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Utilization of pineapple pomace powder as functional ingredient in bread

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Abstract
The study on utilization of pineapple pomace powder (PPP) and defatted soyabean flour (DSF) in bread was undertaken to upgrade the nutritional quality, as well as fibre enhancement. The bread was prepared from composite flours by incorporating 5.0g to 10g of pineapple pomace powder with corresponding 5g of soyabean flour into all-purpose flour. The bread was analyzed for their physical properties, chemical composition and sensory properties. Loaf weight increased from 180.22 to 186.32g, loaf volume and specific volume decreased from 879.96 cc to 689.66 cc and 4.88 to 3.72 cc/g with increase of PPP in blends. With increase in the concentration of PPP there was an increase in fibre content and the bread supplemented with 5% PPP was found to be more acceptable.

Keywords: Pineapple pomace powder (PPP), defatted soya flour (DSF), all-purpose flour (APF)

Introduction
The pineapple (*Ananas comosus*) is part of the bromeliaceae family. The cultivated types belong to the genus *Ananas*, which covers several species, the most familiar of which, exploited for commercial purposes is *Ananas comosus*. The various pineapple species seems to have originated from South America and more particularly from a large area encompassing Brazil, northern Argentina and Paraguay. The fruit probably originated from the basins of the Rivers Parana and Paraguay (Anon, 2016) [2]. The major pineapple growing countries in the world are Brazil, Thailand, Philippines, Costa Rica, China and India. The total area under pineapple cultivation in the world is 909.84 thousand hectares with production around 19412.91 thousand tons (Anon, 2014) [1]. Pineapple is an important fruit of India. Pineapple is cultivated in an area of 89 thousand hectares and total production is 1,415.00 thousand tons. It is abundantly grown in almost entire North East region, West Bengal, Kerala, Karnataka, Bihar, Goa and Maharashtra states.

Pineapple (*Ananas comosus*) processing generates major by-products in the peel that represents the largest portion (30–42 %, w/w); followed by the core (9–10%); stem (2–5%, w/w); and crown (2–4%, w/w). These by-products account for 50% (w/w) of total pineapple weight and are a potential source of important compounds such as sucrose, glucose, fructose, cellulose, fibre, bromelain and phenolics. These compounds can be extracted to obtain bromelain and cellulose nano-crystals (Dorta and Sogi, 2017) [3]. Peel flour has very good prebiotic potential to support probiotic bacteria in the gut. Fermentable sugars and other nutrients make pineapple waste extracts excellent media to produce enzymes, single cell proteins, bacterial cellulose and organic acids. Waste can also be utilized to produce vinegar and vanillin and to extract bioactive compounds that can be used in food, pharmaceutical or allied industries. The waste also has the potential to act as alternative source of energy.

Around the globe, white bread is the commonly consumed bread. Thus, for meeting the fiber requirement, the enrichment of bread with higher fiber content is the best way to increase the fiber daily intake (Wang *et al.* 2002) [5]. Pineapple pomace powder is one of the excellent sources of dietary fiber. However, the addition of these fibers causes a neglected effect on the final bread quality. Addition of too much fiber produces bread of poor quality in terms of texture, loaf volume, and appearance (Gómez *et al.* 2003; Wang *et al.* 2002) [5]. High levels of fiber dilute gluten lowers gas retention thus causing a decrease in loaf volume. In the present experiment, different levels of pineapple pomace powder were incorporated to study physico-chemical quality of nutri-enriched bread as a functional ingredient.

Materials and methods
The present investigation was carried out in the Department of Post-Harvest Technology, College of Horticulture, Bagalkot. Pineapple fruits, wheat flour, sugar, shortenings, baking

powder and skimmed milk powder were procured from the local market, Bagalkot and defatted soya bean flour purchased from Ahmed Shopping Centre, Bangalore.

Productions of Pineapple pomace powder

Firstly the top leaves are cut off then outer hard core was peeled from fruits and inner core is removed from the fruit. Then fresh fruit was cut into small pieces using stainless steel knife and subjected for juice extraction and remaining left over fruit pomace was squeezed in muslin cloth and removed the left over juice. Later pineapple fruit pomace was placed in a tray drier at 55 ºC for 6 hour to obtain dried pomace. The dried pineapple fruit pomace was crushed by food grinder in to powder.

Standard formulation for preparation of cookies

The standard formula was used for preparation of pineapple pomace bread (Fig 1). Only the main ingredient all-purpose flour was replaced with pineapple pomace powder at 5.0% to 10% and soyabean powder 5% (Table 1).

Treatment details

Table 1: Recipe for pineapple pomace powder incorporated bread

Treatments	Pineapple pomace powder (g)	Defatted soy flour (g)	Other ingredients				
			All-purpose flour (g)	Shortenings (g)	Yeast (g)	Sugar (g)	Milk powder (g)
T_1	0	0	100.0	50	5	50	5
T_2	5.0	5.0	90.0	50	5	50	5
T_3	7.5	5.0	87.5	50	5	50	5
T_4	10.0	5.0	85.0	50	5	50	5
T_5	12.5	5.0	82.5	50	5	50	5

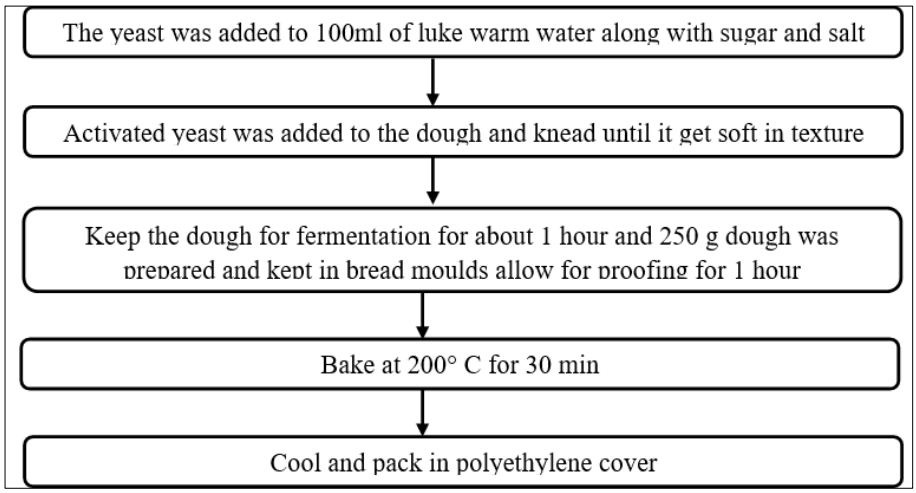

Fig 1: Methodology for preparation of pineapple pomace enriched bread

Observations recorded

Loaf weight (g)

Loaf weight is measured within 10 min after the bread was removed from the oven.

Loaf volume (cc)

Loaf volume is measured within 10 min after the bread was removed from the oven.

Specific volume (cc/g)

The specific volume (cc/g) of bread was calculated from the average loaf volume and weight.

Specific volume= loaf volume (cc)/ loaf weight (g)

Moisture (%)

Moisture was determined by using moisture balance.

Water activity (a_w)

Water activity of bread was measured by using water activity meter.

Crude fiber (%)

Crude fiber estimation was done by using Fibra plus-FES-6 instrument.

Texture (N)

Texture measurements in this study were obtained using TA-XT-plus Texture Analyzer (Stable Micro Systems, London, England) as used by Park and Baik (2004).

Color (*L, *a**, *b**)**

Bread color was measured with a Color Flex EZ (Model CFEZ 1919, Hunter Associates Laboratory, Inc., Reston) with a 45 mm (diameter) measuring tube using a white tile background. *L**, *a** and *b** values denote lightness (white-black), red-green and yellow-blue scales, respectively.

Sensory Evaluation

Sensory evaluation of "Physico-chemical and sensory characteristics of nutritional enriched pineapple pomace powder incorporated bread" was carried out by 9 point hedonic scale.

Statistical analysis

The data on sensory evaluation, quality analysis of nutritional enrichment studies in bread by incorporating pineapple pomace powder was carried out by using Completely Randomized Design (CRD) analysis. The data was interpreted in accordance with Panse and Sukhatme (1985) [7]. The average, mean and standard deviation of basic statistical tools were adopted. The level of significance used in 'F' and 't' test

was p=0.01. Critical difference values were calculated whenever 'F' test found significant.

Results and Discussion

Loaf weight (g)

Table 2 depicts maximum loaf weight of 186.32g was recorded highest in the treatment T_5 (82.5 % APF +12.5 % PPP + 5 % DSF) followed by T_4 (85.0% APF + 10 % PPP + 5% DSF;186.15 g) and lowest loaf weight is observed in T_1 (100 % APF; 180.22 g). The bread loaf weight increases as the percentage of pineapple pomace powder increases since it holds more water with increase in PPP. Moreover, increased substitution to the wheat flour resulted to an increase in weight of the loaf which could be as a result of the high fibre content of the pineapple pomace (Ndife *et al.*, 2009) [10].

Loaf volume (cc) and specific volume (cc/g)

Table 2 represents highest score (879.96 cc) for loaf volume of pineapple pomace powder bread was seen in the treatment T_1 (100% APF) and it is followed by T_2 (719.20 cc). The lowest score for loaf volume is recorded in the treatment T_5 (627.60 cc). The treatments differed significantly in influencing specific volume of nutritional enrichment studies in pineapple pomace powder incorporated bread**.** Highest scores of 4.88 cc/g for specific volume were recorded in the treatment T_1 (100% APF) followed by T_2 (3.85 cc/g), whereas minimum scores of 3.37cc/g for specific volume was recorded in T_5 (82.5 % APF +12.5 % PPP + 5 % DSF). Loaf volume decreases due to decrease in gas retention capacity.

The specific volume also reduced drastically. The deleterious effects of addition of the pineapple pomace powder could be due to dilution of gluten network which in turn impaired gas retention rather than gas production (Ndife *et al.*, 2009) [10] which stated that progressive inclusion of pineapple pomace and soy bean flour to wheat flour decreased the bread volume.

Table 2: Effect of treatments on physical parameters of pineapple pomace enriched bread

Treatments	Physical parameters		
	Loaf weight (g)	Loaf volume (cc)	Specific volume (cc/g)
T_1	180.22	879.96	4.88
T_2	184.87	719.20	3.85
T_3	185.00	677.47	3.66
T_4	186.15	689.66	3.72
T_5	186.32	627.60	3.37
Mean	184.51	718.78	3.90
SEm±	0.76	45.17	0.24
CD @ 1%	3.19	136	1.03

Moisture (%) and water activity (a_w)

The data on moisture content of nutritional enriched bread incorporating pineapple pomace powder as influenced by different treatments is presented in Table 3. Minimum moisture content (22.39 %) was recorded in the treatment T_1 (100% APF). Maximum moisture content (31.48%) was observed in T_5 (82.5% APF +12.5% PPP + 5% DSF).

The data on water activity content of nutritional enriched breads incorporating pineapple pomace powder as influenced by different treatments is presented in Table 3. Least water activity (0.80%) was recorded in the treatment T_1 (100% APF). Maximum water activity content (0.86%) was observed in T_5 (82.5% APF +12.5% PPP + 5% DSF) and it was found to be on par with T_4 (0.85%).

The moisture content and water activity of bread increases with increase in incorporation of pineapple pomace powder this might due to fibre absorbs moisture and as the fibre content increases moisture content also increases. Water activity has a positive relationship with the moisture content during storage. As the moisture increases water activity also increases (Czuchajowska and Pomeranz, 1989) [8]. The addition of fibers to dough would alter dough's water absorption, causing poor visco-elastic property (Collar *et al.*, 2007) [9].

Texture and crude fibre

The results for crude fibre of nutritional enriched bread incorporating pineapple pomace powder as influenced by different treatments is presented in Table 3. Significant differences were found among the treatments with respect to texture content of nutritional enriched bread. Significantly highest crude fibre (16.48 %) content of breads was found in the treatment T_5(82.5% APF +12.5% PPP + 5% DSF) and it is on par with treatments T_4 (15.62 %). Lowest crude fibre (9.87 %) content was recorded in the treatment T_1 with 100% all-purpose flour.

The data pertaining to texture of nutritional enriched bread incorporating pineapple pomace powder as influenced by different treatments is presented in Table 19. Significant differences were found among the treatments with respect to texture content of nutritional enriched biscuits. Significantly maximum hardness (0.21 N) of breads was found in the treatment T_5 (82.5 % APF +12.5 % PPP + 5 % DSF) followed by T_4 (0.20 N). Minimum hardness (0.14 N) was recorded in the treatment T_1 with 100% all-purpose flour.

As the incorporation of pineapple pomace powder increases texture and crude fibre content also increased. The crude fibre content texture increases due to high fibre content of incorporated fibre rich powder (Gopalan *et al.*, 2004) [12]. On the other hand refined wheat flour is a poor source of fibre in comparison to substituted powder (Peter and John, 2012) [11]. The PPP enriched bread had higher hardness and gumminess that resulted from the competition of water absorption between PPP from the rigid nature of the fiber. Because insoluble dietary fibre (DF) is the major type of DF in PPP biscuits, incorporating PPP into the dough system may interfere with the formation of the gluten network. This lowers cohesiveness, springiness, and specific volume of the bread PCF-enriched steamed bread (Yin Wu and and Yu Shiau, 2015) [13].

Table 3: Effect of moisture, water activity, crude fibre and texture on pineapple pomace powder enriched bread

Treatments	Moisture (%)	Water activity (a_w)	Crude fibre (%)	Texture (N)
T_1 : 100% APF	22.39	0.80	9.87	0.14
T_2 : 90% APF +5% PPP + 5% DSF	24.03	0.83	14.15	0.17
T_3: : 87.5 APF +7.5% PPP + 5% DSF	26.44	0.83	15.14	0.19
T_4 : :85 .0% APF +10% PPP + 5% DSF	26.66	0.85	15.62	0.19
T_5: 82.5% APF +12.5% PPP + 5% DSF	31.48	0.86	16.48	0.20
Mean	26.20	0.84	14.25	0.18
SEm±	0.503	0.003	0.181	0.02
CD @ 1%	2.10	0.012	0.759	0.035

Colour (*L*, a* b) value**

L* **value**

The results pertaining to changes in *L** value of nutritional enriched bread incorporating pineapple pomace powder as influenced by different treatments is presented in Table 4. Lightness value (*L**) was found to be maximum (63.67) in the treatment T_1 *i.e.* control followed by T_2 (48.24) and minimum (40.42) *L** value was recorded in the treatment T_5 (82.5% APF +12.5% PPP + 5% DSF). Significantly maximum *L**(Lightness) value in bread was observed in the treatment with 100 per cent all-purpose flour (T_1) indicating more light colour of bread. *L** value decreases as the level of incorporation of pineapple pomace powder increases. This might be due to the fact that the bread in T_1 was prepared from pure all-purpose flour and remaining treatments contained different levels of incorporation of pineapple pomace powder leading to higher L* value compared to remaining treatments. Minimum *L** value (40.42) was observed in T_5 which contains 12.5% pineapple pomace powder.

a* **and** ***b**** **value**

The results presented in the (Table 4) on *a** value of nutritional enriched bread incorporating pineapple pomace powder. The higher *a** value (6.41) was noticed in the T_5 (12.5% APF +12.5% PPP + 5% DSF) followed by T_4 (6.36) .Lowest *a** value was found in T_1 (1.20). The results of *b** value observed in nutritional enriched bread incorporating pineapple pomace powder are presented in Table 4. The data revealed that there were significant differences among the treatments with respect to *b** value of nutri-enriched bread. The higher *b** value (24.63) was noticed in the T_5 (82.5% APF +12.5% PPP + 5% DSF) followed by T_4 (23.69). Lowest *b** value was observed in T_1 (13.13). Here both *a** and *b** value increases with increase in incorporation of pineapple pomace powder level. This might be due to fact that the incorporation of pineapple pomace powder in bread caused darkening effect, reduced the lightness (All- purpose flour) and turned them more yellowish (carotenoid pigment in pineapple) due to influence of pigment present in them, being slightly reddish grey and yellowish in colour, compared to control treatment. Darkness of bread might be due to the Maillard reaction between reducing sugar and protein due to inclusion of fruits containing sugar. Similar observations were also done by earlier researcher (Sangnark and Noomhorm, 2004; Mohamed *et al.*, 2010) [14, 15]. Surprisingly, the same studies also mentioned that substitution of high fibre ingredient in to bread also darkens the colour of bread.

Table 4: Effect of colour (*L**, *a**, *b**) values on pineapple pomace powder enriched bread

Treatments	Colour values		
	L*	***a****	***b****
T_1 : 100% APF	63.67	1.20	13.13
T_2 : 90% APF +5% PPP + 5% DSF	48.24	5.66	22.66
T_3: : 87.5 APF +7.5% PPP + 5% DSF	43.83	6.02	22.92
T_4 : :85 .0% APF +10% PPP + 5% DSF	41.50	6.36	23.69
Mean	47.53	5.13	21.41
SEm±	0.55	0.15	0.426
CD @ 1%	2.335	0.635	1.763

Sensory evaluation

Significant differences were observed for variables such as crust colour, crumb colour, texture, taste and flavour, mouth feel and overall acceptability for pineapple pomace enriched bread (Table 5 and fig 2). The mean score for crust colour of pineapple pomace enriched biscuits ranged from 7.05 to 8.44, crumb colour 6.92 to 8.35, texture 6.80 to 8.20, taste & flavour 6.81 to 8.25, mouth feel 6.59 to 7.60 and overall acceptability 6.68 o 8.54.

The highest score recorded in T_2 (90% APF + 5% PPP + 5% DSF) and lowest score was observed in T_5 (82.5 APF +12.5% PPP + 5% DSF) on a nine point scale for different attributes indicating that products were acceptable for all the attributes studied. The incorporation of bread with pineapple pomace powder with 5% PPP found more acceptable probably due to more appeal of colour, flavour, taste, mouth feel and over acceptability to judges. T_5 found to be least acceptable and it might be due to 12.5% of PPP level affected the water holding capacity, dough rising, it's proper mixing with the wheat flour thus resulting inferior quality product. The quality and appearance of bread is also affected by factor such as composition of bread flour, colour of substituted ingredients, biochemical make up of horticultural products especially sugar and their interactions during baking at high temperature (150-200 ºC). The crust characteristic is known to be associated with Maillard reaction, thus containing more protein can increase the Maillard reaction and browner colour (Gomez *et al.*, 2003) [4].

Table 5: Effect of treatments on sensory attributes of pineapple pomace enriched bread

Treatments	Sensory attributes (* Score out of 9)					
	Crust colour*	Crumb colour*	Texture*	Taste and flavour*	Mouth feel*	Overall acceptability*
T_1	7.70	7.89	7.05	6.94	7.37	7.18
T_2	8.44	8.35	8.20	8.25	7.60	8.54
T_3	8.22	8.30	7.87	7.35	7.22	7.94
T_4	7.48	7.52	8.18	7.62	6.87	8.31
T_5	7.05	6.92	6.80	6.81	6.59	6.68
Mean	7.78	7.79	7.62	7.39	7.14	7.73
SEm±	0.24	0.26	0.25	0.21	0.186	0.15
CD @ 1%	1.006	1.11	1.067	0.873	0.766	0.674

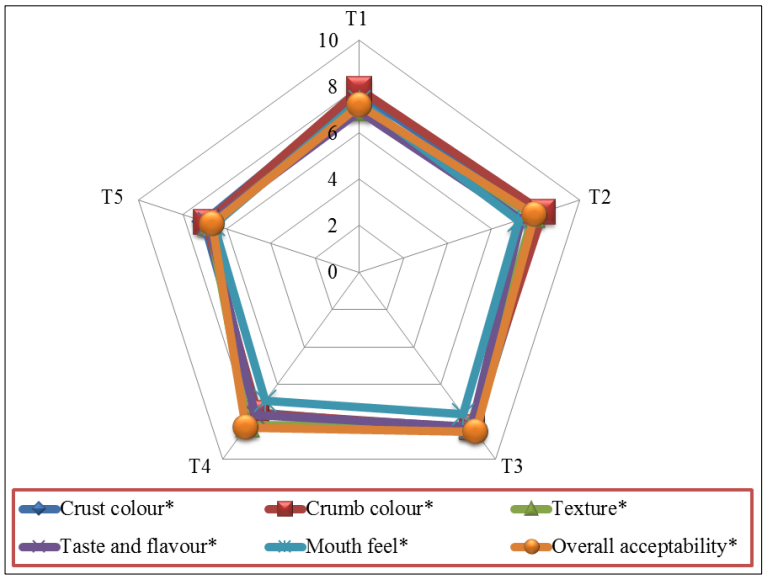

Fig 2: Effect of treatments on Sensory attributes of pineapple pomace enriched bread

Conclusion

Present days of low fibre in diet is driving force for exploration of dietary fibre as novel ingredient in food products. The interest in the utilization of pineapple pomace powder for fiber enhancement is due to its better functionality owing to the presence of balanced amount of soluble and insoluble dietary fibre and association of bioactive compounds with them. Also, opens up a doorway of efficient waste management for juice manufacturing industry to earn profit. Hence the final study reports that the composition of T_2 (90 % APF + 5% PPP + 5% DSF) was found to be superior in the terms of physico-chemical and sensory properties and it can be concluded that the substitution of all-purpose flour with pineapple pomace powder up to 5% into the formulation of bread enhanced its physico-chemical as well as sensory characteristics.

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