

Prickly pear seed: from vegetable fiber to advanced applications: A review

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Abstract

The prickly pear seed is a part rich in fatty substances; it can be exploited for the extraction of oils for food, cosmetic, pharmaceutical, and medical use. The focus of this review is to define one of the most expensive oils in the world "Prickly Pear Seed Oil" (PPSO). Its method of obtaining by cold pressing of its seeds makes it rich in active ingredients. For this, we will present a description of the cactus plant and its botanical classification, its chemical composition for either the pulp, the bark, or the seed. The morphology of the seed and its different applications, in addition to the seeds oil, presents extraordinary properties.

Keywords: Prickly Pear Seed; Vegetable Fiber; Prickly Pear Seed Oil; Applications

I. Introduction

The valorization of agricultural wastes for achieving lignocellulosic fillers (or fibers) represents a promising strategy to develop green materials with appropriate performance and high sustainability from an economic and ecological point of view [1].

The prickly pear (PP) or *Opuntia ficus-indica* (OFI), its scientific name comes from Latin *Opuntia* of *Oponte*; the name of the Greek city [2]. The common name is the cactus, which comes from the Greek word "kaktos", which means: the thorny plant [3]. According to Schweizer (1997), the plant may have a different name depending on the local idiom: Nopal, Tuna, African thistle, Prickly pear, El-tin-el-Choki, and others [2]. The *Opuntia* is native to Mexico, besides, the fruit of the prickly pear appears on the emblem of the Mexican flag [4]. It grows mainly in arid and semi-arid areas and extreme conditions. Its geographical distribution is located mainly in Mexico, Sicily, Chile, Brazil, Turkey, Korea, Argentina, and North Africa [5]. Low water exigency and a high water-use efficiency ratio favor the extension of cactus production, as underlined by the Food and Agriculture Organization [6].

Seeds constitute about 10–15% of the edible pulp and are usually discarded as waste after extraction of the pulp [7]. The

oil processed from the seeds constitutes 7–15% of whole seed weight and is characterized by a high degree of unsaturation wherein linoleic acid is the major fatty acid (56.1–77%) [8]. According to Regalado-Rentería et al. (2018), this oil could be used in foods as a nutritional supplement, as well as an ingredient in cosmetics and pharmaceuticals. A major advantage is that the residual oilcake can be directly used in animal feed or other secondary products [9]. Edible cold-pressed oils are functional products because of their bioactive substances such as polyunsaturated fatty acids, tocopherols, sterols, phenols, carotenoids and chlorophyll. These oils have specific characteristics which provide additional health benefits [10].

The main objective of this review is to define prickly pear (PP), PPS and PPSO. Furthermore, to demonstrate the method of obtaining it by cold pressure of the prickly pear seeds (PPS) vegetable fiber, which is considered as food waste. In addition to this to make a valorization to its waste and to know the chemical compositions, physical and morphological characteristics, and the various applications of PPSO and PPS.

II. Botanical classification

Many authors have elaborated classifications of the genus *Opuntia*. The classification considered the most valid to date is undoubtedly that established by Britton and Rose in 1963 [11] :

- ✓ Kingdom : Plants.
- ✓ Order : Caryophyllales.
- ✓ Subclass: Caryophyllidae.
- ✓ Family : Cactaceae.
- ✓ Group : Opuntiaeae.
- ✓ Genus : *Opuntia*.
- ✓ Subgenus : *Platyopuntia*
- ✓ Species: *Opuntia ficus-indica*, *Opuntia megacantha*.

The family Cactaceae has about 130 genus and 1500 species, of which 300 belong to the genus *Opuntia* [12].

The species of *Opuntia* the most widespread in Algeria are: *Opuntia cylindrica*, *Opuntia mieckleyi*, *Opuntia vulgares*, *Opuntia schumanni*, *Opuntia megacantha*, *Opuntia maxima* and *Opuntia ficus indica* [13].

III. Plant description

The prickly pear (PP) is a robust arborescent plant of (3 to 5 m) height, PP has a thick and woody trunk and an organization in flattened articles, of the elliptic or ovoid shape of green-mat color, having a length of (30 to 50 cm), a width of (15 to 30 cm) and a thickness of (1.5 to 3 cm) called cladodes or racquets. The cladodes ensure the chlorophyllic function and are covered with a waxy cuticle (the cutin) which limits the transpiration and protects them against predators [14].

The leaves are conical in shape and a few millimeters long, ephemeral, appearing on young cladodes, at their base are the areoles (about 150 per cladode) which are modified axillary buds.

The spines are whitish, solidly implanted, and long (1 to 2 cm). The glochids are fine spines of a few millimeters of a brownish color, easily detached, implanting themselves solidly in the skin [15].

The *Opuntia* bears flowers and fruits in abundance. The flowers are hermaphrodite; it is on the top of the rackets that appear beautiful and big lateral corollas, wide of (4 to 10 cm), of yellow to red color with all the intermediate nuances and become reddish with the approach of the senescence of the plant. In certain hot and arid regions the plant flowers and carries fruits twice in the year [2].

The seeds of the fruit are used to extract very valuable oil that is widely used in many fields. About 300 seeds for a 160 g of one fruit [16].

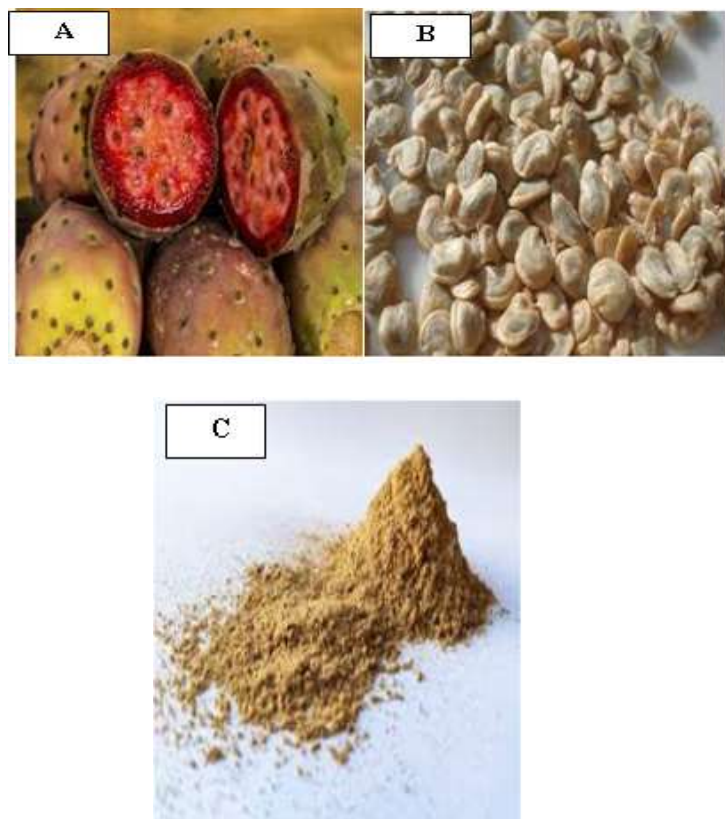


Figure 1: Prickly Pear Seed (A. Cactus, B Prickly Pear Seed, C. crushed Prickly Pear Seed)

IV. Chemical composition of Prickly pear (PP)

The (chemicals, minerals, vitamins and dietary fibers) compositions of prickly pear are summarized in the following tables.

Table 1: Chemical composition of prickly pear (g/100g of dry matter) [17]

Components	Pulp	Skin	Seed
Protein	0.5 – 5.3	8.3	11.8
Lipids	0.7 – 1	2.40	6.77
Total fiber	20.50	40.8	54.2
Ashes	0.4 – 8.5	12.10	5.90
Sugar	11 - 16	-	-

Table 2: Chemical composition of prickly pear of carbohydrate (% of dry matter) [17 - 18]

Sugar	Pulp	Skin
Sucrose	0.19	2.25 – 2.3
Glucose	29 – 35	14 – 21
Fructose	24 – 29.6	2.29 – 2.9

Table 3: Chemical composition of prickly pear of amino acids (mg/100g of dry matter) [19]

Amino acids	Pulp	Seed
Alanine	3.17	4.75
Arginine	1.11	6.63
Asparagine	1.52	Trace
Serine	6.34	8.46
Histidine	1.64	3.11
Glutamine	12.59	Trace
Methionine	2.01	0.70
Proline	46.00	Trace
Taurine	15.79	Trace

Table 4: Mineral composition of prickly pear (mg/100g of dry matter) [17]

Mineral elements	Pulp	Skin	Seed
Ca	163	2090	92 – 258
Mg	76	322	79 - 208
Na	7.8	<0.8	<0.8 – 12
K	559	3430	122 – 275
P	0.1	0.1	110 – 124
Fe	16.5	8.3	1.2 – 12.1
Cu	<0.8	0.9	<0.8 – 0.23
Zn	1.5	1.7	1.4 – 4.2
Mn	7	73	<0.8 – 2.3
Mb	<0.3	<0.3	<0.3

Table 5: Dietary fiber compositions of prickly pear (mg/100g of dry matter) [17]

	Pulp	Skin	Seed
Hemicellulose	2.5 – 6.4	20.8	9.9
Cellulose	14.2 – 2.24	71.4	83.2
Pectin	0.21 – 1.45	7.7	6.69
Lignin	0.01	0.06	0.19

Table 6: Vitamin compositions of prickly pear (mg/100g of dry matter) [19]

	Pulp	Skin	Seed
Vitamin K	53.2	109	52.5
Vitamin C	34 – 40	-	-
Vitamin E	527.4	2182	106

V. Prickly pear seeds (PPS)

V.1. Morphological description

According to the morphological analysis made by Habibi et al, (2004), the prickly pear seed consists of two layers: the pericarp is the outer layer of the seed and the endosperm is the layer located inside the seed [16].

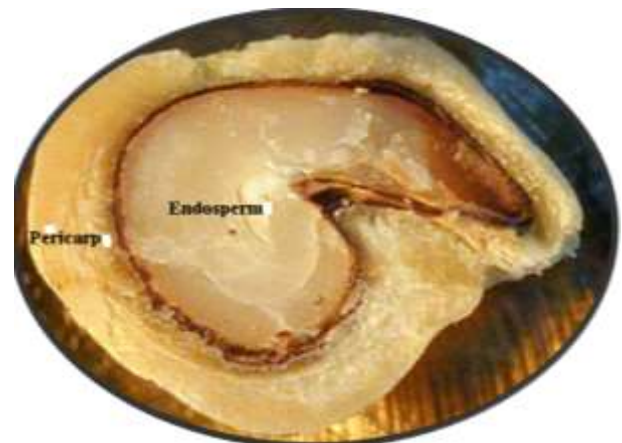


Figure 2: Cross section of the prickly pear seed PPS [16]

- ✓ **Pericarp:** there are two types of cells, mostly spindle fibers or sclerenchyma fibers and some spiral vessels. This support tissue is widely found in many cells such as fruit stones, spines and prickles of stems and leaves ... And what guarantees their thick walls is the regular layers of cellulose.
- ✓ **Endosperm:** it consists mainly of starch granules embedded in a tile-shaped parenchymatous cell wall.

V.2. Chemical composition of PPS

In recent years, many studies have multiplied to characterize the seeds of prickly pear and their constituents to assess their nutritional value.

Sawaya et al. [8] studied the composition of seeds, their potential uses in animal feed. They reported a protein content

of 16.6%, 17.2% of fatty substances, 49.6% of fiber and 3.0% of ash. The mineral content is high in sodium (67.6 mg 100 g⁻¹), potassium (163.0 mg 100 g⁻¹) and phosphorus (152.0 mg 100 g⁻¹).

V.3. Prickly pear seed applications

Cerezal and Duarte [20] used the cactus pear pericarp to formulate marmalade. The seed meal seems to have potential use as a dietary fiber source for human consumption, for the extraction of oil.

Literature reports studies, several researchers have been working on prickly pear seed. PPS is used as a vegetable filler added to the polymer to strengthen its physic-chemical, mechanical, or thermal properties. As reported in the work of Malainine et al.[21] who was studied PPS / Poly(propylene) composites. And Scaffaro et al.[22] PPS was added to PLA, to prepare biocomposites by melt processing. Bellache et al. have incorporated the biodegradable polymer polyhydroxy (butyrate-co-valerate) with PPS to study the enzymatic [23] and hydrolytic [24-25] degradation of this biocomposite.

VI. Prickly pear seed oil (PPSO)

The prickly pear seed is a part rich in fatty substances; it can be exploited for the extraction of oils for food, cosmetic, pharmaceutical, and medical use.

Prickly pear seed oil (PPSO) belongs to the family of polyunsaturated oils like most vegetable oils. PPSO is a very rare and precious oil. Its yield is very low, there is only 6% oil in a small seed obtained by cold pressing, it must therefore treat about a ton of figs to obtain 1 liter of oil, a figure however variable depending on the parameters mentioned above but also the performance of the equipment used that is why this precious oil is very expensive.

Prickly pear seeds oil belongs to the family of polyunsaturated oils like most vegetable oils.

The commercial value of this oil is interesting because of its cosmetic characteristics sought. It is rich in unsaturated fatty acids such as linoleic acid (64.43%) and oleic acid (18.46%). Among the saturated fatty acids, the most important are palmitic acid (12.60%) and stearic acid (2.82%). On the other hand, its particularity lies in its richness in unsaponifiable matter (sterols and tocopherols). This characteristic could be a lever for its exploitation in the field of cosmetology, given the beneficial effects of these substances on the elasticity of the skin, cellular metabolism and restoration of the skin structure. It has remarkable cosmetic characteristics, as it prevents aging

and wrinkles in the skin. The seeds are also used for the preparation of cream for dermal use.

An interesting content of polyphenols that are natural antioxidants and reduce the risk of cancer, cardiovascular diseases and neurodegenerative diseases such as Alzheimer's [26].

Conclusions

This review concludes that the vegetable fiber of prickly pear seeds has given much interest in recent years; Seed meal appears to have the potential for use as a source of dietary fiber for human consumption, and oil extraction and this latter present's one of the most expensive oils in the world.

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