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Utilization of Prickly Pear By-Products to Improve The Nutritional Value of Balady Bread

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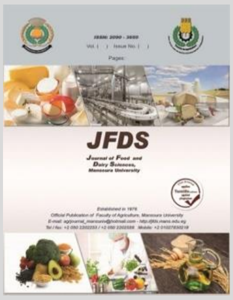

ABSTRACT

Industrial food by-products are rich in functional compounds that can be used to boost the nutritional value and health properties of everyday baked goods. The purpose of this study was to look into the nutritional value and bioactive components of prickly pear by-products peels and seeds as replacements for wheat flour (WF) at different levels (5, 10, and 15%) for preparing balady bread. The prickly pear seeds (PPS) had a higher ether extract content (8.84%) and crude fiber content (49.02%) than those of prickly pear peels (PPP) and WF (82%). While PPP has the highest ash content (10.97%), PPS (1.52%), and WF (1.38%) follow. Furthermore, the PPP contained high amount of total phenolic compounds and flavonoids than the PPS and WF. While the PPS had exhibited the highest antioxidant activity. In addition, PPS mineral content calcium and potassium were higher than the others. While, the PPS was richer in phosphorus and iron than the PPP. Fatty acids composition of PPP and PPS oils was primarily unsaturated (68.39 and 84.31%, respectively). The ratios of unsaturated to saturated acids were higher in PPS oil (5.37) than in PPP oil (2.16). The PPP had a higher proportion of total essential amino acids (42.03%) than the PPS (39.68%). Ether extract, dietary fiber, and ash contents of balady bread prepared with PPP and PPS increased significantly as the replacement ratio was increased. According to the sensory evaluation results, supplementing with PPP and PPS up to 15% is acceptable for the sensory properties of bread samples.

Keywords: prickly pear by-products, nutritive value and balady bread.

INTRODUCTION

The fruit of the Opuntia cactus plant includes prickly pear known as cactus fruit, cactus figs, Indian figs, Barbary figs, and tunas. The cactus is a member of the Cactaceae family and is native to arid and semi-arid climates. The genus Opuntia contains approximately 1500 species of cactus that are found in Europe, Mediterranean countries, Africa, the southwestern United States, northern Mexico, and other areas. Cactus pear is considered a potential alternative crop for dry regions due to its ability to withstand prolonged drought. Opuntia fruit consists of fleshy, elongated berries that vary in shape, size, and color (orange, yellow, red, purple, green, and white). They have an even distribution of hard seeds. Their weight ranges from 80 to 140 g, with an average edible portion of 54.18% (Shetty, *et al.*, 2012 and Belhadj *et al.*, 2021).

According to the CAPMS (2022), the annual Egypt yield of cactus pear fruits is approximately 27796 tonne produced from 2734feddan of fruitful cactus pear trees. Mexico, which produces 45% of the world's cactus pear fruits, is the greatest producer and exporter in the world, followed by Italy (12.2%) and South Africa (3.7%) (Andreu-Coll *et al.*, 2020). Because it is a significant source of dietary antioxidants and bioactive chemicals, which may both be beneficial to consumer health, prickly pears have a high bioactive potential (Albano, *et al.*, 2015 and Akkol, *et al.*, 2020). According to Ramirez-Rodriguez *et al.* (2020) and Ramadan *et al.* (2021), food scientists and technologists are becoming more interested in Opuntia spp. Due to its abundance in nutrients and bioactive components like fiber, vitamin C, phenolic compounds, vitamin E, amino acids, minerals, and naturally occurring colors like betalains, plants are a good source of these nutrients. These bioactive components have anti-inflammatory, immunomodulatory, and antioxidant properties. The high antioxidant levels in Opuntia fruits are principally caused by the presence of phenolic compounds, betacyanins, betalains, and certain vitamins in high concentrations. Certain amino acids (like taurine) and minerals including iron, potassium, magnesium, calcium, salt, and phosphorus are present in opuntia fruits (Gouws *et al.*, 2019 and Rahimi *et al.*, 2019).

Despite evidence that they contain significant amounts of bioactive molecules, opuntia by-products have received little attention. Opuntia peels account for 60% of the total fruit weight but are underutilized (Milán-Noris *et al.*, 2016 and Oumato *et al.*, 2016). As a result, Opuntia peel by-products are frequently excreted after consumption of the fruit (Ramadan and Mörsel, 2003). Furthermore, as a low-cost and cost-effective alternative, the production of nutraceuticals from plant byproducts such as Opuntia peels using food processing techniques will continue to expand (Aruwa *et al.*, 2018).

The bakery industry in Egypt has expanded dramatically in recent years. Bakery products are differentiated by the addition of value-added ingredients, dietary fiber and phytochemicals have received a lot of

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attention as added ingredients. Several years ago, many studies reported that combining flour with plant by-product powder improved the nutritional and functional properties of cookies and bread (Elhassaneen *et al*., 2013 and Ahmed, 2016).

Bread has long been a staple in the Mediterranean diet and plays an important role in the Mediterranean food tradition. Consumers are becoming more concerned with the consumption of "healthy foods" these days. As a result, the bakery industry has begun to develop a diverse range of baked goods enriched with bioactive ingredients such as dietary fibers, antioxidants, and phenolic compounds (Gomez and Martinez, 2018 and Spina *et al.,* 2019).

Carlos *et al.* (2010) reported that commercially available formulated food products with high dietary fiber contents are now available. Cereals are the primary source of dietary fiber, which is found in these products. Because all of these materials are high in soluble dietary fibers, the use of byproducts from various fruits and vegetables seems potential. Food manufacturers prize dietary fiber-rich byproducts because consumers want natural supplements and worry that synthetic ones could be hazardous. Moreover, dietary fiber has extraordinary nutritive and human protective properties, including the reduction of risk for cardiovascular disease and colon cancer. Therefore, the main goal of this study was to investigate the nutritional value of prickly pear by-products (peels and seeds) as wheat flour substitutes in the preparation of balady bread as a new food industries product in the Egyptian market.

MATERIALS AND METHODS

Materials:

Prickly pear fruit (*Opuntia ficus-indica*) obtained from a small farm in Al-Behayrah Governorate, Egypt, at August 2021 harvested mature fresh with yellow skin that was defect-free. The Delta Middle and West Milling Company in Tanta, Egypt, supplied the majority (82%) of the wheat flours. All of the chemicals used in this investigation were provided by the Egyptian companies El-Gomhoria Company for Chemicals and Pharmaceuticals and Merk Company for Chemicals and Biodiagnostica.

Methods:

Preparation of prickly pear peels and seeds samples:

Prickly pear samples were scrubbed with a brush to reduce thorns before being washed with water to eliminate any dirt. Hand peeling with a sharp knife separated the PPP. According to Ibrahim., (2003) the peels were divided into slices and dried using the sun dryer system in the energy department of the National Research Center, as well as indirectly dried using the solar drying system employing forced circulation . The dried peels were ground in a mixer grinder and stored in plastic bags at -18 °C. In a mixer, the pulp was mixed for a few minutes. The seeds, on the other hand, were recovered from the resulting pulp juice by straining and washing several times with distilled water. The seeds were milled in a miller after drying at room temperature and passing through a 20 mesh sieve. The powder was immediately stored at -18 °C in clean, tight polyethylene bags.

Chemical composition of prickly pear peels, seeds and balady bread:

Moisture, ether extract, crude protein, ash content, and crude fiber fiber of PPP, PPS, and balady bread were determined using AOAC (2012) methods. The available carbohydrate content was calculated using the difference method.

Extraction and determination of total phenolic and flavonoids compounds:

Anagnostopoulou *et al.* (2006) described a method for extracting total phenolic compounds. Furthermore, the phenolic extracts were spectrophotometrically determined using the Folin-ciocalteau reagent according to the method described by Kahkonen *et al.* (1999), and the phenolic acid content was estimated using a standard curve prepared with Gallic Acid. On the other hand, total flavonoid was determined by the method of Djeridane, *et al.* (2006) and used to estimate the flavonoids content using a standard curve prepared using rutin (RE).

Determination of DPPH radical scavenging capacity:

Assay antioxidant activity (DPPH) was measured using the (1, 1-diphenyl-2- picrylhydrazyl) DPPH method described by Lim and Quah, (2007).

Determination of minerals contents of PPP , PPS and WF

Content of minerals using the Pearson (1976) method, calcium, iron, magnesium, and zinc measurements were made with the atomic absorption spectrophotometer Perken Elmer Model 20180. While, using flam photometer to determine potassium. Using the Murphy and Riley (1962) described ascorbic acid method, total phosphorus was measured colorimetrically.

Chromatographic analysis of polyphenols compounds of PPP and PPS:

Qualitative and quantitative phenolic compounds were determined by HPLC according to the method of Schieber *et al*.,(2001).

Determination of the fatty acids composition of PPP and PPS:

Gas-Liquid Chromatography (GLC) GC Model, Shimadzu-4CM (PFE), equipped with FID detector and glass column 2.5mX 3mm id, was used to analyse the fatty acid composition of PPP and PPS (Radwan, 1978). Fatty acid esterification was carried out in accordance with Atta and Imaizumi (1998).

Determination of amino acids composition of PPP and PPS:

Using a Beckman amino acid analyzer, Model 119 CL, as described by Sadasivam and Manickam (1992), amino acids in the hydrolyzate were calculated.

Chemical score essential amino acids:

The chemical score of PPP and PPS was calculated according to FAO/WHO (2007*)* as follows:

$$\text{Chemical score} = \frac{mg/g \text{ of essential amino acid in test protein}}{mg/g \text{ of essential amino acid in refrance protein}} \times 100$$

Rheological properties:

Farinograph and extensograph tests carried out on wheat flour as a control and replacers of wheat flour at different levels (5, 10, and 15%) using PPP or PPS mixtures used methods A.A.C.C. (2005). Water absorption dough development time, dough stability, dough tolerance index, and weakening of the dough were determined as farinograph properties using a Brabender Farinograph type (910/05001 West Germany Hz50) at Rheological Lab., Food Technology Research Institute. Res. Cent., Giza Egypt. In addition, extensibility, elasticity after 5 min, maximum elasticity, proportional number, and energy were determined as extinsograph properties using a Brabender Extinsograph type (86001 West Germany Hz50) at the same lab.

Preparation of balady bread:

Balady bread was manufactured from wheat flour (82% extraction) and replacers of wheat flour at different levels (5, 10, and 15%) of PPP or PPS mixtures using the following formula as described by El-Talawy and Khorshid, (1982*)*.

Sensory evaluation of balady bread:

The balady bread was also examined for its organoleptic proprieties including color, appearance, taste, aroma, and texture *(Singh et al., 1990).*

Staling of balady bread:

The freshness of balady bread, loaves for reach formula tested by alkaline water retention capacity determination, according to the method (Kitterman and Rubenthaler, 1971).

Statistical analysis:

Data were analyzed according to Steel and Torrie, (1980) procedures (Duncan's multiple range test DMRT).

RESULTS AND DISCUSSION

Gross chemical composition (%) and bioactive compounds of WF, PPP and PPS:

Table 1 shows the chemical compositions of WF, PPP, and PPS. WF has a significantly higher crude protein content (11.88%) than PPS (8.18%) and PPP (6.48%), according to the results. PPS has the highest fat content (8.84%), followed by PPP (1.46%), and WF (1.38%). Furthermore, PPP contains significantly more ash than PPS, and WF. However, the PPS has more fiber than the PPP, and wheat flour has 82% fiber. These findings are consistent with those of El-Shahat *et al*., (2019), Abdelfattah *et al*., (2020), Ali et al., (2020), and Fiad *et al*., (2020). Table 1 also displays total phenolic compounds, total flavonoids, and antioxidant activity of PPP, PPS, and WF. It was observed from these results that the total phenolic compounds and total flavonoid content were higher in PPP than PPS and WF (82%), while PPS were higher than them in DPPH . According to Chang *et al.* (2008), methanolic extracts of *O. dillenii* fruit have significant antioxidant activity, with seed extracts having stronger antioxidant properties than peel and pulp extracts. These findings agreed with those of Toure *et al*., (2015), Anwar and Sallam, (2016), Belviranl *et al*., (2019), and Parafati *et al*., 2020). They claimed that the types of compounds present in the extract, the techniques and solvents utilized for the extraction, the age of the fruit, the climate, and the quantification methodology all influence the total phenolic compounds and total flavonoid levels.

Table 1. Chemical composition (% on a dry weight) and bioactive compounds of WF, PPP and PPS.

Samples	Chemical composition (%)						Antioxidants compounds		
	Moisture	Crude protein	Ether extract	Ash content	Crude fiber	AV*	TPC (mgGAE/100g)	TF(mg RE/100g)	DPPH (%)
WF	10.71^a ± 0.14	11.88^a ± 0.08	1.38^b ± 0.10	0.92^c ± 0.08	1.38^c ± 0.02	85.82^a ± 0.10	0.65^c ± 0.09	0.15^c ± 0.07	51.33^c ± 0.07
PPP	4.27^c ± 0.08	6.48^c ± 0.08	1.46^b ± 0.30	10.97^a ± 0.07	5.25^b ± 0.15	81.09^b ± 0.22	1106.4^a± 3.79	43.40^a ± 0.41	67.18^b ± 0.38
PPS	5.36^b ± 0.33	8.18^b ± 0.17	8.84^a ± 0.13	1.52^b ± 0.00	49.02^a ± 0.77	81.46^b ± 0.14	89.79^b ± 0.16	3.18^b ± 0.04	91.75^a ± 0.10

The standard deviation (±SD) of three determinations is the average of the means.
Means in a column with the same letters are not statistically different at≤ 0.05.
AV*: Available Carbohydrate were calculated by differences.
WF: wheat flour extract 82%, PPP: Prickly pear peels and PPS: Prickly pear seeds, TPC: Total phenolic compounds and TF: total flavonoids.

Mineral content of WF 82%, PPP and PPS:

The prickly pear is beneficial in preventing osteoporosis due to the presence of magnesium and calcium (Castiglioni *et al*., 2013). According to Table 2, prickly pear is regarded as a rich supplier of the minerals calcium, potassium, and magnesium. All of the aforementioned elements had higher values in PPP and PPS, with the exception of phosphorus, which was higher in WF (82%) than PPP. In addition, compared to the PPS (467.50, 287.25, and 338.50 mg/100g, respectively), the PPP had higher concentrations of calcium (2256.25 mg/100g), potassium (2049.75 mg/100g), and magnesium (730.50 mg/100g). However the PPP's phosphorus and iron content were lower (51.02 and 4.55 mg/100 g, respectively) in comparison to the PPS (156.75 and 6.85 mg/100 g, respectiveely). The location of the plants, the method of cultivation, the application of fertilisers and irrigation, the climate, and the genetic variances between the kinds, according to Abba Touré *et al.* (2016), could all affect the variation in the mineral levels reported by writers in various nations. In addition, Saenz and Berger (2006). According to a report, calcium's high concentration in the peel may be related to the mineral's function as a structural material, which is typically linked to pectin compounds that help preserve shape and structure. The outcomes matched those published by EL Kossori *et al.* (1998); Hailemichael (2016) and El-Shahat *et al*. (2017).

Table 2. Minerals content (mg/100g dry weight) of WF 82%, PPP and PPS.

Components Samples	P	K	Ca	Fe	Mg	Zn
WF	141.8	130.2	36.20	1.56	130.6	0.77
PPP	51.02	2049.75	2256.25	4.55	730.50	3.63
PPS	156.75	287.25	467.50	6.85	338.50	2.29

WF: Wheat flour 82%. PPP: Prickly pear peels. PPS: Prickly pear seeds.

Fractionation of phenolic and flavonoids compounds of PPP and PPS:

Phenolic and flavonoid components in PPP and PPS were isolated and categorised using High-Performance Liquid Chromatography (HPLC). The results are summarised in Table 3 and 4. In the PPP and PPS, fifteen phenolic compounds (Table 3) were discovered. PPP and PPS include thirteen flavonoids (Table 4). Moreover, the flavonoid components in prickly peel powder were extracted. The results are shown in Table 3. Pyrogallol 1891.64, P-OH-Benzoic 612.60, Benzoic acid 440.44, Chlorogenic 287.96, Salycilic 280.7, Catechin 190.39, Caffeic 160.81, Ellagic 140.46, Ferulic 113.45, Gallic 106.92, Caffeine 76.83, and Vanillic 76.12 ppm were the principal phenolic components in PPP. The most prevalent flavonoid chemicals in the PPP were hesperidin (397.69), apige 6 -arabinose 8 -glactose (394.91), luteolin (7-glucose) 295.94, rosmarinic (116.48), qurectrin (68.23), and rutin (65.98 PPm).The results are similar to El-Dreny *et al.* (2021). Moreover, Table 3 findings revealed that vanillic (36.59 ppm), pyrogallol (81.09 ppm), ferulic (45.83 ppm), and caffeic were the principal phenolic components in PPS (31.42 ppm). Although the PPS had the highest concentrations of apige 6 -arabinose 8 -glactose (191.12), qurectrin (63.71), hesperdin (52.93), and rutin (30.77 PPm) of flavonoid compounds (Table 4). The findings concur with those of Kolniak-Ostek et al.(2020). The presence or lack of certain bioactive compounds in leaves, fruits, roots, seeds, and other naturally occurring byproducts is generally influenced by geographic and environmental factors such as humidity, temperature, season, pollution, altitude, and others. Because of this, it is extremely difficult to standardise the composition of natural products, but it is acceptable to link their therapeutic advantages to the presence and concentration of particular compounds in the extracts employed, as described by González-Ponce et al (2016).

Table 3. Identification of phenolic compounds (ppm on a dry weight) of PPP and PPS.

Phenolic compounds	PPP (ppm)	PPS (ppm)
Pyrogallol	1891.64	36.59
Gallic	106.92	0.95
Catechol	28.93	0.99
4- Amino benzoic	25.63	1.18
Catechin	190.39	22.62
Chlorogenic	287.96	13.91
Benzoic acid	440.44	10.18
P-OH-Benzoic	612.6	4.54
Vanillic	76.12	31.42
Caffeic	160.81	81.09
Caffeine	76.83	10.84
Ferulic	113.45	45.83
Salycilic	280.7	15.66
Ellagic	140.46	16.15
Coumarin	49.49	6.24

PPP: Prickly pear peels PPS: Prickly pear seeds.

Table 4. Fractionation and identification of flavonoids (ppm on a dry weight) of PPP and PPS.

Flavonoid compounds	PPP (ppm)	PPS (ppm)
Apige 6 -arabinose 8 -glactose	394.91	191.12
Hesperdin	397.69	52.93
Luteolin 7 - glucose	295.94	9.13
Rosmarinic	116.48	1.5
Rutin	65.98	30.77
Apigenin 7 - glucose	20.8	4.46
Qurectrin	68.23	63.71
Naringin	22.37	1.18
Naringen	7.42	1.78
Qurcetin	11.73	1.97
Kaemferol 3-2-P- coumaryl-glucose	30.1	5.87
Kaemferol	6.61	0.72
Apigenin	2.14	0.22

PPP: Prickly pear peels PPS: Prickly pear seeds.

Fatty acids composition of PPP and PPS:

Findings shown in Table 5 demonstrate that unsaturated fatty acids, particularly mono-unsaturated fatty acids (oleic) and poly-unsaturated fatty acids, make up the majority of the fatty acid composition of PPP and PPS oils (68.39 and 84.31%, respectively) (linoleic and linolenic). Moreover, PPS oil's unsaturated acid to saturated acid ratio (5.37) was larger than PPP oil's (2.16). Because polyunsaturated fatty acids have a positive impact on health, essential fatty acids are of great interest. Fatty acids are thought to have a natural preventive effect on heart disease and other illnesses, as well as help to make some of them go away (Faremi and Ekanem, 2011). Moreover, polyunsaturated fats have been demonstrated to support the reduction of total and LDL cholesterol as well as a slight but significant reduction in HDL cholesterol (Ajayi and Ajayi, 2009 and Chougui *et al.*, 2013). In addition, it has been suggested that consuming monounsaturated and polyunsaturated fatty acids (MUFAs and PUFAs, respectively) offers health benefits. It helps to improve a number of health issues like obesity, cardiovascular disease, diabetes, and even some forms of cancer (Rodríguez-Cruz *et al*., 2005 and Serra *et al*., 2013).

Table 5. Fatty acids composition (% on a dry weight): of PPP and PPS.

Samples Fatty acids	PPP (%)	PPS (%)
C11:0	0.11	0.12
C12:0	0.29	0.23
C14:0	0.95	0.10
C15:0	0.46	0.44
C16:0	22.21	11.09
C17:0	0.95	---
C18:0	4.47	3.28
C20:0	2.18	0.43
Total saturated FA	31.62	15.69
C16:1	1.32	0.52
C17:1	0.50	0.47
C18:1	23.30	26.16
C18:2	27.18	56.94
C18:3	16.08	0.22
Total unsaturated FA	68.39	84.31
Unsaturated/saturated FA	2.16	5.37

PPP: Prickly pear peels PPS: Prickly pear seeds.

The results presented in Table 5 also demonstrate that in the PPS oil, linoleic acid predominated as the major fatty acid (56.94%), followed by oleic acid (26.16%), palmitic acid (11.09%), and stearic acid (3.28%), while linolenic, arachidic, and palmitoleic acids were only present in trace amounts (0.22, 0.43, and 0.52%, respectively). The table also reveals a decrease in the amount of linoleic and oleic fatty acids in PPP oil compared to PPS oil (27.18 and 23.30%, respectively), but an increase in the amount of palmitic, linolenic, stearic, arachidic, and palmtioleic acid (22.21, 16.09, 4.47, 2.18, and 1.32%, respectively). Our data share some similarities with those of El-Beltagi *et al.* (2019), Abdelfattah *et al*. (2020), and El-Said *et al.* (2011).

Amino acid analysis of PPP and PPS:

The ratio of amino acids in a protein determines some of its quality. Leucine, valine, alanine, glycine, and phenylalanine were the next most abundant amino acids in the PPP (Table 6), followed by glutamic, proline, and aspartic acid (13.23, 12.68, and 11.03 g/100 g protein, respectively). The majority of amino acids in PPS are glutamic acid (20.73 g/100 g protein), arginine (12.52 g/100 g protein), aspartic acid (7.77 g/100 g protein), glycine acid (7.34 g/100 g protein), and leucine (6.26 g/100 g protein). Also, Table 6 shows that the PPP had a larger proportion of total essential amino acids (42.03%) than the PPS (39.68%) and that the PPS had a higher proportion of non-essential amino acids (60.22 and 57.88%, respectively) than the PPP. The value of the proteins produced by the PPS depends on the presence of a specific set of amino acids, including all exogenous amino acids, lysine, leucine, methionine, tryptophan, valine, threonine, isoleucine, and phenylalanine as well as the relatively exogenous histidine. Nonetheless, the most important amino acids for nutrition are lysine, Sulphur amino acids, threonine, tryptophan, valine, and isoleucine (Kolniak-Ostek *et al*., 2020).

Table 6. Amino acids composition (g AA/100g protein) of PPP and PPS:

Amino acid	PPP (%)	PPS (%)
Lysine	3.30	3.02
Leucine	7.72	6.26
Isoleucine	4.96	3.23
Methionine + Cysteine	2.36	5.82
Cysteine	2.20	3.45
Methionine	0.16	2.37
Phenylalanine +Tyrosine	9.92	9.92
Phenylalanine	5.51	4.53
Tyrosine	4.41	5.39
Threonine	4.96	4.10
Valine	6.61	4.31
Histidine	2.20	3.02
Total essential amino acids (EAA)	42.03	39.68
Arginine	3.86	12.52
Aspartic	11.03	7.77
Glutamic	13.23	20.73
Serine	4.41	3.88
Proline	12.68	4.75
Glycine	6.06	7.34
Alanine	6.61	3.23
Total Non-essential amino acids (Non-EAA)	57.88	60.22
EAA / Non-EAA	0.73	0.66
Lysine/ Arginine	0.85	0.24
1st limiting AA	Lysine	Lysine
2nd limiting AA	Cysteine + Methionine	Leucine

PPP: Prickly pear peels. PPS: Prickly pear seeds.

Glutamic acid, arginine, aspartic acid, and leucine accounted up half of the protein's amino acid makeup, according to Abdelfattah *et al.* (2020). Methionine and cysteine, which are normally the amino acids with the greatest degree of restriction in seed proteins, made up a significant amount of the prickly pear seed protein. Sesame protein is comparable to prickly pear seed protein in this way because it is rich in sulfur-containing amino acids and includes about 6 g of methionine + cysteine. By examining the amino acid composition of the protein found in prickly pear seeds, Kolniak-Ostek *et al.* (2020) discovered that the variety had a significant impact on the content of each amino acid and their sum in the analyzed samples. PPS has a lower Lysine/Arginine ratio (0.24) than PPP (0.24). (0.85). these numbers are lower than those for casein (2.0), animal proteins (0.91), and soybean proteins (0.91). (13.78). Also, since ingesting proteins with a high ratio can have certain lipidemic and atherogenic effects, lysine/arginine ratios have been used to assess the nutritional value of proteins (Nguyen *et al*., 2020). According to the information in Table 6, lysine was the initial limiting amino acid for the PPP and PPS. This finding is in agreement with Kolniak-Ostek *et al.* (2020). Leucine was the second limiting amino acid for the PPS, whereas the second limiting amino acids for the PPP were cysteine and methionine. These findings concur with those of the research of AbdelFattah *et al* (2020).

Rheological properties of wheat flour (82%) dough and its blends:

The farinograph established the flour's behavior during the bread-making process. It demonstrates the dough's flexibility and plasticity when it is continuously mixed at a steady temperature (Stikic, *et al*., 2012). Table 7 displays the effects on the farinograph parameters of substituting levels of 5, 10, and 15% for WF (82%) for PPP and PPS. Based on the results was an increase in the water absorption percentage from 60.50% for the control sample (100% WF) to (66 and 65%, respectively) at 15% replacement levels of PPP and PPS. These results follow the same general pattern as those reported by Mahloko *et al.* (2019), who suggested that the higher dietary fiber content of Opuntia derivatives may be responsible for the increases in water absorption. Large amounts of hydroxyl groups included in the structure of dietary fibers absorb a sizable amount of water by hydrogen bonding with water. The dough development time is necessary to describe how long it takes to make the stable dough in minutes. The dough development time increased with replaced PPP compared to control, while replacement PPS 5% climbed to 6.5 and the dough development time decreased with increasing replaced PPS. The results are in line with those of El-Shahat *et al.* (2019), who discovered that dough made with wheat flour substituted with 7.5% dry cactus pear peel took longer to develop than dough made with wheat flour (control). It is clear that how long it takes to combine components to form dough depends on the fiber structure and the phenolic compounds that can form complexes with proteins and/or polysaccharides. Reversible complexation can occur when the hydroxyl groups of phenols and the carbonyl groups of peptide residues in proteins establish a hydrogen bond. In addition, according to Shin and Lee, (2005), adding more prickly pear powder to wheat flour reduces the parameter for dough mixing time, which is increased with the addition of the powder. The stability time reveals the strength of the dough. The findings indicate that the stability time reduced dramatically as the amount of PPP replacement in the dough increased, most likely because of PPP's diluting influence on the samples' gluten concentration. In contrast, the addition of PPS increased stability when compared to control wheat flour. The data in the same Table demonstrate that the inclusion of PPS decreased the degree of softening relative to control, whereas the replacement of PPP caused the degree of softening to increase. These findings concurred with information gathered by Anwar and Sallam (2016) and El-Shahat *et al*., (2019).

Table 7. Effect of different levels of PPP and PPS as a partial substitute with wheat flour (82%) on farinograph parameters:

Parameters Samples	Farinograph parameters: Water absorption (%)	Arrival time (min)	Dough development (min)	Stability time (min)	Degree of softening (BU)
Control(100%WF)	60.50	0.50	6.00	10.00	90
95%WF+5%PPP	63.50	2.00	6.50	8.50	110
90%WF+10%PPP	64.50	2.00	6.50	8.00	120
85%WF+15%PPP	66.00	3.00	6.50	6.50	130
95%WF+5%PPS	62.00	1.50	6.50	10.00	90
90%WF+10%PPS	63.50	1.50	6.00	11.00	90
85%WF+15%PPS	65.00	2.00	6.00	11.00	70

WF: wheat flour (82%), PPP: Prickly pear peels, PPS: Prickly pear seeds.

The viscoelastic behavior of the dough is revealed by the extensograph. This apparatus examines the dough's extensibility and extension resistance. For dough properties, a strong flexibility and good resistance results are necessary (Walker and Hazelton, 1996). Data in Table 8 demonstrated the impact of replacing wheat flour with PPP ratios of 5, 10, and 15% and PPS ratios of 5, 10, and 15% on the extensograph parameters. These results showed that the addition of PPP decreased the resistance to elasticity, extensibility, proportion number, and energy while the addition of PPS decreased extensibility and energy but increased elasticity and proportion number (550 B.U. and 6.11, respectively) that decreased with the addition of PPS

15%. (280B.U. and 3.5, respectively). These findings concur with Anwar and Sallam (2016).

Sensory evaluation of balady beard substituted by different levels of PPP and PPS:

Table 9 illustrates the organoleptic characteristics of balady bread made with various amounts of PPP or PPS flour. For control and all levels of replacement, there was a statistically significant ($p \leq 0.05$) change in the score values for flavor, odor, crumb color, crumb uniformity, crust color, crust quality, general appearance, and overall acceptance. According to the findings, control bread, loaves substituted with 5, 10, and 15% PPP, and bread substituted with 5%PPS all had the highest taste ratings. While the taste score significantly dropped with increased PPS addition. The examined loaves' odor ratings ranged from 7.36 to 8.73. The control bread's odor, loaves substituted with 5 and 10% PPP, and breads substituted with 5% PPS received the highest ratings (8.73, 8.55, 8.45, and 8.45, respectively). Significant drops in the odor scores occurred at higher PPP addition levels (10 and 15%) or higher PPP levels (15%).

Table 8. Effect of different levels of PPP and PPS as a partial substitute with wheat flour (82%) on extinsograph parameters:

Parameters Samples	Extinsograph parameters			
	Elasticity (BU)	Extensibility (mm)	PN	Energy (Cm^2)
Control (100%WF)	380	130	2.92	55
95% WF+5% PPP	360	115	3.13	40
90%WF+10%PPP	360	85	4.23	35
85%WF+15%PPP	210	115	1.82	25
95% WF+5% PPS	550	90	6.11	45
90%WF+10%PPS	480	85	5.64	40
85%WF+15%PPS	280	80	3.50	25

WF: wheat flour (82%), PPP: Prickly pear peels PPS: Prickly pear seeds PN: proportion number

Table 9. Sensory evaluation of balady beard substituted by different levels of PPP and PPS.

Samples	Control	PPP			PPS		
Parameters	(WF)	5%	10%	15%	5%	10%	15%
Taste	$8.64^a \pm 0.67$	$8.55^a \pm 0.93$	$8.27^a \pm 0.19$	$7.91^b \pm 1.221$	$8.27^a \pm 0.19$	$7.09^b \pm 0.04$	$6.82^c \pm 0.07$
Odor	$8.73^a \pm 0.46$	$8.55^a \pm 0.52$	$8.45^{ab} \pm 0.68$	$7.82^{bc} \pm 0.87$	$8.45^{ab} \pm 0.52$	$7.82^{bc} \pm 0.07$	$7.36^c \pm 0.67$
Crumb color	$8.82^a \pm 0.75$	$8.64^a \pm 0.12$	$8.36^a \pm 0.36$	$7.45^b \pm 0.63$	$8.64^a \pm 0.20$	$6.73^b \pm 0.19$	$6.55^b \pm 0.03$
Crumb uniformity	$8.36^a \pm 0.67$	$8.32^a \pm 0.78$	$8.23^a \pm 0.75$	$7.45^b \pm 0.82$	$8.27^a \pm 0.64$	$7.55^b \pm 0.68$	$7.14^b \pm 0.71$
Crust color	$8.27^a \pm 0.78$	$8.18^a \pm 0.75$	$8.09^{ab} \pm 0.73$	$7.45^{bc} \pm 0.68$	$7.91^{abc} \pm 0.94$	$7.27^c \pm 0.46$	$6.40^d \pm 0.48$
Crust quality	$8.45^a \pm 0.68$	$8.41^a \pm 0.49$	$8.36^a \pm 0.67$	$7.64^{bc} \pm 0.67$	$7.91^{ab} \pm 0.70$	$7.18^c \pm 0.75$	$7.05^c \pm 0.72$
General appearance	$8.59^a \pm 0.58$	$8.27^{ab} \pm 0.78$	$8.23^{ab} \pm 0.75$	$7.64^{bc} \pm 0.80$	$7.91^{abc} \pm 0.83$	$7.27^{cd} \pm 0.78$	$6.91^d \pm 0.70$
Overall acceptability	$8.86^a \pm 0.68$	$8.81^{ab} \pm 0.63$	$8.00^{ab} \pm 0.08$	$7.36^c \pm 0.91$	$8.36^b \pm 0.50$	$7.91^d \pm 0.30$	$6.22^e \pm 0.95$

Means are an average of twenty determinations± SD.
In a row, means with the same letters are not significantly different at ≤ 0.05.
WF: Wheat flour 82%, PPP: Prickly pear peels PPS: Prickly pear seeds

The tested bread had ratings ranging from 7.14 to 8.36 for crumb homogeneity. There were no appreciable ($P \leq 0.05$) changes in the consistency of the crumb between the control bread, the bread substituted with 5 and 10% PPP, and the bread substituted with 5% PPS. With the control bread, the replacement breads with 5 and 10% PPP, and the replacement breads with 5% PPS, respectively, the crust color and quality of the loaves were recorded at higher values. These values of crust color and crust quality of breads decline when replacement of PPP (15%) and PPS (10 and 15%) increase. The examined breads received scores ranging from 6.91 to 8.59 for their overall look. The control bread's overall appearance, loaves substituted with 5 and 10% PPP, and breads substituted with 5% PPS received the highest scores, with scores of 8.59, 8.27, 8.23, and 7.91, respectively. The general appearance scores significantly declined with higher additions of PPP (15%) or PPS (10 and 15%). Low levels of 10% PPP and 5% PPS substitution had no effect on the bread's sensory qualities, but at these higher levels, the bread's sensory qualities became low. Low levels of 10% PPP and 5% PPS substitution had no effect on the sensory qualities of the breads, but at these levels, the bread's overall acceptability decreased. Our results agree with those of Ali *et al.* (2020).

Chemical composition of balady bread substituted by different levels of PPP and PPS:

As the replacement levels of PPP in the dough were elevated, there was a considerable rise in the moisture, ether extract, ash, and crude fiber content of balady bread Table 10. The noticeably higher ash and crude fiber content of PPP may be the cause of the rise in ash and crude fiber content of balady bread substituted with PPP. Protein and total carbs, on the other hand, have gradually declined. The aforementioned impacts get stronger as replacement levels are higher. Due to PPP's noticeably lower protein content when compared to wheat flour, the protein content of balady bread enriched with PPP may have decreased. According to the aforementioned results, replacing wheat flour with PPS in balady bread had a substantial impact on the bread's ether extract, ash content, and crude fiber content, all of which increased as the replacement levels of PPS in the dough rose. The noticeably greater ether extract, ash, and crude fiber content of PPS may be the cause of the rise in ether extract, ash, and crude fiber content of balady bread substituted with PPS. Moreover, the substitution caused a progressive drop in both protein and carbohydrates. The results of Ali *et al.* (2020) support these results.

Table 10. Chemical composition of balady beard substituted by different levels of PPP and PPS.

Samples	Control	PPP			PPS		
Chemical composition	WF	5%	10%	15%	5%	10%	15%
Moisture	$30.06^c \pm 0.18$	$30.50^b \pm 0.24$	$31.88^a \pm 0.08$	$32.18^a \pm 0.19$	$29.91^c \pm 0.16$	$29.13^d \pm 0.17$	$28.77^e \pm 0.20$
Crude protein	$10.85^a \pm 0.19$	$10.21^c \pm 0.15$	$9.91^d \pm 0.12$	$9.84^d \pm 0.07$	$10.82^a \pm 0.02$	$10.67^{ab} \pm 0.08$	$10.51^b \pm 0.08$
Ether extract	$1.56^d \pm 0.05$	$1.67^d \pm 0.03$	$1.74^d \pm 0.05$	$1.94^c \pm 0.04$	$2.08^c \pm 0.06$	$2.69^b \pm 0.23$	$3.73^a \pm 0.05$
Ash	$1.38^f \pm 0.04$	$1.77^d \pm 0.09$	$2.28^b \pm 0.04$	$2.77^a \pm 0.10$	$1.49^{ef} \pm 0.08$	$1.60^e \pm 0.02$	$1.99^c \pm 0.07$
Crude fiber	$1.51^g \pm 0.13$	$1.71^f \pm 0.06$	$2.04^e \pm 0.14$	$2.30^d \pm 0.05$	$2.70^c \pm 0.05$	$3.37^b \pm 0.07$	$4.59^a \pm 0.08$
*Carbohydrates	$86.21^a \pm 0.24$	$86.35^a \pm 0.10$	$86.07^a \pm 0.15$	$85.45^b \pm 0.09$	$85.61^b \pm 0.01$	$85.04^c \pm 0.26$	$83.77^d \pm 0.07$

Means are an average of three determinations± SD.
In a row, means with the same letters are not significantly different at ≤ 0.05.
WF: Wheat flour 82%, PPP: Prickly pear peels. PPS: Prickly pear seeds.
***Carbohydrate were calculated by differences.**

Staling rate of balady beard substituted by different levels of PPP and PPS:

In order to determine the degree of staling in balady bread baked with wheat flour and various levels of PPP or PPS, the alkaline water retention capacity (AWRC) test was used. The findings are shown in Table 11. For balady bread stored in polyethylene bags at room temperature, the AWRC was calculated after 0, 24, and 48 hours of storage. Table 11 shows that, when PPP flour was added to wheat flour at higher levels than the control, the rate of AWRC in the tested balady bread samples rose. Bread samples with varying amounts of PPP flour had freshness loss values that were lower than those of the control sample. They can be the result of absorbing a lot of water, which might lengthen the shelf life. These findings concur with those of Anwar and Sallam (2016), who found that the prickly pear peels had improved (AWRC). Prickly pear peels' high ascorbic acid, pectin, and dietary fiber content may be to blame for this improvement. By retaining water, these ingredients modify the food products' water binding activity and lengthen their shelf lives. When balady bread was produced with various PPS concentrations, the rate of AWRC was lower than it was for the control. resulted to higher bread freshness loss values in comparison to the control. The results are consistent with those of El-Sayed *et al.* (2019), who attributed this effect to fiber's capacity to bind water and probable interactions with starch. Water loss and starch retrogradation during storage are postponed under these circumstances.

Table 11. Staling rate of balady bread substituted by different levels of PPP and PPS:

Samples	Alkaline water retention capacity (AWRC)				
	Fresh zero time %	After 24 hr.		After48 hr.	
		%	RD %	%	RD %
Control (100%WF)	228.00^{c} ± 0.217	195.54^{d} ± 0.560	14.24	162.41^{d} ± 0.655	28.77
95%WF+5%PPP	228.92^{c} ± 0.554	202.38^{c} ± 0.744	11.59	178.04^{c} ± 0.588	22.23
90%WF+10%PPP	243.56^{b} ± 0.435	211.71^{b} ± 0.410	13.08	186.19^{b} ± 0.350	23.55
85%WF+15%PPP	253.14^{a} ± 1.570	223.02^{a} ± 0.445	11.90	195.53^{a} ± 1.262	22.76
95%WF+5%PPS	226.65^{d} ± 0.645	192.99^{e} ± 0.215	14.85	159.98^{e} ± 0.734	29.42
90%WF+10%PPS	220.12^{e} ± 0.538	179.50^{f} ± 0.681	18.45	149.79^{f} ± 0.449	31.95
85%WF+15%PPS	217.45^{f} ± 0.504	167.97^{g} ± 0.290	22.75	137.82^{g} ± 0.737	36.62

Means are an average of twenty determinations± SD.
In a row; means with the same letters are not significantly different at ≤ 0.05.
WF: Wheat flour 82%, PPP: Prickly pear peels PPS: Prickly pear seeds RD: Reduce decrease.

CONCLUSION

The study's results might be summarized as follows: prickly pear peels and seeds may contain bioactive compounds. Bread that has been treated with PPP and PPS provides a significant number of nutrients, including carbs, ash, dietary fiber, and bioactive compounds. Up to a 15%, sensory evaluation of bread samples is considered appropriate, PPP and PPS can be applied.

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الاستفادة من مخلفات التين الشوكى لتحسين القيمة الغذائية للخبز البلدى

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الملخص

المخلفات الثانوية الصناعية الغذائية غنية بالمركبات الوظيفية التي يمكن استخدامها لرفع القيمة الغذائية والخصائص الصحية لمنتجات المخابز. اجريت هذه الدراسة بغرض تقدير القيمة الغذائية والمكونات الفعالة لمخلفات التين الشوكي الثانوية القشور والبذور كبدائل لدقيق القمح بنسب مختلفة (5 ، 10 ، 15٪) عند اعداد الخبز البلدي. اظهرت النتائج بأن بذور التين الشوكي تحتوي على نسبة أعلى من مستخلص الإيثر (8.84٪) ومحتوى ألياف خام (49.02٪) من قشور التين الشوكي ودقيق القمح (82%). بينما، تحتوي قشور التين الشوكى على أعلى محتوى من الرماد (10.97٪) ، يليه بذور التين الشوكى (1.52%) و دقيق القمح (1.38%) بالاضافة الى احتواء قشور التين الشوكى على المركبات الفينولية الكلية والفلافونويد بنسبة أكبر من بذور التين الشوكى و دقيق القمح. بينما ، كان لبذور التين الشوكى نشاط مضاد للأكسدة مقارنة بالعينات الاخرى. على الجانب الاخر، احتوت قشور التين الشوكى على نسبة مرتفعة من الكالسيوم والبوتاسيوم والمغنيسيوم مقارنة ببذور التين الشوكى والتى كانت غنية بالفوسفور والحديد. اظهرت تحاليل الأحماض الدهنية لزيوت قشور وبذور التين الشوكى ارتفاع فى الاحماض الدهنية الغير مشبعة وكانت نسبتها 68.39 و 84.31٪ على التوالي. أيضا، كانت نسبة الأحماض الدهنية غير المشبعة إلى المشبعة أعلى في زيت بذور التين الشوكى (5.37%) مقارنة بزيت قشور التين الشوكى (2.16%). احتوت قشور التين الشوكى على نسبة أعلى من إجمالي الأحماض الأمينية الأساسية (42.03٪) من بذور التين الشوكى (39.68%). زاد مستخلص الأثير والألياف الغذائية ومحتويات الرماد للخبز البلدي المصنوع من قشور وبذور التين الشوكى بشكل ملحوظ مع زيادة نسبة الاستبدال. وفقًا لنتائج اختبارات التقييم الحسي ، فإن قشور وبذور التين الشوكى المضافة لعينات الخبز بنسبة استبدال 15 ٪ اعطت درجة قبول عالية.

الكلمات الداله: مخلفات التين الشوكي - القيمة الغذائية - الخبز البلدي.