other factors such as temperature, the degree of methylation, the concentration of pectin used, or any alkaline earth salts that may be present (Panda 2011). Acidity is one of the most vital parameters influencing pectin gelation, texture and overall quality of fruit jams that should be controlled (Garrido *et al*., 2015). The acidity of the control treatment correlated with pH slightly increased from 0.65% ± 0.00 to 0.68% ± 0.01 at the end of storage. Acidity increased due to reduced sugars or pectin conversion to pectic acid, and this result was similar to the finding of Kanwal *et al*. (2017). The bright indication for dry matter contents varied in all treatments between 64.10 ± 0.00 and 65.00 ± 0.00 %. Meanwhile, in all treatments, dry matter was slightly increased during the storage period. Increase in brightness may be due to solublization of jam ingredients or components throughout storage and acid hydrolysis of pectin and fiber. This is similar to Muhammad *et al*. (2008) and Safdar *et al*. (2012) findings.

Table 3: Chemical parameters of strawberry Jam with addition of DPP.

Storage Time (months)	Replacement (%)	Acidity (%)	pH	Brix°
0	0	$0.65^{hij} \pm 0.00$	$2.90^{fg} \pm 0.01$	$64.30^{ij} \pm 0.00$
	25	$0.63^{lmn} \pm 0.00$	$2.99^{c} \pm 0.01$	$64.20^{kl} \pm 0.00$
	50	$0.62^{n} \pm 0.00$	$3.07^{b} \pm 0.06$	$64.20^{kl} \pm 0.00$
	75	$0.63^{mn} \pm 0.01$	$3.15^{a} \pm 0.01$	$64.10^{mn} \pm 0.00$
	100	$0.64^{klm} \pm 0.01$	$3.17^{a} \pm 0.06$	$64.00^{o} \pm 0.00$
1	0	$0.65^{hij} \pm 0.00$	$2.88^{gh} \pm 0.01$	$64.33^{hi} \pm 0.06$
	25	$0.63^{klm} \pm 0.01$	$2.98^{c} \pm 0.01$	$64.23^{jk} \pm 0.06$
	50	$0.63^{mn} \pm 0.01$	$3.03^{b} \pm 0.06$	$64.23^{jk} \pm 0.06$
	75	$0.64^{ijk} \pm 0.01$	$3.07^{b} \pm 0.01$	$64.13^{lm} \pm 0.06$
	100	$0.64^{ijk} \pm 0.01$	$3.13^{a} \pm 0.06$	$64.03^{no} \pm 0.06$
2	0	$0.65^{ghi} \pm 0.01$	$2.85^{hi} \pm 0.01$	$64.40^{gh} \pm 0.00$
	25	$0.64^{ijk} \pm 0.01$	$2.96^{cd} \pm 0.01$	$64.30^{ij} \pm 0.00$
	50	$0.63^{klm} \pm 0.01$	$2.97^{cd} \pm 0.01$	$64.30^{ij} \pm 0.00$
	75	$0.65^{hij} \pm 0.00$	$2.93^{de} \pm 0.01$	$64.23^{jk} \pm 0.06$
	100	$0.66^{fgh} \pm 0.01$	$2.99^{c} \pm 0.01$	$64.13^{lm} \pm 0.06$
3	0	$0.66^{fgh} \pm 0.00$	$2.83^{ij} \pm 0.01$	$64.43^{g} \pm 0.06$
	25	$0.65^{ghi} \pm 0.01$	$2.87^{ghi} \pm 0.01$	$64.43^{g} \pm 0.06$
	50	$0.64^{jkl} \pm 0.00$	$2.93^{ef} \pm 0.01$	$64.33^{hi} \pm 0.06$
	75	$0.66^{fgh} \pm 0.01$	$2.88^{gh} \pm 0.01$	$64.33^{hi} \pm 0.06$
	100	$0.66^{fgh} \pm 0.01$	$2.88^{gh} \pm 0.01$	$64.23^{jk} \pm 0.06$

Table 3, cont.

Storage Time (months)	Replacement (%)	Acidity (%)	pH	Brix°
4	0	0.66^{efg} ± 0.01	2.81^{jk} ± 0.01	64.60^{ef} ± 0.00
	25	0.66^{efg} ± 0.01	2.85^{hi} ± 0.01	64.63^{de} ± 0.06
	50	0.66^{fgh} ± 0.01	2.88^{gh} ± 0.01	64.53^{f} ± 0.06
	75	0.68^{bcd} ± 0.01	2.85^{hi} ± 0.01	64.43^{g} ± 0.06
	100	0.68^{cd} ± 0.00	2.78^{klmno} ± 0.01	64.33^{hi} ± 0.06
5	0	0.67^{de} ± 0.01	2.80^{jkl} ± 0.01	64.77^{bc} ± 0.06
	25	0.67^{de} ± 0.01	2.79^{klm} ± 0.01	64.73^{bc} ± 0.06
	50	0.67^{ef} ± 0.01	2.81^{jk} ± 0.01	64.70^{cd} ± 0.00
	75	0.69^{ab} ± 0.01	2.79^{klmn} ± 0.01	64.53^{f} ± 0.06
	100	0.69^{bc} ± 0.01	2.76^{mno} ± 0.01	64.53^{f} ± 0.06
6	0	0.68^{bcd} ± 0.01	2.79^{klm} ± 0.01	65.00^{a} ± 0.00
	25	0.68^{bcd} ± 0.01	2.74^{o} ± 0.01	64.80^{b} ± 0.00
	50	0.68^{bcd} ± 0.01	2.77^{lmno} ± 0.01	64.77^{bc} ± 0.06
	75	0.70^{a} ± 0.01	2.76^{mno} ± 0.01	64.63^{de} ± 0.06
	100	0.70^{a} ± 0.01	2.75^{no} ± 0.01	64.60^{ef} ± 0.00

Mean ± SD Within columns, means followed by the same letter are not significantly different according to Duncan's (0.05).

Physical Parameters

The physical characteristics of strawberry jam after addition of DPP like Bostwick, viscosity, hardness, adhesiveness, and cohesiveness are shown in table 4. Bostwick consistency indicator values due to 0.1% and 0.2 % DPP usage (which represent 25% and 50% replacement of pectin), was almost identical to the control sample values at the beginning of storage period. However, during storage progressing, it increased compared to the control sample. In line with present research objectives, improvement of consistency of jam by using different kinds of fiber was the target point for studies including peach dietary fiber (Grigelmo-Maguel and Martin-Belloso 1999) bamboo fibre (Igual *et al*., 2014), tomato pomace fiber (Belovic´ *et al*., 2017), and pomegranate peel fiber (Abid *et al*., 2018).

Viscosity results at 50 and 100 rpm of strawberry jam after additions of DPP particularly for 0.2% and 0.3 % treatments (which represent 50% and 75% replacement of pectin) did not appear to increase with DPP fiber addition until the second month of storage. Developments of viscosity as a result of fiber adding were mentioned in similar researches (Igual *et al*., 2014; Belovic´ *et al*., 2017; Abid *et al*., 2018). Richness in thickeners, with regards to gelling agent caused the highest hardness or firmness and adhesiveness (Al-Hooti *et al*., 1995). Hardness or firmness for strawberry jam after addition of DPP (Table 4) is defined as the force required in achieving a given deformation. Hardness value is directly proportional to the DPP addition at the beginning of storage period while treatments 0.2% and 0.3% retained the increase of hardness until the last month of storage (the 6th month). Therefore, these results support pectin replacement by DPP fiber due to an increase of elasticity active polymeric chains in the pectin structure as reported by both Basu and Shivhare (2010) and Belovic´*et al*. (2017). They asserted that fiber particles are incorporated in jam pectin network to act as a lubricant. As pectin was used to obtain a viscous texture suitable for increasing the viscosity of preparation, the viscosity of jam was noted to rise with the gradual increase in pectin concentration. This is in line with the studies previously done by Nwosu *et al*. (2014).

Viscosity, adhesiveness, cohesiveness, and texture of pectin replaced jam by DPP increased during the storage period. This could be due to effect of the hydration properties of the DPP fiber matrix as reported in the study of Thibault *et al.* (1992). However, Abid (2018) indicated that pomegranate fiber weakened texture strength of jam.

Replacing commercial pectin by DPP fiber enhanced firmness and adhesiveness concerning the characteristics of pectins as reported by Abid *et al*. (2017a and b). Samples enriched with DPP (particularly 50% replacement) exhibited higher firmness and adhesiveness according to Dhingra *et al.* (2012). Fibers supported jam enrich network formed by pectin. This is consistent with the study of Igual *et al*. (2014). The ability of DPP dietary fiber to avoid syneresis and increase water binding capacity was reported by Kuntz (1994) and matching fiber matrix with a gelling agent as reported by Thibault *et al*. (1992).

Table 4: Physical parameters of strawberry Jam with addition of DPP.

Storage Time (Months)	Replacement (%)	Bostwick	Viscosity at 50 rpm	Viscosity at 100 rpm	Hardness(g)	Adhesiveness (g.mm)	Cohesiveness
0	0	8.0^{a} ± 0.00	13633^{z} ± 57.7	9643^{z} ± 5.8	242^{y} ± 0.6	149^{t} ± 0.6	146^{u} ± 1.2
	25	7.0^{b} ± 0.00	11633^{z} ± 57.7	8153^{z} ± 57.7	285^{x} ± 1.2	135^{xy} ± 0.0	160^{t} ± 0.6
	50	6.8^{c}± 0.06	8163^{z} ± 5.8	6280^{z} ± 0.0	426^{p} ± 0.0	228^{b} ± 0.6	188^{r} ± 1.2
	75	6.5^{d} ± 0.06	7567^{z} ± 57.7	5083^{z} ± 5.8	486^{k} ± 1.7	192^{mn} ± 0.6	197^{q} ± 1.7
	100	5.5^{e} ± 0.06	6833^{z} ± 57.7	4637^{z} ± 28.9	237^{z} ± 0.0	261^{a} ± 0.6	223^{p} ± 3.0
1	0	2.0^{i} ± 0.00	44433^{z} ± 57.7	23133^{yz} ± 57.7	299^{v} ± 0.0	151^{s} ± 0.6	200^{q} ± 1.2
	25	2.3^{g} ± 0.06	77567^{r} ± 57.7	23133^{yz} ± 57.7	293^{w} ± 1.5	135^{y} ± 0.6	178^{s} ± 0.6
	50	2.1^{h} ± 0.06	81033^{p} ± 57.7	33633^{r} ± 115.5	438^{o} ± 1.5	227^{bc} ± 0.6	244^{o} ± 1.2
	75	2.1^{h} ± 0.00	87033^{n} ± 57.7	23033^{z} ± 57.7	507^{j} ± 5.1	193^{m} ± 0.6	223^{p} ± 1.2
	100	2.4^{f} ± 0.06	39033^{z} ± 57.7	33133^{s} ± 57.7	238^{z} ± 0.6	220^{d} ± 0.6	299^{j} ± 1.7
2	0	1.0^{m} ± 0.00	53867^{y} ± 57.7	37267^{q} ± 57.7	363^{s} ± 0.6	165^{p} ± 0.0	224^{p} ± 1.7
	25	1.4^{j} ± 0.00	98133^{i} ± 57.7	44167^{l} ± 115.5	296^{v} ± 2.5	136^{x} ± 0.0	199^{q} ± 1.7
	50	1.1^{l} ± 0.00	96000^{l} ± 0.0	56833^{g} ± 57.7	446^{n} ± 1.2	226^{c} ± 1.2	29^{9} ± 1.2
	75	1.2^{k} ± 0.06	99067^{h} ± 115.5	39633^{m} ± 57.7	531^{g} ± 1.7	195^{l} ± 0.0	268n ± 1.2
	100	0.5^{o} ± 0.00	47033^{z} ± 57.7	38033^{o} ± 57.7	238^{z} ± 0.6	197^{k}± 1.7	335^{g} ± 2.3
3	0	0.5^{o} ± 0.00	64833^{u} ± 57.7	48500^{j} ± 100	387^{r} ± 0.6	180^{o} ± 0.6	246^{o} ± 1.7
	25	0.6^{m} ± 0.06	102433^{g} ± 57.7	62067^{f} ± 115.5	399^{q} ± 1.7	138^{v} ± 0.6	246^{o} ± 2.5
	50	0.3^{p} ± 0.06	124000^{d} ± 0.0	70767^{d} ± 57.7	543^{e} ± 0.0	220de ± 0.0	301^{j} ± 1.2
	75	0.2^{q} ± 0.00	123233^{e} ± 57.7	54733^{h} ± 115.5	543^{e} ± 1.7	202^{j} ± 1.2	300^{j} ± 1.7
	100	0.1^{r} ± 0.06	58433^{x} ± 57.7	23233^{y} ± 57.7	303^{u} ± 2.9	159^{q} ± 1.2	399^{d} ± 2.3
4	0	0.5^{o} ± 0.06	81533^{o} ± 57.7	44067^{l} ± 115.5	396^{q} ± 3.5	191^{n} ± 0.6	266^{n} ± 2.3
	25	0.5^{o} ± 0.00	99133^{h} ± 57.7	66167^{e} ± 208.2	513^{i} ± 2.3	138^{w} ± 0.6	266^{n} ± 0.0
	50	0.2^{q} ± 0.00	154000^{c} ± 0.0	80233^{c} ± 57.7	647^{d} ± 2.3	219^{fg} ± 0.6	306^{i} ± 2.9
	75	0.2^{qr} ± 0.06	97033^{k} ± 57.7	50233^{i} ± 115.5	546^{e} ± 3.5	216^{i} ± 0.6	345^{f} ± 1.2
	100	0.1^{rs} ± 0.00	60067^{w} ± 115.5	24333^{x} ± 57.7	350^{s} ± 0.6	156^{r} ± 0.6	412^{c} ± 1.5

Table 4, cont.

Storage Time (Months)	Replacement (%)	Bostwick	Viscosity at 50 rpm	Viscosity at 100 rpm	Hardness(g)	Adhesiveness (g.mm)	Cohesiveness
5	0	0.2^{q} ± 0.00	99033^{h} ± 57.7	37567^{p} ± 115.5	462^{m} ± 2.9	202^{j} ± 1.2	272^{m} ± 1.7
	25	0.3^{p} ± 0.06	89233^{m} ± 57.7	45067^{k} ± 115.5	517^{h} ± 1.7	141^{u} ± 1.2	280^{kl} ± 1.7
	50	0.1^{rs} ± 0.00	180000^{a} ± 0.0	99767^{c}± 57.7	655^{c} ± 1.7	218^{fg} ± 1.2	320^{h} ± 1.7
	75	0.1^{rs} ± 0.00	66067^{j} ± 115.5	39167^{n} ± 57.7	698^{b} ± 0.6	219^{ef} ± 0.0	368^{e} ± 1.2
	100	0.0^{t} ± 0.00	64100^{r} ± 173.2	26067^{w} ± 115.5	426 ^{p}± 1.2	151^{s} ± 0.6	446^{b} ± 2.5
6	0	0.0^{t} ± 0.00	106433^{f} ± 57.7	26367^{v} ± 57.7	475^{l} ± 0.0	218^{gh} ± 0.6	278^{l} ± 0.6
	25	0.2^{qr} ± 0.06	80767^{q} ± 57.7	28100^{u} ± 173.2	535^{f} ± 1.7	144^{u} ± 0.0	282^{k} ± 2.3
	50	0.1^{qrs} ± 0.06	188800^{a} ± 0.0	110433^{a} ± 57.7	644^{d} ± 2.0	217^{hi} ± 0.6	335^{g} ± 4.6
	75	0.1st ± 0.06	47267^{j} ± 115.5	32467^{t} ± 115.5	823^{a} ± 5.5	221^{d} ± 0.6	370^{e} ± 2.6
	100	0.0^{t} ± 0.00	67267^{s} ± 115.5	22067^{z} ± 115.5	443^{n} ± 3.5	144^{u} ± 1.2	461^{a} ± 1.5

Mean ± SD Within columns, means followed by the same letter are not significantly different according to Duncan's (0.05).

Sensory Evaluation

The sensory properties of DPP strawberry jam for appearance, flavor, mouthfeel, and texture during storage, as shown in Table 5, indicated insignificant differences ($p>0.05$) in the sensory scores for color, taste, texture and overall acceptability in comparison to control sample. Overall, acceptability increased steadily up to the 6th month of storage, after that it was reduced with insignificant impact. The scores of appearance, flavor, mouthfeel, and texture were slightly higher at the end of the storage period than when freshly prepared. Similarly, overall acceptability fluctuated with the storage period. Appearance scores decreased somewhat due to chemical reactions between the components and organic acids in the jam. The decrease of jam color scores could be attributed to Maillard reactions, ascorbic acid degradation, and polymerization of anthocyanins with other phenolic (Akhtar *et al*., 2009 and Isah, 2017). Organic acid and sugars ratio primarily creates a sense of taste, which is felt by specialized taste buds in the tongue. The increase in the taste score might be due to an increase in reducing sugars as well as soluble solids content. The overall flavor impression is the result of the taste perceived by the taste buds in the mouth and the aromatic compounds detected by the epithelium of the olfactory organ in the mouth. The scores for flavor decreased with storage probably due to storage effect. Changes in taste are the most sensitive index for detection of quality deterioration during storage, followed by color (Akhtar *et al*., 2009). Texture is comprised of those properties of a product that can be appraised visually or by touch. Jam and syrup remained acceptable to the panelists up to the end of the storage period. Akhtar *et al*. (2009) reported that sensory traits are not generally inter-related and contribute independently towards the overall sensory perception.

Table 5: Sensory Evaluation of strawberry Jam with addition of DPP.

Storage Time (Months)	Replacement (%)	Appearance	Texture	Flavor	Mouthfeel	Overall
0	0	8.8^{bc} ± 0.26	8.8^{bcdef} ± 0.26	9.2^{bcd} ± 0.26	9.1^{cd} ± 0.26	8.3^{gh} ± 0.26
	25	8.8^{bc} ± 0.26	8.8^{bcdef} ± 0.26	9.7^{a} ± 0.26	9.7^{a} ± 0.26	9.3^{abc} ± 0.26
	50	9.2^{ab} ± 0.26	9.2^{abcd} ± 0.26	9.2^{bcd} ± 0.26	9.2^{bcd} ± 0.26	9.3^{abc} ± 0.26
	75	8.8^{bc} ± 0.26	9.1^{abcde} ± 0.26	9.1^{cd} ± 0.26	9.3^{abcd} ± 0.26	8.9^{bcdef} ± 0.26
	100	8.3^{ef} ± 0.26	8.4^{fgh} ± 0.26	8.3^{ef} ± 0.26	8.4^{e} ± 0.26	8.5^{efgh} ± 0.26

Table 5, cont.

Storage Time (Months)	Replacement (%)	Appearance	Texture	Flavor	Mouthfeel	Overall
1	0	$8.8^{bc} \pm 0.26$	$8.8^{bcdef} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.0^{d} \pm 0.26$	$8.4^{efgh} \pm 0.26$
	25	$8.9^{abc} \pm 0.26$	$8.9^{abcdef} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.3^{abc} \pm 0.26$
	50	$9.2^{ab} \pm 0.26$	$9.2^{abcd} \pm 0.26$	$9.0^{d} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.5^{ab} \pm 0.26$
	75	$8.8^{bc} \pm 0.26$	$9.2^{abcd} \pm 0.26$	$9.3^{bcd} \pm 0.26$	$9.3^{abcd} \pm 0.26$	$8.9^{bcdef} \pm 0.26$
	100	$8.3^{ef} \pm 0.26$	$8.8^{cdefg} \pm 0.26$	$8.2^{ef} \pm 0.26$	$8.3^{e} \pm 0.26$	$8.4^{efgh} \pm 0.26$
2	0	$8.8^{bc} \pm 0.26$	$8.8^{cdefg} \pm 0.26$	$9.3^{bcd} \pm 0.26$	$9.1^{cd} \pm 0.26$	$8.4^{efgh} \pm 0.26$
	25	$8.9^{abc} \pm 0.26$	$8.9^{abcdef} \pm 0.26$	$9.6^{ab} \pm 0.26$	$9.6^{ab} \pm 0.26$	$9.3^{abc} \pm 0.26$
	50	$9.3^{a} \pm 0.26$	$9.3^{abc} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.3^{abcd} \pm 0.26$	$9.2^{abcd} \pm 0.26$
	75	$8.8^{bc} \pm 0.26$	$9.1^{abcde} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.0^{bcde} \pm 0.26$
	100	$8.3^{ef} \pm 0.26$	$8.4^{fgh} \pm 0.26$	$8.2^{ef} \pm 0.26$	$8.3^{e} \pm 0.26$	$8.6^{defgh} \pm 0.26$
3	0	$8.9^{abc} \pm 0.26$	$8.9^{abcdef} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.1^{cd} \pm 0.26$	$8.3^{gh} \pm 0.26$
	25	$8.8^{bc} \pm 0.26$	$8.8^{bcdef} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.6^{ab} \pm 0.26$	$9.5^{ab} \pm 0.26$
	50	$9.2^{ab} \pm 0.26$	$9.2^{abcd} \pm 0.26$	$9.0^{d} \pm 0.26$	$9.0^{d} \pm 0.26$	$9.3^{abc} \pm 0.26$
	75	$8.8^{bc} \pm 0.26$	$9.1^{abcde} \pm 0.26$	$9.3^{bcd} \pm 0.26$	$9.1^{cd} \pm 0.26$	$8.8^{cdefg} \pm 0.26$
	100	$8.2^{ef} \pm 0.26$	$8.4^{fgh} \pm 0.26$	$8.5^{e} \pm 0.26$	$8.5^{e} \pm 0.26$	$8.5^{efgh} \pm 0.26$
4	0	$8.8^{bc} \pm 0.26$	$8.8^{cdefg} \pm 0.26$	$9.3^{bcd} \pm 0.26$	$9.3^{abcd} \pm 0.26$	$8.3^{fgh} \pm 0.26$
	25	$8.8^{bc} \pm 0.26$	$8.8^{bcdef} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.5^{ab} \pm 0.26$
	50	$9.3^{a} \pm 0.26$	$9.3^{abc} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.3^{abc} \pm 0.26$
	75	$8.8^{bc} \pm 0.26$	$8.8^{cdefg} \pm 0.26$	$9.1^{cd} \pm 0.26$	$9.1^{cd} \pm 0.26$	$8.9^{bcdef} \pm 0.26$
	100	$8.2^{ef} \pm 0.26$	$8.6^{efg} \pm 0.26$	$8.1^{f} \pm 0.26$	$8.1^{e} \pm 0.26$	$8.7^{defgh} \pm 0.26$
5	0	$8.7^{cd} \pm 0.26$	$8.7^{defg} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.3^{abcd} \pm 0.26$	$8.3^{fgh} \pm 0.26$
	25	$8.9^{abc} \pm 0.26$	$8.9^{abcdef} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.7^{a} \pm 0.26$	$9.5^{ab} \pm 0.26$
	50	$9.2^{ab} \pm 0.26$	$9.2^{abcd} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.7^{a} \pm 0.26$
	75	$8.8^{bc} \pm 0.26$	$9.4^{a} \pm 0.26$	$9.3^{bcd} \pm 0.26$	$9.3^{abcd} \pm 0.26$	$8.8^{cdefg} \pm 0.26$
	100	$8.3^{ef} \pm 0.26$	$8.3^{gh} \pm 0.26$	$8.3^{ef} \pm 0.26$	$8.5^{e} \pm 0.26$	$8.5^{efgh} \pm 0.26$
6	0	$7.9^{f} \pm 0.26$	$7.9^{h} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$8.4^{efgh} \pm 0.26$
	25	$8.9^{abc} \pm 0.26$	$8.9^{abcdef} \pm 0.26$	$9.5^{abc} \pm 0.26$	$9.5^{abc} \pm 0.26$	$9.3^{abc} \pm 0.26$
	50	$9.2^{ab} \pm 0.26$	$9.3^{ab} \pm 0.26$	$9.0^{d} \pm 0.26$	$9.0^{d} \pm 0.26$	$9.3^{abc} \pm 0.26$
	75	$8.8^{bc} \pm 0.26$	$8.8^{bcdef} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$9.2^{bcd} \pm 0.26$	$8.9^{bcdef} \pm 0.26$
	100	$8.3^{de} \pm 0.26$	$9.3^{ab} \pm 0.26$	$8.3^{ef} \pm 0.26$	$8.3^{e} \pm 0.26$	$8.2^{h} \pm 0.26$

Mean ± SD Within columns, means followed by the same letter are not significantly different according to Duncan's (0.05).

CONCLUSION

DPP could be a successful source of dietary fiber functional food used as gelling agent. The use of DPP may also be an alternative to pectin in jam production.

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تأثيرات إحلال البكتين بمطحون نوى التمر في مخاليط مربى الفراولة

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الملخص

أهمية نوى التمر كمخلف زراعي تكمن في احتوائه على نسبة كبيرة من الألياف الغذائية رغم محدودية تطبيقاته في التصنيع الغذائي. ولهذا السبب فإحلال البكتين لاستحداث الهلام في المربى تعد غاية بحثية للتطوير في إنتاج المربى، الأمر الذي استهدفته تلك الدراسة بتقييم تأثيرات إحلال البكتين في مربى الفراولة بمطحون نوى تمر الخلاص كمصدر مبتكر للألياف الغذائية. حل مطحون نوى التمر محل البكتين بنسبة إحلال بلغت 25 % (0.1 % مطحون، 0.3 % بكتين)، 50 % (0.2 % مطحون، 0.2 % بكتين)، 75 % (0.3 % مطحون، 0.1 % بكتين)، و100 % (0.4 % مطحون، 0 % بكتين) مقارنة بالعينة الضابطة (0 % مطحون، 0.4 % بكتين). تلك المعاملات المحضرة من مربى الفراولة تم تقييم خواصها الكيماوية والحسية والقوام شهريا خلال فترة التخزين التي بلغت ستة أشهر. هذا وقد دلت نتائج معاملات الإحلال للبكتين على علاقة إيجابية مع محددات اللون، وعلى نحو آخر لوحظت زيادات طفيفة في قيم الحموضة والجوامد الصلبة ومؤشر التناسق خلال فترة التخزين. معاملات إحلال البكتين 50 %، 75 % بمطحون نوى التمر أظهرت زيادات متفاوتة في اللزوجة والصلابة والتماسك والالتصاق لعينات المربى خلال فترة التخزين، كما لم تكن هناك أية اختلافات معنوية في التقييم الحسي للون والطعم والقوام، وكان هناك قبول عام له خلال فترة التخزين. لذلك استخدام مطحون نوى التمر كمصدر مبتكر للألياف الغذائية يمكن أن يكون من البدائل للبكتين في صناعة المربى.

الكلمات المفتاحية: الألياف الغذائية، بدائل البكتين، خواص القوام، مربى الفراولة، مطحون نوى التمر.