Peel of prickly pear (*Opuntia ficus-indica*) fruit as an innovative ingredient for processed food

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Keywords: Food by-product valorization, Novel food, Chemical characterization, Fiber, Antioxidant activity
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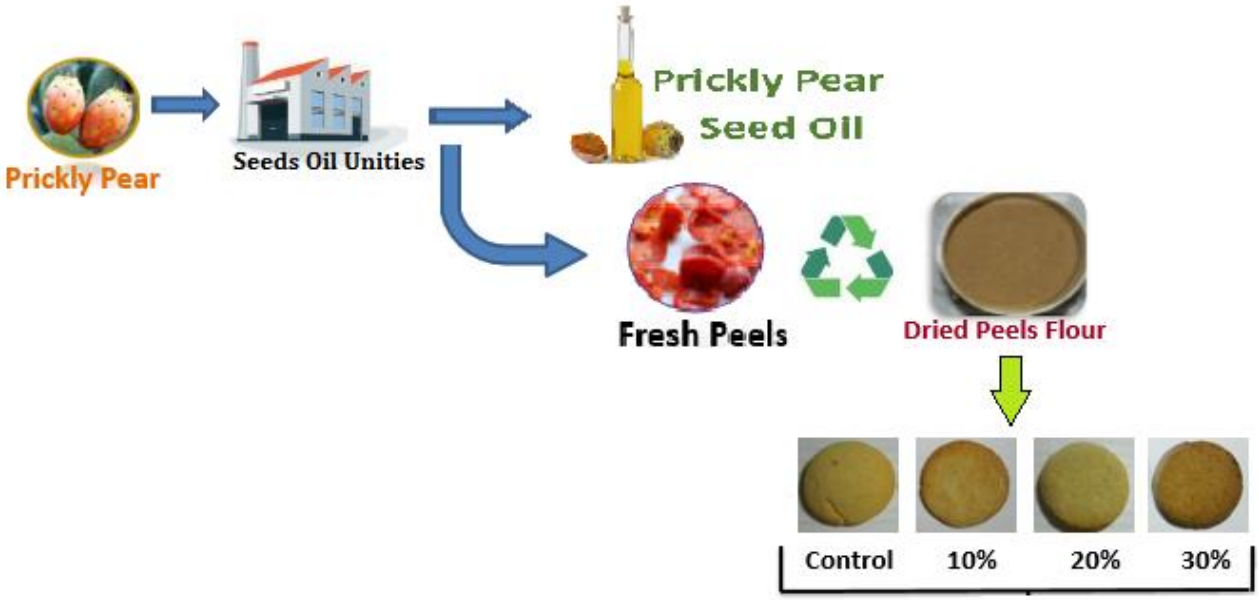
In Tunisia, the number of companies that extract oil from cactus seeds has grown in the last decade. Despite this thriving business, the millions of kilograms of prickly pear (*Opuntia ficus-indica*) fruit peels per year represent a huge disposal problem to be addressed. Indeed, peel represents around 50% of the whole prickly pear. However, an investigation on the chemical and physical characterization of this by-product could conveniently lead to its rational use as an important source of nutrients, fibers, minerals, and phytochemicals, such as phenolics, carotenoids, betalains, and other pigments with high antioxidant activity. For instance thanks to this rich chemical patrimony, prickly pear peels could be incorporated into processed food and nutraceuticals (El-Said *et al*, 2010).

Prickly pear peel has already been tested as an ingredient for the preparation of biscuits (Bouazizi *et al*, under evaluation), as exemplified in figure 1. The present study aimed at assessing the aptitude of prickly pear peel to be transformed into flour and at obtaining its chemical and physical characterization.

Figure 1. Scheme of valorization of prickly pear fruit for oil and peel flour production



Fully-ripened prickly pear fruits were collected from Zelfen (Kasserine, Tunisia). After cleaning, peels were separated from their pulps, cut into small pieces (1.5 cm^2) and dried in an oven at 45 °C for 48 h. The dried material was milled through a grinder to achieve a fine powder that was sifted using two sieves in series (400 µm and 100 µm mesh).

The chemical composition of prickly pear peel (AOAC, 2000) is shown in Table 1. The moisture content of fresh peel was as high as 90.38, while it dropped to 9.11% in the dried peel. Strong dehydration is necessary to stabilize and preserve the material also because its pH is not sufficiently low. However, the drying and grinding processes caused the loss of some nutrients to vary degrees. As for simple sugars, only glucose and fructose were quantified, while sucrose and galactose were not detected at all. The evident loss of glucose and fructose after peel drying can be explained by their reaction (non-enzymatic browning) with protein substances guided by an adequately high pH.

The crude dietary fiber (20.70 g/100 g D.W.) represents one the most relevant substance contained in prickly pear peel due to its key role in the human diet as well as in the structure of some processed food such as bakery goods. Total phenolic content showed high values that mainly contribute to the antioxidant activity. Finally, carotenoids and chlorophylls, along with betalains, are the pigments that characterize the color of prickly pear peel and pulp. Carotenoids can be used as an indicator of interesting functional and antibacterial activities (FAO, 2017).

Table 1. Proximate composition of orange *Opuntia ficus-indic*a peels (mean ± standard deviation)

	Fresh peels	**Dried peel**
Moisture (g/100 g)	90.38 ± 0.06	9.11 ± 0.07
pH	4.67 ± 0.13	4.78 ± 0.12
Titratable acidity (g citric acid equivalents/100 g)	0.056 ± 0.010	0.060 ± 0.010
Ash (g/100 g)	2.03 ± 0.02	14.57 ± 0.02
Protein (g/100 g)	0.91 ± 0.04	3.31 ± 0.20
Glucose (g/100 g)	2.02 ± 0.08	3.05 ± 0.70
Fructose (g/100 g)	1.67 ± 0.03	3.13 ± 0.60
Crude fiber (g/100 g)	4.78 ± 0.13	20.7 ± 0.06
Cellulose	*1.84 ± 0.01*	*7.48 ± 0.15*
Hemicellulose	*1.350 ± 0.002*	*8.14 ± 0.64*
Water-soluble polysaccharides	*0.46 ± 0.01*	*1.57 ± 0.05*
Total carotenoids (mg beta-carotene equivalents/100 g)	2.47 ± 0.05	10.90 ± 0.04
Total chlorophylls (mg/100 g)	6.86 ± 0.83	14.06 ± 0.12
TPC (mg gallic acid equivalents/g)	3.03 ± 0.01	277.6 ± 0.4
Antioxidant activity RSA	33.3 ± 0.2	82.7 ± 0.2

The results obtained showed that the prickly pear peels are a rich source of minerals, fibers, and antioxidant compounds. Furthermore, they have shown to be suitable for stabilization in the form of flour and usable in the preparation of baked products. Other possible applications include prickly pear peel flour as an antibacterial edible coating, an emulsifying agent in food preparation, and a filler for the production of biocomposite materials.

Acknowledgment
We wish to thank the National Institute of Applied Science and Technology of Tunis (INSAT) for its financial support.

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