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Quality Characteristics and Sensory Profile of Stirred Yogurt Enriched with Papaya Peel Powder

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ABSTRACT

Dietary fibre enriched food is gaining more popularity due to their numerous health benefits. In this study, papaya peel powder was prepared as a source of dietary fibre to be fortified in yogurt at different concentrations (1.5 and 3.0 % w/w). Papaya peel was dried at three different temperatures (45, 55 and 65°C) and the results showed that drying at temperature of 55 and 65°C was able to retain higher total dietary fibre content of 40.21 and 48.00 g/100 g, respectively, and was used for enrichment in yogurt. The quality characteristics in terms of viscosity, pH and colour (*L**, *a**, *b**, chroma, hue angle and total colour difference) of stirred yogurt added with papaya peel powder stored at 4°C was investigated weekly up to 21 days. Sensory evaluation (9-point hedonic scale) was also conducted for the yogurt samples prepared. Results showed the viscosity of yogurt was higher when the amount of papaya peel powder added was increased. It also showed an increasing trend during 21 days of storage. The pH values of the samples prepared had no significant difference ($P > 0.05$) as the concentration of powder was raised. However, a notable reduction in pH was observed after storage. Colour parameters were also significantly affected ($P < 0.05$) by the addition of powder, with fortified samples exhibiting darker (lower *L** value) and more yellowish (higher *b** value) colour than the control sample.

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Nonetheless, the parameters remained unchanged during storage of 21 days. Sensory results revealed that the stirred yogurt with 1.5% concentration of papaya peel powder dried at 55°C received the highest sensory scores among other samples.

Keywords: Papaya peel, quality characteristics, sensory analysis, stirred yogurt, storage analysis

INTRODUCTION

Papaya or paw-paw (*Carica papaya*) is a tropical fruit which belongs to the family of Caricaceae. This fruit is originally native to Tropical America and is grown in many countries; Australia, Hawaii, India, Philippines and Malaysia to name a few (Anuar et al., 2008; Yogiraj et al., 2014). Papaya has gained popularity owing to its numerous health benefits and is often termed as a nutraceutical fruit. It is low in calories and is a source of antioxidants, minerals, fibre and vitamins (Prajapati et al., 2017). This has led the fruit to be consumed in large quantities globally and thus, resulting in a huge amount of by-products.

The by-products of papaya mainly constitute of peels and seeds, which make up 20 to 25% by fruit weight (Pavithra et al., 2017). Papaya peels have been found to be rich in fibre as they constitute total, soluble and insoluble dietary fibre (g/100) with 59.8 ± 0.5, 19.93 ± 0.01 and 39.9 ± 0.5, respectively (Calvache et al., 2016). Besides being rich in nutrients like protein, carbohydrates, ash, fat and minerals (phosphorous and potassium), they are also a potential source of antioxidants (Ang et al., 2012; Jamal et al., 2017). Large quantities of waste generated are disposed into the environment without subjecting to further treatment. This not only poses as a threat to the environment, but is also a loss of potential by-products which can be utilized and converted into value added products, materials for industries or even animal feed/fodder after proper treatments are performed. Recovery and re-utilization of these wastes will profit the agriculture sector economically and also be beneficial to the environment (Laufenberg et al., 2003).

Nowadays, dietary fibre rich-products are becoming more desirable in terms of health benefits. Consumers also prefer natural sources as to synthetics ones as they are feared to be toxic to health. Papaya peels present with a generous amount of fibre and can be utilized in the development of innovative products (Calvache et al., 2016). Fibre enriched food products are shown to have many health benefits. They reduce the chances of heart diseases and some forms of cancer, gastro- intestinal disorders, decrease blood cholesterol and help in controlling obesity. Since, they are not digested or absorbed in the small intestine of humans, they therefore increase faecal bulk and promote healthy bowl movement. Supplementation of fibre into food also enhances various functional properties including increase in water and oil holding capacity, emulsification and gel formation. Addition into bakery, dairy, jams and meat products leads to modification in the textural properties, prevention of syneresis, stabilization of high fat and emulsions and overall improvement in shelf life (Elleuch et al., 2011).

Yogurt is the most popular fermented dairy product which provides large health benefits. It is easy to digest, provides high nutrition and contains lactic probiotic cultures. Yogurt is known for relieving gut inflammations, infections, bowl problems and cholesterol levels (García-Pérez et al., 2005; Jaster et al., 2018). On the basis of flavour, yogurt can be classified into plain, fruit and flavoured yogurt. While on the basis of textural properties it can be grouped as set or stirred/drinking yogurt. Essentially, the only difference between set and stirred type yogurt is that the later involves stirring or agitation at the end of its processing. Nowadays, yogurt products are added with different food ingredients to make them more attractive to consumers in terms of flavour and nutrition (Tamime & Robinson, 2007).

Even though plain yogurts are tagged as healthy dairy products, they still lack when it comes to dietary fibre content (Tseng & Zhao, 2013). Yogurt can therefore act as a perfect candidate to be used in this study for addition with dietary fibre. Previous studies have also utilized this method where pineapple peel, passion fruit peel, pomegranate peel extracts and orange fibres were used to enrich yogurt (El-Said et al., 2014; García-Pérez et al., 2005; Sah et al., 2016; Vieira et al., 2015). Thus, the objective of this study is to enrich commercial yogurt with papaya peel powder as a dietary source. The quality characteristics such as viscosity, pH and colour of fortified yogurt during storage was studied. Also, a sensory analysis was conducted to investigate consumer acceptance on the papaya peel powder fortified yogurt.

MATERIALS AND METHODS

Preparation of Papaya Peel Powder

Carica papaya var. Sekaki were procured from a wet market in Seri Kembangan, Selangor, Malaysia with an approximate weight of 1.77 ± 0.28 kg. Ripe papaya fruits were selected as per ripeness index chart given by Ruslan and Roslan, (2016). The fruits were washed and sliced into peels, pulp and seeds using a stainless-steel knife. The peels were rinsed with water again to remove any adhering mucilages and then cut into pieces of 2x2 cm^2 and thickness of approximately 3.45 mm. The peels were not blanched as ripe papaya shows very low activity of polyphenol oxidase which is responsible for enzymatic browning (Othman, 2014). They were distributed uniformly on a 40 x 28 cm stainless-steel tray and dried using a convection oven (Memmert, Schwabach, Germany) at 45, 55 and 65^{o}C until constant weight was obtained after 8 to 48 hours. Then, the peels were ground using a hammer mill (Perten-120, Perten Instruments A.S. Sweden) and the powder obtained was passed through a sieve shaker (MINOR, Endecotts Limited, England) with a sieve size of 250µm. Sieving was done to standardize the particles for stirred yogurt enrichment. The powders were then were kept in a Ziplock bag and stored at 4^{o}C.

Determination of Total Dietary Fibre

Total dietary fibre content in papaya peel powders obtained by convection oven at three temperatures of 45, 55 and 65°C after drying for 8 - 48 hours till constant weight were established using Enzymatic-gravimetric method (AOAC 985.29). Gelatinization of dried samples was carried out with heat stable α-amylase. It was then digested enzymatically with protease and amyloglucosidase for removing protein and starch, respectively. Soluble dietary fibre was precipitated out by adding four volumes of ethyl alcohol. After filtering the residue, it was washed with ethyl alcohol and acetone and dried in an oven overnight. One test portion was used to determine protein content while the other was incinerated at 525°C to determine ash. The total dietary fibre was calculated using the formula given below:

$$\text{Total dietary fibre (\%)} = \frac{\text{weight residue} - \text{protein} - \text{ash} - \text{blank}}{\text{weight test portion}} \times 100 \qquad [1]$$

The powder was selected on the basis of maximum retainment of total dietary fibres. The optimized levels (PP1 and PP2) obtained after drying were then further used as a source of dietary fibre in stirred yogurt.

Preparation of Fortified Stirred Yogurt

Commercial plain yogurt (Nestl*é*) of net weight 1400 g was purchased from a local supermarket in Seri Kembangan, Selangor, Malaysia. It was stored at 4°C and used to make papaya peel powder fortified stirred yogurt. Papaya peel powder PP1 and PP2 were the optimized levels which were added at 1.5 g and 3.0 g to make a 100 g of yogurt (w/w). Coagulation of yogurt was broken by manually stirring by the same person until the peel powder was uniformly incorporated. A control stirred yogurt was also prepared by stirring in the same manner. These concentrations were selected in order to avoid any unappealing lump formation and achieve good sensory acceptability. This amount is in compliance with what has been set by the USA regulations for fibre-fortified products. The maximum dose of powder used in this study accounts for only 10% of what is recommended for daily fibre consumption, if 200 mL of yogurt was taken (Fernández-García & McGregor, 1997). The Food and Drug Administration (FDA) recommends 25 g of dietary fibre to be taken daily (Santos et al., 2014). Five samples were obtained, namely, control stirred yogurt with no addition of powder, fortified stirred yogurt with addition of PP1 at 1.5% and 3.0% (1.5% PP1 and 3.0% PP1) and fortified stirred yogurt with PP2 at 1.5% and 3.0% (1.5% PP2 and 3.0% PP2). The mixed yogurt was placed in glass beakers covered with aluminium foil and stored in a refrigerator at 4°C. Quality analysis was conducted on storage Day 0, 7, 14 and 21.

Viscosity

Apparent viscosity of fortified stirred yogurt was measured using a Brookfiled DV-II + Pro Viscometer (Brookfield

Engineering Laboratory Inc., Stoughton, MA). Measurement was conducted at 30 rpm (4°C) with a Helipath spindle (no. D). This spindle is exclusively used for non-Newtonian fluids. Apparent viscosity was measured 10 seconds after the spindle had entered the stirred yogurt. The measurement was done in triplicates and recorded in centipoise as displayed on the screen.

pH Determination

pH determination of stirred yogurt samples was done using a benchtop pH meter (Sartorius PB-10, Germany). The pH meter was calibrated with buffer solution (pH 7 and 4) prior to commencement of analysis. The samples were first homogenized before recording any measurements. Readings of the samples were taken by immersing the electrode up to the immersion level at three different points in each sample container. This corresponded to three replicates and average values were then calculated (Vieira et al., 2015).

Colour Analysis

The colour of stirred yogurt samples was analysed using a Hunter lab UltraScan Pro with EasyMatch QC software (Hunter Associate Laboratory Inc., Reston, USA). CIE $L^*a^*b^*$ was used to determine the brightness parameter, L which denotes whiteness to darkness and chromacity coordinates, a^* and b^* which represents redness to greenness and yellowness to blueness, respectively (Abid et al., 2013). The equipment was first calibrated using light trap and white reference tile before proceeding with the experiment. The yogurt was poured into a glass cuvette and clamped onto the device. The analysis was run in triplicates and average values were taken.

Chroma was determined using the formula given below:

$$C^* = (a^{*2} + b^{*2})^{1/2} \quad [2]$$

Hue angle ranges from 0^0, 90^0, 180^0 to 270^0 and was obtained from a^* and b^* values:

$$H^0 = \tan^{-1} \frac{b^*}{a^*} \quad [3]$$

Total colour difference (ΔE) was determined as shown in the formula:

$$\Delta E = \sqrt{(L^*_i - L^*_t)^2 + (a^*_i - a_t)^2 + (b^*_i - b^*_t)^2} \quad [4]$$

where, L^*_i, a^*_i and b^*_i are the initial values while L^*_t, a^*_t and b^*_t are the corresponding values for stored yogurt samples.

Sensory Analysis

Hedonic test was conducted to evaluate the sensory attributes of the yogurt samples. Permission to conduct consumer acceptance was granted by Ethics Committee, Research Management Centre, Universiti Putra Malaysia with reference number JKEUPM-2018-117 and was conducted in accordance with the Declaration of Helsinki. A respondent's consent form was first signed by the panellist to confirm they met the inclusion criteria for the study and had no allergies to the ingredients in yogurt samples. A 9-point hedonic scale was used for evaluation with 1 to 9 denoting dislike extremely, dislike very much, dislike moderately, dislike slightly, neither like or dislike, like slightly, like moderately, like very much and like extremely respectively (Hashim et al., 2009). Six attributes were evaluated for each sample, namely, colour, appearance, aroma, texture, taste and overall acceptability. Appearance and colour were analysed as two separate parameters as colour alone is not enough to determine the food appearance (MacDougall, 2003). Appearance was evaluated as the shape and size (geometric shape), surface texture (dullness/shininess) and clarity while colour indicates colour perception. The panellists consisted of 30 untrained students from Universiti Putra Malaysia. The analysis was conducted in an environmentally controlled room (25 ± 2 ºC) under white fluorescent light in Faculty of Engineering, Universiti Putra Malaysia. The samples were randomly presented in a transparent cup marked with a 3-digit code. A cup of water was also given for rinsing mouth between tasting.

Statistical Analysis

One-way analysis of variance (ANOVA) was performed to investigate the significant treatment effect of two independent factors: different papaya peel powder concentrations and storage time. Means of sensory acceptance results for each attribute namely, appearance, texture, odour, flavour, colour and overall impression for five samples were analysed by ANOVA and compared at the $P < 0.05$ level by Tukey test. Statistical Package for Social Sciences (SPSS, version 18.0) was used for analysis.

RESULTS AND DISCUSSION

Total Dietary Fibre of Papaya Peels

The total dietary fibre content of papaya peel powder dried at 45, 55 and 65°C were 31.84, 40.21 and 48.00 g/100 g, respectively. These values were in agreement with previously reported total dietary fibre as 44.66% by Pavinthra et al., (2017), 33.05 ± 0.70 g/100 g for *Hawai* and 34.70 ± 0.54 g/100 g for *Calimosa* papaya cultivars by Santos et. al. (2014). As per the results, drying temperature at 55 and 65°C presented with the highest retention of total dietary fibre and therefore were used for enrichment in yogurt. This trend is in agreement with previous studies by Quispe-Fuentes et. al. (2017) on native Chilean berries. It was found that an increase in dietary fibre content was observed with increase in drying temperature. Dried Cape gooseberry showed that the highest total dietary fibre content was present at 90°C drying temperature while the lowest was at 50°C drying temperature (Vega-Gálvez et al., 2015).

Viscosity

Figure 1 portrays apparent viscosity of samples at Day 0 versus time in seconds at a steady spindle rotation (30 rpm). This figure establishes that yogurt is a non-Newtonian fluid, which exhibits a thixotropic behaviour. The decreasing of yogurt viscosity is time-dependent and was reported by Denin-Djurdjević et al. (2002). This behaviour observed provides justification for the use of Helipath spindle which is essentially ideal for determining viscosity in a non-Newtonian fluid. The T spindle attached to Helipath system moves up and down inside the sample in a vertical motion as it rotates, preventing any local syneresis and exceedingly small viscosity readings (Tamime & Robinson, 2007).

The apparent viscosity of stirred yogurt is illustrated in Table 1. The addition of papaya peel powder resulted in an increase in viscosity. This might be due to the absorption of some water from the yogurt by the added fibre and thus, resulting in a viscous product as compared to the control sample. Yogurt added with 3.0% of peel powder for both types of dietary fibre (3.0% PP1 and 3.0% PP2) exhibited significant higher viscosity than yogurt added with 1.5% peel powder (1.5% PP1 and 1.5% PP2) as seen in Table 1. Prior study reported by Vieira et al. (2015) on passion fruit peel flour enrichment in yogurt is in agreement with this. The resulting yogurt had higher viscosity values as the passion fruit peel flour concentration was increased.

In addition, the viscosity was increased significantly ($P < 0.05$) during 21 days storage for all samples. The lowest viscosity was observed on Day 0 and it rose until

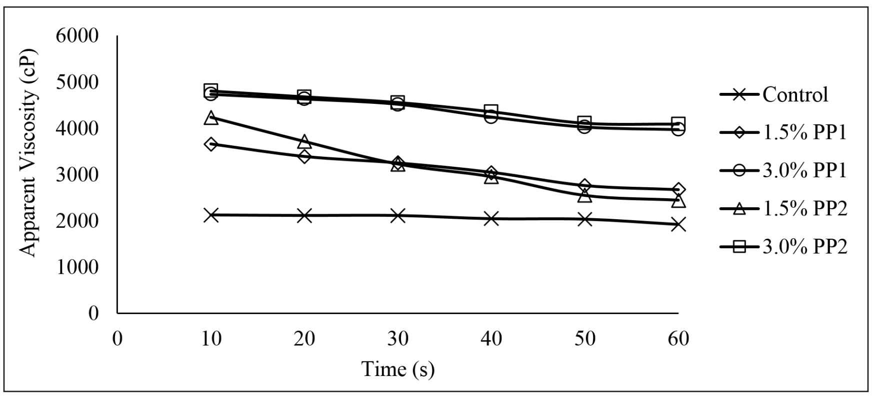

Figure 1. Apparent viscosity of stirred yogurt samples at 10 second interval on Day 0

Table 1
Apparent viscosity (centiPoise) of stirred yogurt samples with 21-Day storage

	Days	Stirred yogurt types at two treatments				
		Control	1.5% PP1	3.0% PP1	1.5% PP2	3.0% PP2
Viscosity (centiPoise)	0	2122 ± 19.05^{Aa}	3656 ± 19.63^{Ab}	4733 ± 33.50^{Ac}	4233 ± 33.50^{Ad}	4803 ± 50.08^{Ae}
	7	2385 ± 25.98^{Ba}	3639 ± 34.83^{Ab}	4911 ± 19.05^{Bc}	4823 ± 40.71^{Bd}	5648 ± 41.87^{Be}
	14	2841 ± 35.73^{Ca}	3919 ± 17.06^{Bb}	4974 ± 36.14^{Bc}	5407 ± 44.91^{Cd}	5818 ± 31.75^{Ce}
	21	2911 ± 19.05^{Da}	3956 ± 19.63^{Bb}	5348 ± 45.37^{Cc}	5607 ± 60.28^{Dd}	5933 ± 33.50^{De}

Note. Means followed by the same lowercase superscript letters (a–e) in the same row were not significantly different for stirred yogurt types ($P > 0.05$)
Means followed by the same uppercase superscript letters (A–D) in the same column were not significantly different for same type of sample at 0, 7, 14 and 21 day of refrigerated storage ($P > 0.05$)
Mean ± standard deviation of 3 replicates

it reached the highest value on 21st day. This increasing viscosity observed in yogurts can be attributed to the phenomenon of rebodying. In other words, there is a recovery of the structure in yogurt with passage of time as similarly found by Sah et al. (2016) for pineapple peel powder added to probiotic yogurt and by Tufeanu et al. (2017) for chia powder added to stirred yogurt.

Figure 2 displays the percentage change of viscosity during storage for each stirred yogurt sample type. Control and 1.5% PP1 sample showed the highest percentage change on Day 14 while for 1.5% PP2 and 3.0% PP2 sample, the highest change was observed on Day 7. For 3.0% PP1 sample, greatest change was observed on Day 21.

pH

Table 2 displays the pH values recorded for all the yogurt samples. Overall, the yogurt samples exhibited pH value between 3.99 to 4.22, indicating that the yogurt sample fortified with papaya peel was within the limit prescribed in Food and Drug Administration (FDA) (2017). As per FDA, pH of yogurt is defined as 4.6 and lower. However, the pH values may vary and the consumer may appreciate a lower pH of 4.2

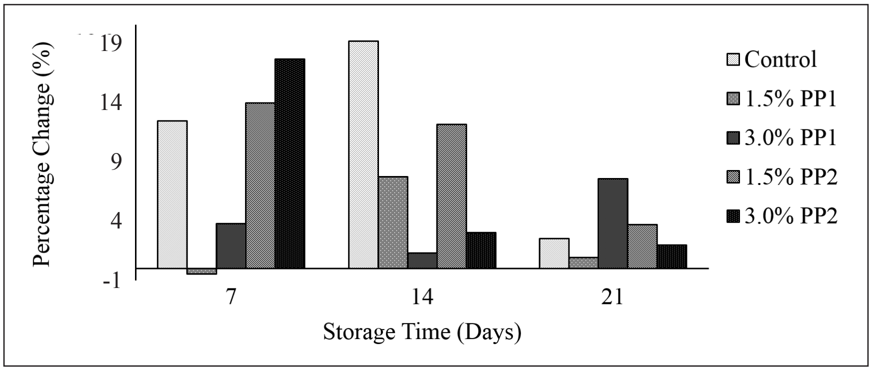

Figure 2. Percentage change in apparent viscosity of stirred yogurt samples with 21-Day storage

Table 2
pH values of stirred yogurt samples with 21-Day storage

	Days	Stirred yogurt types at two treatments				
		Control	1.5% PP1	3.0% PP1	1.5% PP2	3.0% PP2
pH	0	4.24 ± 0.01^{Aa}	4.22 ± 0.01^{Aa}	4.20 ± 0.02^{Aa}	4.20 ± 0.02^{Aa}	4.20 ± 0.01^{Aa}
	7	4.21 ± 0.01^{Aa}	4.21 ± 0.02^{Aa}	4.19 ± 0.02^{Aab}	4.17 ± 0.02^{Aab}	4.16 ± 0.01^{Bb}
	14	4.10 ± 0.02^{Ba}	4.11 ± 0.01^{Ba}	4.09 ± 0.01^{Ba}	4.03 ± 0.02^{Bb}	4.04 ± 0.01^{Cb}
	21	4.04 ± 0.01^{Ca}	4.03 ± 0.01^{Ca}	4.02 ± 0.01^{Ca}	4.02 ± 0.07^{Ba}	3.99 ± 0.01^{Da}

Note. Means followed by the same lowercase superscript letters (a–e) in the same row were not significantly different for stirred yogurt types (P > 0.05)
Means followed by the same uppercase superscript letters (A–D) in the same column were not significantly different for same type of sample at 0, 7, 14 and 21 day of refrigerated storage (P > 0.05)
Mean ± standard deviation of 3 replicates

(Chen et al., 2018). pH values between 4.2 and 4.4 are considered likable by consumers in fermented products (Benedetti et al., 2016).

Although the initial pH values for all samples were not significantly different (P > 0.05), it was noted that the control sample was 0.02 to 0.04 units higher than the other samples during storage. Also, 3.0% PP1 and 3.0% PP2 had slightly acidic pH that their respective lower concentration samples, 1.5% PP1 and 1.5% PP2. These findings are comparable to the effect of passion fruit peel powder dosage on yogurt as reported by Vieira et al. (2015). The final pH measured at 21st day for all the samples showed no significant difference among each other. The fortified samples had pH values 0.01 to 0.05 units lower than the control.

Going through the 21-Day storage, it was observed that the values of pH decreased significantly (P < 0.05). For each stirred yogurt samples, control and fortified, the reduction was by > 0.21 units. The main reason behind the decrease of pH value might be due to the production of lactic acid. During storage, the activity of lactic acid bacteria is increased which consume lactose from the yogurt and produce lactic acid. Thus, making the yogurt more acidic. This decreasing trend in yogurt during storage was also observed by Tseng and Zhao (2013) for wine grape pomace powder enriched yogurt and salad dressing and by Chen et al. (2018) for chickpea powder fortified yogurt. Both the studies concluded that the pH of samples reduced with storage period at 4°C.

Figure 3 illustrates the percentage decrease in pH during storage. It can be seen that on Day 14 the percentage decrease was the highest, followed by Day 21 while the lowest was observed on Day 7 for all the samples.

Colour

Colour of yogurt plays an important role in consumer acceptance and marketability. Any functional yogurts prepared should not only provide essential nutrients but should also be attractive to the consumers (Ajila et al., 2008). The colour parameters measured for stirred yogurt samples were

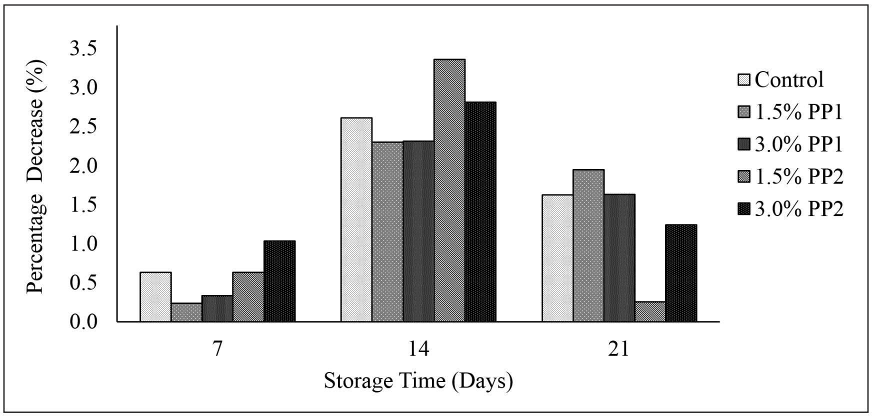

Figure 3. Percentage decrease in pH values of stirred yogurt samples with 21-Day storage

statistically different (P < 0.05) as presented in Table 3. The lightness parameter, *L** was reduced as the concentration of peel powder was increased in yogurt. In other words, the powder had a darkening effect in yogurt samples which may be due to fibres in powder absorbing water. *L** was the highest for control sample as compared to the fortified throughout the storage period. The results obtained in this study can favour consumers as they prefer lower brightness in dairy related products (García-Pérez et al., 2005). In control samples, since there was no addition of papaya peel powder, the redness factor, *a** was in negatives. While for fortified samples, it was noted that the increase in concentration of powder was accompanied by more redness. Similar

Table 3
Colour parameter of stirred yogurt samples with 21-Day storage

Colour parameters	Days	Stirred yogurt types at two treatments				
		Control	1.5% PP1	3.0% PP1	1.5% PP2	3.0% PP2
L*	0	89.73±0.07^{Aa}	77.49±0.01^{Ab}	72.13±0.00^{Ac}	73.51±0.02^{Ad}	67.30±0.01^{Ae}
	7	89.67±0.01^{Aa}	77.06±0.02^{Bb}	72.14±0.02^{Ac}	73.85±0.01^{Bd}	66.95±0.01^{Be}
	14	89.67±0.04^{Aa}	77.03±0.02^{Bb}	72.11±0.02^{Ac}	73.63±0.02^{Cd}	66.91±0.02^{Be}
	21	89.66±0.01^{Aa}	76.98±0.02^{Cb}	72.12±0.02^{Ac}	73.59±0.02^{Cd}	66.85±0.03^{Ce}
*a**	0	-1.87±0.02^{Aa}	3.53±0.01^{Ab}	5.56±0.02^{Ac}	5.21±0.04^{Ad}	7.33±0.01^{Ae}
	7	-1.86±0.03^{Aa}	3.51±0.02^{Ab}	5.20±0.03^{Bc}	4.77±0.02^{Bd}	6.93±0.02^{Be}
	14	-1.87±0.02^{Aa}	3.52±0.03^{Ab}	5.13±0.03^{Cc}	4.55±0.03^{Cd}	6.96±0.03^{Be}
	21	-1.83±0.03^{Aa}	3.53±0.11^{Ab}	5.11±0.02^{Cc}	4.47±0.02^{Dd}	6.46±0.05^{Ce}
*b**	0	13.10±0.02^{Aa}	20.41±0.05^{Ab}	24.66±0.04^{Ac}	24.01±0.06^{Ad}	27.47±0.05^{Ae}
	7	12.38±0.04^{Ba}	19.57±0.06^{Bb}	22.89±0.08^{Bc}	22.27±0.06^{Bd}	25.67±0.07^{Be}
	14	12.32±0.03^{Ba}	19.03±0.01^{Cb}	22.82±0.01^{Bc}	22.16±0.04^{Bd}	25.74±0.03^{Be}
	21	12.33±0.03^{Ba}	19.02±0.01^{Cb}	22.79±0.04^{Bc}	22.18±0.03^{Bd}	25.73±0.02^{Be}
Hue angle (H^o)	0	-81.86±0.05^{Aa}	80.18±0.04^{Ab}	77.29±0.06^{Ac}	77.76±0.11^{Ad}	75.05±0.04^{Ae}
	7	-81.46±0.13^{Ba}	79.84±0.07^{ABb}	77.21±0.05^{Ac}	77.90±0.05^{Ad}	74.90±0.02^{Be}
	14	-81.37±0.08^{Ba}	79.53±0.09^{Bb}	77.34±0.06^{Ac}	78.39±0.08^{Bd}	74.87±0.04^{Be}
	21	-81.58±0.16^{ABa}	79.48±0.31^{Bb}	77.36±0.06^{Ac}	78.60±0.06^{Cd}	75.90±0.10^{Ce}
Chroma (*C**)	0	13.24±0.02^{Aa}	20.72±0.05^{Ab}	25.28±0.03^{Ac}	24.57±0.05^{Ad}	28.44±0.04^{Ae}
	7	12.52±0.05^{Ba}	19.88±0.05^{Bb}	23.48±0.08^{Bc}	22.78±0.06^{Bd}	26.58±0.07^{BCe}
	14	12.46±0.03^{Ba}	19.35±0.01^{Cb}	23.39±0.01^{Bc}	22.62±0.04^{Cd}	26.66±0.03^{Be}
	21	12.47±0.02^{Ba}	19.34±0.02^{Cb}	23.36±0.03^{Bc}	22.63±0.03^{Cd}	26.53±0.00^{Ce}
ΔE	0	0	0	0	0	0
	7	0.73±0.06^{Aa}	0.94±0.02^{Ab}	1.80±0.11^{Ac}	1.83±0.02^{Ac}	1.88±0.05^{Ac}
	14	0.79±0.04^{Aa}	1.46±0.06^{Bb}	1.88±0.02^{Acd}	1.97±0.06^{Bc}	1.82±0.04^{Ad}
	21	0.78±0.02^{Aa}	1.49±0.05^{Bb}	1.92±0.07^{Ac}	1.97±0.02^{Bc}	2.00±0.04^{Bc}

Note Means followed by the same lowercase superscript letters (a–e) in the same row were not significantly different for stirred yogurt types (P > 0.05)
Means followed by the same uppercase superscript letters (A–D) in the same column were not significantly different for same type of sample at 0, 7, 14 and 21 day of refrigerated storage (P > 0.05)
Mean ± standard deviation of 3 replicates

observations were made for values of yellowness factor, *b**. Yogurts with higher levels of powder showed more yellowness. As for control sample, the values of *b** was much lower due to non-supplementation. Chroma and hue angle values were also greater in fortified samples, thus shifting towards yellow. Hue angle was especially in the negatives for control sample owing to the negative *a** value.

ΔE was determined by the taking colour parameters of the sample at Day 0 as a reference for each yogurt type and is illustrated in Figure 4. This was to determine if the difference in colour among the samples during storage which were measured using the device could be perceived by the human eye. Generally, if ΔE value is > 3 then the difference is evident to the human eye (Francis & Clydesdale, 1975). From Table 3, it is observed that all the values among each sample fall below 3. This indicates that the colour did not change much during storage (P > 0.05) and the human eye cannot differentiate it. Similar results were also seen from other colour parameters which did not show much significant difference (P > 0.05) throughout the storage at 4°C. The values were not modified during 21 days, although the difference in dosage of powder effected the colour coordinates. Similar findings of this unchanged behaviour in colour parameters during storage were also reported by García-Pérez et al. (2005) on orange fibre addition in yogurt and Sah et al. (2016) on pineapple peel powder enriched yogurt.

Sensory Properties

The scores from sensory analysis in terms of 9-point hedonic scale are summarized in Table 4. The sensory attributes of appearance, texture, colour and overall acceptability received scores which were statistically different (P < 0.05) excluding odour and flavour. Scores for fortified samples were slightly less than the control sample. 3.0% PP2 sample received the lowest scores for all sensory attributes while the control received the highest. It was noted that the liking scores were affected by the concentration of the papaya peel powder added. From the table it can be seen that 3.0% PP1 and 3.0% PP2 had

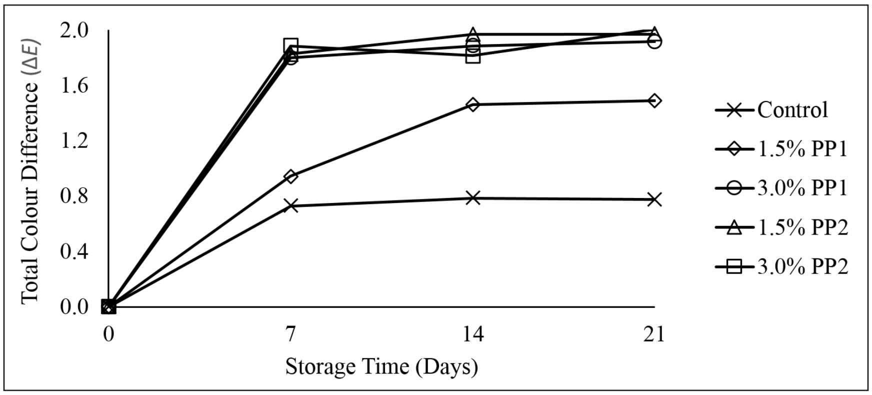

Figure 4. Total colour difference (ΔE) of stirred yogurt samples with 21-Day storage

Table 4
Consumer acceptance of stirred yogurt samples

Sensory attributes	Stirred yogurt types at two treatments				
	Control	1.5% PP1	3.0% PP1	1.5% PP2	3.0% PP2
Appearance	8.00 ± 1.29[a]	7.33 ± 1.35[ab]	6.53 ± 1.78[bc]	6.73 ± 1.62[bc]	5.93 ± 2.13[c]
Texture	8.07 ± 1.11[a]	7.60 ± 1.35[ab]	7.03 ± 1.54[bc]	6.97 ± 1.35[bc]	6.53 ± 1.66[c]
Odour	7.90 ± 1.42[a]	7.40 ± 1.65[a]	6.90 ± 1.84[a]	6.97 ± 2.06[a]	6.93 ± 1.60[a]
Flavour	6.80 ± 1.61[a]	6.37 ± 2.17[a]	5.83 ± 2.07[a]	6.13 ± 2.10[a]	5.70 ± 2.49[a]
Colour	7.93 ± 1.30[a]	7.33 ± 1.30[a]	6.87 ± 1.70[ab]	7.00 ± 1.44[ab]	6.13 ± 1.85[b]
Overall Impression	7.60 ± 1.22[a]	7.13 ± 1.46[ab]	6.67 ± 1.40[ab]	6.73 ± 1.55[ab]	6.27 ± 1.84[b]

Means followed by the same superscript letters (a–c) in the same row were not significantly different by the Tukey test (P > 0.05)
9-point hedonic scale used where 1= extremely dislike till 9 = extremely like; Mean ± standard deviation

lower ratings than their corresponding lower concentration powder yogurts (1.5% PP1 and 1.5% PP2). Consumers gave moderate scores for colour and appearance to all samples prepared, even though there was an evident light-yellow colour in fortified samples. Texture scores ranged from 6.53 to 8.07. Since, higher dosage of powder resulted in a more viscous sample, the stirred yogurt also received lower scores for 3.0% PP1 and 3.0% PP2. Addition of papaya peel powder in yogurt exhibited no significant change in odour and flavour. This means the taste was acceptable to consumers even if the concentration of powder was increased. Overall impression of the samples was moderately positive (6.27 to 7.60). In previous study, yogurts developed from skins of two varieties of grapes mostly met with lower sensory scores due to a grainy texture and sour taste (Marchiani et al., 2016). Tseng and Zhao, (2013) reported that yogurt with 1% concentration of wine grape pomace powder received favourable score for flavour and consistency. Some consumers commented on its fruit taste while few considered of it as chalky and medicine-like. From the current study it can be concluded that the stirred yogurt prepared by adding papaya peel powder dried at 55^{o}C (1.5% PP1) was the most preferable to consumers as compared to other fortified samples. Although measurement by sensory analysis is subjective, the scores given by consumers correspond well with the food preferences (Córdova-Ramos et al., 2018).

CONCLUSIONS

Papaya peels have a significant amount of dietary fibre which can be utilized to develop new products and in turn help to reduce waste disposal. In the present study, it was used as a source of dietary fibre to enrich yogurt. The peels were dried at three temperatures (45, 55 and 65^{o}C) and at drying temperature of 55 and 65^{o}C, the highest dietary fibre content was obtained which was added to yogurt at concentration of 1.5

and 3.0% (w/w). Quality characteristics of the fortified stirred yogurt was analysed weekly for 21 days. The addition of peel powder resulted in an increase in viscosity of yogurt as compared to control. In addition, the viscosity also increased with the storage time. pH values showed no statistical difference (P > 0.05) among the samples prepared. Colour parameter remained unchanged with storage, even though it was significantly altered (P < 0.05) with concentration of papaya peel added. Sensory analysis showed that stirred yogurt enriched with 1.5% papaya peel powder dried at 55^{o}C emerged as the best product in terms of highest sensory scores. Hence, this work can be proposed to the fruit industry that the fruit peels can be utilized as a functional ingredient to improve food quality.

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