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QUALITY CHARACTERISTICS OF PEA POD BLENDED BREAD STICKS FORMULATED FROM COMPOSITE FLOUR

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ABSTRACT

The increasing demand for sustainable food production has encouraged the valorization of agro-industrial by-products such as pea pods, which are often discarded as waste despite being rich in functional parameters. Improper disposal of pea pod waste contributes to environmental pollution and resource loss. Incorporating pea pod powder into bakery products, particularly breadsticks, provides an effective strategy to reduce wastage while improving the nutritional quality of food. For the formulation of pea pod blended bread sticks, refined wheat flour, freeze dried pea pod powder and buckwheat flour were blended in different proportions (T₁-100:00:00, T₂-85:5:10, T₃-80:10:10, T₄-75:15:10, T₅-70:20:30, T₆-65:25:10 and T₇-60:30:10). The prepared pea pod blended bread sticks were packed in laminated pouches and stored for a period of 90 days under ambient conditions. The results showed that highest mean water absorption capacity (1.83 g/ml), oil absorption capacity (2.27 g/ml) were recorded in T₇ while the least values were recorded in T₁ as 1.31 g per ml and 1.63 g per ml, respectively. Maximum mean crude protein (12.20%) and crude fibre (3.60%) were recorded in T₇. Thus, utilizing pea pod waste in breadstick production not only addresses environmental concerns but also offers opportunities for developing value-added functional foods.

Key words : Pea pod, Valorization, Nutritional, Laminated pouches, Formulation, Functional foods.

Introduction

The global food industry is currently facing a significant challenge due to the staggering volume of waste generated throughout its supply chain. Outsized amount of waste either solid or liquid in nature is being produced by food industry nowadays on regular basis. The unwanted artifacts pose not merely disposable concerns but furthermore massive loss of nutrients. Many studies indicate food-processing waste might have potential for reutilizing into raw useful products or by-products of higher value (Laufenberg *et al.*, 2003). According to a recent review, the fruit and vegetable industry accounts for approximately 14.5% of the waste generated (Pérez-Patricio *et al.*, 2018). Interestingly, certain parts of the vegetables, such as hulls, seeds, stems, leaves, and bagasse, are often discarded due to their unfavourable taste or texture (Lau *et al.*, 2021).

Peas are one of the most popular seasonal legumes worldwide, available fresh, frozen, or shelled in supermarkets. Approximately 30–40% of pea pod waste is generated during processing in the pea industry and if not properly utilized or disposed, can attract pathogens, posing a threat to human and animal life. These pea pods are rich reserves of fibre, carbohydrates, and crude proteins and may have numerous food applications. In addition, they are also rich in many functional properties like water absorption capacity, oil absorption capacity, foam capacity and stability (Nasir *et al.*, 2022).

Buckwheat (*Fagopyrum esculentum* Moench) is a highly nutritious pseudo-cereal that belongs to the Polygonaceae family. The Middle Asian origins of buckwheat were brought to Central and Eastern Europe by nomadic tribes. During the thirteenth century, buckwheat gained some attraction in Germany, Australia and Italy before losing ground to the production of other

grains. Originating in China, the crop is currently grown extensively for its culinary value as it is known for having a well-balanced amino acid composition. Buckwheat contains protein which is high in critical amino acids like arginine and lysine. Additionally, the proteins in buckwheat are low in glutelin and prolamin and high in globulin and albumin. According to immunological and chemical research, buckwheat protein is an important dietary component for people with celiac disease and other gluten-sensitive people (Choy *et al.*, 2013). Besides, it is naturally gluten free and contains various kinds of essential nutrients including easily digestible protein, starch, rutin amino and amino acids (lysine). It is low in saturated fat, sodium, and cholesterol (Bonafaccia *et al.*, 2003). Buckwheat is an excellent source of micronutrients like potassium, manganese, copper, iron, and zinc (Jhang *et al.*, 2007). Buckwheat foodstuffs are considered as a good nutritional and medicinal value food because of high concentration of amino acid (Liu *et al.*, 2001). Buckwheat has been shown to have stronger antioxidant activity than the most popular cereals, primarily because of its high rutin level, which may prevent lipid peroxidation. These useful buckwheat ingredients have health advantages such as lowering blood cholesterol, lowering blood pressure, regulating blood sugar, preventing fat buildup, constipation and the development of colon and breast cancer, as well as strengthening capillary blood vessels and inhibiting the formation of gallstones and plasma cholesterol (Tomotake *et al.*, 2000).

Composite flour is a mixture of flours, starch and other ingredients intended to replace wheat flour totally or partially in value added products (Olamiti and Ramashia, 2024). Development of composite flour bakery products is the latest trend in bakery industry. The growing interest in these types of food products is due to their better nutritional properties. Exploitation of nutritious and medicinally valued plant foods can play an important role in meeting consumer demands. Successful enrichment of staple cereal products with pea pod and buckwheat into bakery products can prove to be a sustainable strategy to meet the nutritional needs as well as bring healthiness to people. Breadsticks, often known as grissini in Italy, originating in the northern parts of Italy, specifically in the vicinity of Turin, these delicious nibbles were first developed in the 17th century. They were created as a special delicacy for the Duke of Savoy, who reportedly needed a light, easily digestible snack due to stomach problems (Wadikar *et al.*, 2021). Breadsticks are oblong-round shaped bakery product with low moisture content made from yeast, dough and have fragile structure. They are also known as dipping sticks and are usually pencil-

sized sticks, which are of crisp texture and are extensively consumed for the taste and extended shelf life. The purpose of this study was to valorization of agro-industrial by-products such as pea pods, which are often discarded as waste for the development of pea pod blended bread sticks which supports consumer trends toward healthier, plant-based snacks and aligns with circular economy approaches in the food industry.

Materials and Methods

Procurement and preparation of raw materials

Pea pods were procured from local vegetable vender's selling shelled peas in Jammu. For the development of pea pod blended bread sticks, buckwheat, refined wheat flour, butter, yeast and salt were purchased from local market of Jammu and were taken to Food Processing and Training Centre of the Division of Post Harvest Management, SKUAST-Jammu for further processing.

Pea pod : The pods were sorted, cleaned and blanched using hot water blanching method. For blanching, pea pods were immersed in hot water at 80°C for 2 min. and then immediately placed under running cold water for 3 min. The parchment layer was removed from the blanched pods manually and then subjected to freeze drying method. After that, Firstly, prepared pea pod was frozen at -18°C and then dried in a freeze drier with chamber temperature of -60°C, under vacuum and a condenser temperature of -50°C. It took almost 10 hours to dry the materials from initial moisture content of less than 10 per cent. After that pea pod was ground to fine powder.

Buckwheat : The dried grains of buckwheat were milled into flour using a laboratory mill and was then sieved (74-mesh sieve) and stored in air tight containers till further use.

Standardization of pea pod blended bread sticks

For the development of bread sticks, blends of refined wheat flour, freeze dried pea pod powder and buckwheat flour were prepared by different combination of treatment; T₁-100:00:00 (Control), T₂ (85:05:10 :: Refined wheat flour: Freeze dried pea pod powder: Buckwheat flour), T₃ (80:10:10:: Refined wheat flour: Freeze dried pea pod powder: Buckwheat flour), T₄(75:15:10:: Refined wheat flour: Freeze dried pea pod powder: Buckwheat flour), T₅(70:20:10:: Refined wheat flour: Freeze dried pea pod powder: Buckwheat flour), T₆(65:25:10:: Refined wheat flour: Freeze dried pea pod powder: Buckwheat flour), T₇ (60:30:10:: Refined wheat flour: Freeze dried pea pod powder: Buckwheat flour) for formulation of bread

sticks.

The refined wheat flour, freeze dried pea pod powder and buckwheat flour were blended separately in different ratios (as given in treatment details) with each other along with salt and butter. Dried yeast was activated in luke warm water, then along with all the other ingredients slowly water was added till dough was formed. Prepared dough was kept for fermentation for 30 min. The remixed dough was divided into 15g piece each, then rolling of dough was done manually and was cut into the desired shape having the length of 10 cm, width 1.0 to 1.3 cm and thickness 0.70 to 0.80 cm. Prepared unbaked sticks were put on greased tray and baked in pretreated oven at 180°C for 20-25 min. The tray was removed from the baking oven and cooling of the bread sticks at room temperature was done. The prepared bread sticks were packed in laminated pouches, sealed and stored under ambient conditions ($38\pm 2^{\circ}\text{C}$) for a period of 90 days. The fresh as well as stored samples were analyzed periodically at an interval of 0, 30, 60 and 90 days of storage for functional and proximate composition of pea pod blended bread sticks.

A method described by Amandikwa (2012) was used for the determination of bulk density. The ground sample (10g) was taken in a pre-weighed 25 ml measuring cylinder. The bottom of cylinder was gently tapped on a pad till constant volume was observed. The volume occupied by sample was noted and bulk density was expressed as g per ml. For estimation of water absorption capacity of 1 g sample was mixed in centrifuge tubes with 10 ml distilled water (Khatoniar and Das, 2020). After 30 minutes of sporadic stirring, the material was centrifuged for 10 minutes at 2000 rpm. After centrifugation, the aqueous supernatant was decanted, the test tubes were turned upside down, and were left to drain for five minutes on paper towels. By weighing the residue, water absorption capacity was calculated and expressed as a percentage of water absorbed per gram of sample. The oil absorption capacity of samples was determined by 1.0 g of sample with 10 ml sunflower in centrifuged tube (Adebisi *et al.*, 2016). After 30 minutes of sporadic stirring, the material was centrifuged for 10 minutes at 2000 rpm. After centrifugation, the aqueous supernatant was decanted, the test tubes were turned upside down, and were left to drain for 5 minutes on paper towels. By weighing the residue, oil absorption capacity was calculated and expressed as a percentage of oil absorbed per gram of sample. The 2 g sample was mixed with 50 ml of distilled water at $30\pm 2^{\circ}\text{C}$ in a 100 ml measuring cylinder. The suspension was shaken properly by whipping for 3 minutes to form foam. The content

was then transferred into the measuring cylinder and the volume of the foam after 30 seconds recorded and foam volume was recorded 1 hours after whipping to determine the foam stability as percentage of the initial foam volume (Jain and Singh, 2020).

Moisture content was determined by standard (AOAC, 2012) method by following the oven drying method as the loss in weight due to evaporation from sample at a temperature of $105\pm 1^{\circ}\text{C}$ till constant weight was achieved. Crude fat was determined by the Soxhlet extraction technique (AOAC, 2012). Fat content of the sample was easily extracted into organic solvent (petroleum ether) at 60 to 80°C and followed to reflux for 6 h. The crude protein content was determined by micro Kjeldahl method, using the factor 6.25 for converting nitrogen content into crude protein (Sadasivam and Manickam, 2008). Fibre and ash of the sample was determined by method as described in (AOAC, 2012). The carbohydrate content was estimated by the difference method. It was calculated by subtracting the sum of percentage of moisture, crude fat, crude protein, crude fibre and ash contents from 100 according to AOAC (2012). Energy was calculated by multiplying protein, fat and carbohydrate values obtained from analysis by 4, 9 and 4, respectively and expressed in Kcal per 100 g.

Statistical analysis

The data obtained was analysed statistically using Factorial completely randomized design (CRD) for interpretation of the results through analysis of variance.

Results and Discussion

Functional parameters

Bulk density

Bulk density is the ratio of mass to the apparent volume of specific container; it is an important character that affects the required storage space at processing plant or for shipping (Gandhi, 2018). The lowest mean bulk density of 0.646 g per ml was recorded in T_7 and highest of 0.732 g per ml for T_1 (Table 1). Increase in the level of freeze dried pea pod powder in the pea pod blended bread sticks resulted in decrease in the bulk density value which might be due to the influence of molecular structure, less weight and higher volume of freeze dried pea pod powder (Kumar and Saini, 2016). During storage period of 90 days, mean bulk density decreased from 0.705 to 0.685 g per ml which might be due to moisture loss which reduces the mass while the volume remains constant, leading to lower bulk density (20).

Water absorption capacity

The water absorption capacity measures the volume

Table 1: Effect of treatment and storage on bulk density (g/ml) and water absorption capacity (g/ml) of pea pod blended bread sticks.

Treatment	Bulk density (g/ml)				Mean (Treatment)	Water absorption capacity (g/ml)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T ₁ (RWF:PPP:BWF::100:00:00)	0.742	0.737	0.728	0.723	0.732	1.42	1.36	1.27	1.20	1.31
T ₂ (RWF:PPP:BWF::85:05:10)	0.736	0.730	0.725	0.716	0.726	1.45	1.39	1.32	1.26	1.35
T ₃ (RWF:PPP:BWF::80:10:10)	0.729	0.727	0.719	0.708	0.720	1.50	1.41	1.38	1.35	1.41
T ₄ (RWF:PPP:BWF::75:15:10)	0.711	0.702	0.695	0.686	0.698	1.63	1.52	1.49	1.43	1.52
T ₅ (RWF:PPP:BWF::70:20:10)	0.687	0.681	0.676	0.672	0.679	1.73	1.66	1.60	1.54	1.63
T ₆ (RWF:PPP:BWF::65:25:10)	0.678	0.699	0.661	0.653	0.665	1.80	1.72	1.63	1.59	1.68
T ₇ (RWF:PPP:BWF::60:30:10)	0.652	0.647	0.644	0.642	0.646	1.91	1.85	1.81	1.75	1.83
Mean (Storage)	0.705	0.699	0.692	0.685		1.63	1.55	1.50	1.44	
Effect	CD(p≤0.05)		SE (m)			CD(p≤0.05)		SE (m)		
Treatment	0.02		0.0008			0.02		0.008		
Storage	0.02		0.0008			0.01		0.004		
Treatment × Storage	0.06		0.0024			0.05		0.002		

Table 2 : Effect of treatment and storage on oil absorption capacity (g/ml) and foam capacity (%) of pea pod blended bread sticks.

Treatment	Oil absorption capacity (g/ml)				Mean (Treatment)	Foam capacity (%)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T ₁ (RWF:PPP:BWF::100:00:00)	1.52	1.59	1.68	1.73	1.63	11.52	11.56	11.62	11.70	11.60
T ₂ (RWF:PPP:BWF::85:05:10)	1.65	1.71	1.76	1.84	1.74	11.41	11.49	11.58	11.67	11.53
T ₃ (RWF:PPP:BWF::80:10:10)	1.82	1.92	1.98	2.05	1.94	11.34	11.45	11.54	11.61	11.48
T ₄ (RWF:PPP:BWF::75:15:10)	1.88	2.00	2.09	2.14	2.02	11.28	11.36	11.42	11.53	11.39
T ₅ (RWF:PPP:BWF::70:20:10)	1.94	2.04	2.11	2.19	2.07	11.20	11.27	11.39	11.48	11.33
T ₆ (RWF:PPP:BWF::65:25:10)	2.08	2.17	2.24	2.28	2.19	11.13	11.21	11.30	11.37	11.25
T ₇ (RWF:PPP:BWF::60:30:10)	2.16	2.25	2.31	2.37	2.27	11.02	11.09	11.17	11.24	11.13
Mean (Storage)	1.86	1.95	2.02	2.08		11.27	11.34	11.43	11.51	
Effect	CD(p≤0.05)		SE (m)			CD(p≤0.05)		SE (m)		
Treatment	0.03		0.012			0.04		0.016		
Storage	0.02		0.008			0.03		0.012		
Treatment × Storage	0.06		0.024			0.08		0.003		

occupied by the granule or starch polymer after swelling in excess of water and determines the ability of the flour to absorb water and swell for improved consistency in food (Abiodun *et al.*, 2014). The highest mean water absorption capacity of 1.83 g per ml was recorded in T₇ whereas, T₁ showed lowest mean water absorption capacity of 1.31 g per ml (Table 1). As is evident from the data that an increase in mean water absorption capacity was observed among treatments might be due to higher water absorption capacity of raw materials. With the progression of storage period, the mean water absorption capacity of bread sticks decreased significantly from 1.63 to 1.44 g per ml which might be due to the decrease in

crude fibre content and increase in hydrophobic amino acid residues during storage (Kumar and Thakur, 2017).

Oil absorption capacity

The oil absorption capacity of food is an important parameter determining the ability of proteins to physically bind fat by capillary action and plays role in flavour retention and enhances the mouthfeel of food (Kumar and Saini, 2016). The maximum and minimum mean oil absorption capacity of 2.27 and 1.63 g per ml were recorded for T₇ and T₁, respectively (Table 2). The increase in mean oil absorption capacity might be due to higher oil absorption capacity of freeze dried pea pod powder. The mean oil absorption capacity of bread sticks

Table 3 : Effect of treatment and storage on foam stability (%) and moisture content (%) of pea pod blended bread sticks.

Treatment	Foam stability (%)				Mean (Treatment)	Moisture content (%)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T ₁ (RWF:PPP:BWF::100:00:00)	89.32	89.40	89.45	89.56	89.43	5.21	5.29	5.36	5.42	5.32
T ₂ (RWF:PPP:BWF::85:05:10)	85.12	85.18	85.26	85.34	85.22	5.07	5.13	5.22	5.25	5.16
T ₃ (RWF:PPP:BWF::80:10:10)	81.74	81.79	81.87	81.93	81.83	4.95	4.99	5.10	5.16	5.05
T ₄ (RWF:PPP:BWF::75:15:10)	79.19	79.25	79.32	79.44	79.30	4.79	4.85	4.96	5.04	4.91
T ₅ (RWF:PPP:BWF::70:20:10)	74.63	74.91	75.68	75.95	75.29	4.65	4.73	4.84	4.89	4.77
T ₆ (RWF:PPP:BWF::65:25:10)	71.07	71.15	71.23	71.31	71.19	4.50	4.54	4.62	4.71	4.59
T ₇ (RWF:PPP:BWF::60:30:10)	66.52	66.58	66.67	66.74	66.62	4.35	4.42	4.48	4.55	4.45
Mean (Storage)	78.22	78.32	78.49	78.61		4.78	4.85	4.94	5.00	
Effect	CD(p≤0.05)		SE (m)			CD(p≤0.05)		SE (m)		
Treatment	0.05		0.02			0.05		0.02		
Storage	0.04		0.02			0.04		0.01		
Treatment × Storage	0.11		0.04			0.11		0.04		

increased from 1.86 to 2.08 g per ml during 90 days of storage period which might be due to increase in hydrophobic/non-polar amino acid residues which form complex structure (Shobha *et al.*, 2014).

Foam capacity and stability

Foam capacity and stability are desirable attributes intended for the production of variety of baked products and also act as functional agents in other food formulations. Foam stability (FS) describes the ability of the proteins to form strong cohesive film around air vacuole that resists air diffusion from the vacuole (Baranwal and Sankhla, 2019). The highest mean foam capacity and stability was recorded for T₁ having values of 11.60 and 89.43 per cent, respectively. The lowest mean foam capacity and stability were observed for T₇ with values of 11.13 and 66.62 per cent, respectively (Tables 2 and 3). This decrease in the foam capacity and stability might be caused by some anti-nutritional factors or fat and protein interaction involved in foam generation, which reduces surface tension (Akter and Ahiduzzaman, 2017). During storage period of 90 days, the overall mean foam capacity and stability increased significantly from 11.27 to 11.51 per cent and 78.22 to 78.61 per cent, respectively which might be due to partial denaturation of proteins, exposing hydrophobic groups, improving interfacial activity, hence enhanced both foam capacity and stability during storage (Negi and Roy, 2000).

Chemical parameters of pea pod blended bread sticks

The maximum mean moisture content of 5.32 per cent was observed in T₁ and the minimum mean value of 4.45 per cent was recorded for T₇ (Table 3). It is evident

from the results that there was a decrease in moisture content with the increasing proportion of freeze dried pea pod powder which might be due to lower moisture content in freeze dried pea pod powder and buckwheat flour than refined wheat flour. The overall mean moisture content increased from 4.78 to 5.00 per cent during 90 days of storage which might be due to higher relative humidity in storage environment and hygroscopic nature of bread sticks resulting in absorption of moisture (Negi and Roy, 2000).

The highest mean crude protein content of 12.20 per cent was recorded for T₇ while least value of 10.56 per cent was recorded for T₁ (Table 4). The supplementation of freeze dried pea pod powder increased the value of crude protein content which might be due to high amount of protein in freeze dried pea pod powder. On assessing the effect of storage on crude protein content a decreasing trend was observed on mean crude protein from 11.56 to 11.38 per cent during storage period of 90 days which might be attributed to Maillard reaction involving reaction between amino acids and sugars along with the disorganised protein structure resulting from moisture gain during storage further resulting in their degradation (Naik and Chetti, 2017).

The highest mean crude fat content (4.90 %) was recorded in T₇ and lowest (2.41%) was observed in T₁ (Table 4). The supplementation of freeze dried pea pod powder and buckwheat flour increased the crude fat of bread sticks which might be attributed to higher crude fat percentage in buckwheat flour and pea pod powder. During storage period of 90 days, the mean crude fat content decreased from 4.12 to 3.68 per cent in pea pod blended bread sticks which might be due to the

Table 4: Effect of treatment and storage on crude protein (%) and crude fat (%) of pea pod blended bread sticks.

Treatment	Crude protein (%)				Mean (Treatment)	Crude fat (%)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T ₁ (RWF:PPP:BWF::100:00:00)	10.63	10.59	10.55	10.48	10.56	2.62	2.51	2.35	2.18	2.41
T ₂ (RWF:PPP:BWF::85:05:10)	11.20	11.17	11.10	10.96	11.10	3.79	3.70	3.56	3.34	3.59
T ₃ (RWF:PPP:BWF::80:10:10)	11.39	11.35	11.28	11.19	11.30	3.96	3.75	3.62	3.50	3.70
T ₄ (RWF:PPP:BWF::75:15:10)	11.61	11.54	11.47	11.41	11.50	4.02	3.81	3.68	3.57	3.77
T ₅ (RWF:PPP:BWF::70:20:10)	11.82	11.80	11.76	11.63	11.75	4.48	4.33	4.19	4.06	4.26
T ₆ (RWF:PPP:BWF::65:25:10)	12.04	12.00	11.95	11.88	11.96	4.92	4.74	4.58	4.51	4.68
T ₇ (RWF:PPP:BWF::60:30:10)	12.28	12.23	12.17	12.15	12.20	5.11	5.01	4.83	4.66	4.90
Mean (Storage)	11.56	11.52	11.46	11.38		4.12	3.97	3.83	3.68	
Effect	CD(p≤0.05)		SE (m)			CD(p≤0.05)		SE (m)		
Treatment	0.06		0.02			0.04		0.01		
Storage	0.05		0.01			0.03		0.02		
Treatment × Storage	0.12		0.05			0.08		0.04		

Table 5: Effect of treatment and storage on crude fibre (%) and ash content (%) of pea pod blended bread sticks.

Treatment	Crude fibre (%)				Mean (Treatment)	Ash (%)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T ₁ (RWF:PPP:BWF::100:00:00)	1.19	1.08	1.02	0.94	1.05	1.54	1.48	1.39	1.33	1.43
T ₂ (RWF:PPP:BWF::85:05:10)	1.72	1.63	1.54	1.45	1.58	1.60	1.55	1.51	1.45	1.52
T ₃ (RWF:PPP:BWF::80:10:10)	2.10	2.01	1.92	1.84	1.96	1.71	1.64	1.56	1.49	1.60
T ₄ (RWF:PPP:BWF::75:15:10)	2.49	2.40	2.33	2.25	2.36	1.78	1.73	1.68	1.57	1.69
T ₅ (RWF:PPP:BWF::70:20:10)	2.93	2.88	2.81	2.72	2.83	1.83	1.80	1.74	1.61	1.74
T ₆ (RWF:PPP:BWF::65:25:10)	3.32	3.26	3.19	3.10	3.21	1.94	1.88	1.79	1.72	1.83
T ₇ (RWF:PPP:BWF::60:30:10)	3.71	3.65	3.57	3.48	3.60	2.02	1.97	1.92	1.89	1.95
Mean (Storage)	2.49	2.41	2.34	2.25		1.77	1.72	1.65	1.58	
Effect	CD(p≤0.05)		SE (m)			CD(p≤0.05)		SE (m)		
Treatment	0.05		0.01			0.05		0.02		
Storage	0.04		0.01			0.06		0.01		
Treatment × Storage	0.10		0.03			N.S		0.04		

increase in relative humidity which stimulates the activity of lipase, breakdown of fat into fatty acid and glycerol (Zahra *et al.*, 2020).

The bread sticks prepared, from T₁ recorded minimum mean crude fibre content of 1.05 per cent while T₇ recorded maximum mean crude fibre content of 3.60 per cent (Table 5). With the incorporation of freeze dried pea pod the crude fibre content increased which might be due to higher percentage of crude fibre in freeze dried pea pod powder than other raw materials. With the advancement in storage period, the mean crude fibre content decreased from 2.49 to 2.25 per cent which might be due to degradation of structural polysaccharides and hemicelluloses during storage. Also heat and moisture solubilizers can degrade pectic substances leading to the

decrease in the fibre content (Sharon and Usha, 2006).

Ash content is the measure of total amount of minerals present within a food (Table 5). With the incorporation of pea pod powder the mean ash content of bread sticks increased from 1.43 to 1.95 per cent which might be due to higher ash content in pea pod powder. The increase in ash content of bread with increase in substitution levels of *Pleurotus plumonarius* has been reported by (Okafor *et al.*, 2012). During 90 days of storage, the mean ash content of pea pod blended bread sticks decreased from 1.77 to 1.58 per cent. The decrease in ash content might be due to the mineral losses from binding of minerals by Maillard reaction products during storage (Nadarajah and Mahendran, 2015).

On analysing the mean carbohydrate content of pea

Table 6 : Effect of treatment and storage on Carbohydrates (%) and energy content (Kcal/100g) of pea pod blended bread sticks.

Treatment	Carbohydrates (%)				Mean (Treatment)	Energy (Kcal/100g)				Mean (Treatment)
	Storage period (days)					Storage period (days)				
	0	30	60	90		0	30	60	90	
T ₁ (RWF:PPP:BWF::100:00:00)	73.23	73.58	73.95	74.31	73.76	409.24	408.50	407.57	406.84	408.03
T ₂ (RWF:PPP:BWF::85:05:10)	72.08	72.46	72.77	73.26	72.64	408.09	407.06	406.04	405.55	406.68
T ₃ (RWF:PPP:BWF::80:10:10)	71.45	71.80	72.15	72.58	71.99	406.96	406.09	405.63	404.78	405.86
T ₄ (RWF:PPP:BWF::75:15:10)	70.77	71.16	71.48	71.84	71.31	406.52	405.68	404.52	403.74	405.11
T ₅ (RWF:PPP:BWF::70:20:10)	69.99	70.33	70.64	71.22	70.54	406.26	404.66	404.49	402.77	404.54
T ₆ (RWF:PPP:BWF::65:25:10)	69.19	69.82	70.10	70.45	69.89	404.66	404.50	403.35	402.58	403.77
T ₇ (RWF:PPP:BWF::60:30:10)	68.67	69.02	69.43	69.67	69.19	403.98	403.39	402.27	401.38	402.75
Mean (Storage)	70.76	71.16	71.50	71.90		406.53	405.69	404.83	403.94	
Effect	CD(p≤0.05)				SE (m)	CD(p≤0.05)				SE (m)
Treatment	0.05				0.01	0.04				0.01
Storage	0.03				0.01	0.03				0.02
Treatment × Storage	0.10				0.03	0.08				0.04

pod blended bread sticks (Table 6), the highest mean carbohydrates content of 73.76 per cent was recorded in T₁ whereas, T₇ exhibited lowest mean carbohydrate content of 69.19 per cent. Carbohydrate content decreased with the increasing proportion of freeze dried pea pod powder which might be attributed to lower carbohydrates in pea pod. During storage period of 90 days, the carbohydrates content increased from 70.76 to 71.90 per cent. The carbohydrates content is determined by calculation difference of other components (moisture, protein, fibre, fat and ash) which might have automatically increased the carbohydrate content (Rokhsana *et al.*, 2007).

The lowest mean energy content was recorded in T₇ as 402.75 Kcal per 100 g, whereas, T₁ recorded highest mean energy value of 408.03 Kcal per 100 g (Table 6). This decrease in energy content with blending might be due to lower energy content in freeze dried pea pod powder. During storage period of 90 days, the energy content decreased from 406.53 to 403.94 Kcal per 100 g which might be attributed to decrease in crude protein and crude fat content with increase in storage period (Regmi *et al.*, 2009).

Conclusion

Pea pod powder can be added to composite flour for improving its nutritional value and functionality, while encouraging waste valorization in the creation of breadsticks. Pea pods greatly enhances the chemical makeup of breadsticks by improving their crude protein, crude fat, ash and crude fiber content. The extent of replacement affects functional factors like foaming qualities, oil absorption, and water absorption capacity,

which frequently results in increased health benefits and better textural stability. Thus, pea pod fortification not only gives value to a frequently thrown-away by-product, but it also offers a sustainable method of creating functional bakery goods that are high in fiber and satisfy customer desire for environmentally friendly and health-conscious foods.

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