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Effects of processing on the nutraceutical profile of quinoa

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Abstract

Quinoa flour was subjected to a variety of thermal processes. Both unprocessed and processed quinoa samples were subjected to successive extractions in methanol and ethyl acetate solvents. Effects of processing were gauged via comparison of HPLC chromatograms of the quinoa extracts. Quinoa flour subjected to processing via roasting and extrusion resulted in a significant impact on the chemical profile when compared to unprocessed quinoa flour. Steam pre-conditioning had minimal effects on the chemical profile of quinoa flour. Process-enhanced isolate from roasted and extruded quinoa possessed a molecular weight of 480 D, was dissolved in methanol and ethyl acetate, and possessed a NMR spectra reminiscent of a terpenoid compound. This research suggests that thermal processing of quinoa flour can result in degradation of saponin molecules. Saponin decomposition may influence sensory or pharmacological properties.

Keywords: Quinoa; *Chenopodium quinoa*; Roasting; Processing; Extrusion; Saponins

1. Introduction

Quinoa (*Chenopodium quinoa*) is a pseudo-cereal with origins dating to the Incas. The pre-Colombian Andean people used the seed as a staple food component, and at times, replaced the animal protein in their diet with quinoa (Koziol, 1992). Today, quinoa is mainly cultivated in Argentina, Bolivia, Chile, Colombia, Ecuador, and Peru, locations that mostly coincide with the limits of the Inca Empire. Quinoa has also shown promise in tests of farm-scale cultivation in high altitudes of Colorado, and near sea level in Washington and Oregon, as well as in England and in Scandinavia (National Research Council, 1989).

The quinoa plant grows from 3 to 6 ft., in height and bears leaves that extend from the stalk. Quinoa seeds grow in large clusters at the end of the stalk, and seed color varies from pink, orange, red, purple, tan, to black. Quinoa seeds, shape of which resembles sesame seeds, can be consumed whole or ground into flour. Quinoa is commonly referred to as a pseudo-cereal since it is not a member of the grass family, but produces seeds that can be milled into flour and used much like a cereal crop.

The shortage of provisions in needy countries can potentially be solved by cultivation of quinoa (or otherwise act as an ideal human food supplement) since it can survive the most barren farming conditions (potential for cultivation in marginal lands and temperate regions) while maintaining a high nutritive value and supplying a reasonable yield (Prakash, Nath, & Pal, 1993). Quinoa can survive low rainfall, high altitudes, thin cold air, hot sun, sub-freezing temperatures, salinity, and poor sandy alkaline soils (Przybylski, Chauhan, & Eskin, 1994). The adaptability of different cultivars to salt stress merits special note (National Research Council, 1989). However, growth for most strains is optimized with short day lengths and cool temperatures.

Quinoa has economical potential to be realized since the entire plant can be utilized. The leaves can be consumed in a salad and are rich in various minerals. The seeds can be consumed whole or ground into flour for a variety of food applications (Coulter & Lorenz, 1990). Seeds are usually soaked in water to remove the soapy saponins, bitter

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glucoside–triterpenoid compounds that cover the surface of the seeds. The residual water can be used to shampoo the hair. The leaves, roots, and stalks can be used for animal fodder.

Research efforts in quinoa have been focused on its chemical composition, with considerable attention paid to saponins in quinoa. There has been some work accomplished in processing quinoa, focused mainly on the effects of dehulling and washing on changes in chemical composition; specifically removal of saponins. Usually, quinoa is processed by means of soaking, rubbing, rinsing, and boiling in the domestic setting. It is industrially processed by means of wet and dry milling (Becker & Hanners, 1990).

Today's health conscious consumers are illustrating a preference towards value added products, and in general, more nutritious food items. The opportunity to supplement or completely replace common cereal grains (corn, rice and wheat) with a cereal of higher nutritional value (such as quinoa) is inherently beneficial to the public interests.

In this study, quinoa flour was subjected to steam preconditioning, extrusion, and roasting. Effects of these processes on quinoa were determined via HPLC analysis. Process enhanced compounds were characterized with instrumental analysis.

2. Materials and methods

2.1. Materials

Quinoa. Quinoa seeds (*Chenopodium quinoa* Willd) were purchased from Quinoa Corporation, Gardena, CA.

Solvents. HPLC grade methanol, HPLC grade ethyl acetate, HPLC grade acetonitrile, HPLC grade water, and formic acid were purchased from Sigma-Aldrich, St. Louis, USA.

Extraction medium. Sample extraction for HPLC analysis was prepared with Whatman # 42 filter paper, ashless 70 mm circles. Acrodisc 0.45 μm × 3 mm syringe filters further refined extracts prior to direct HPLC injection.

2.2. Methods

Milling. Quinoa seeds were pulverized with a model D Fitz Mill (W.J. Fitzpatrick Co., Chicago, USA) to produce quinoa flour.

Steam pre-conditioning. Steam pre-conditioning was performed with a 57 l Varimixer (Welbilt, South Plainfield, NJ, USA) modified for steam injection. 11 kg of milled quinoa flour were mixed while being exposed to 100 °C steam for 15, 30, 45 and 60 min. Temperature of the flour was recorded using an Omega Microprocessor Thermometer, model HH21, complete with Omega type T thermocouple (Omega Engineering, Stamford, CT, USA). The thermocouple was placed at the center of the kettle.

Extrusion. Extrusion was performed with a twin screw extruder (model ZSK-30 from Coperion, formerly Werner and Pfleiderer Corp., Ramsey NJ, USA). The extruder has two co-rotating, self wiping screws (30.7 mm diameter, 4.7 mm channel depth, and 878 mm processing length; $L/D = 28.6$) in a steel barrel with five zones. Each zone is heated by resistive electric heaters and the temperature of each zone can be controlled independently. The screw configuration used in extrusion experiments consisted of forward conveying elements, mild mixing elements, kneading elements, and reverse elements (Table 1). The die had two circular orifices (3 mm diameter, 5 mm long). Quinoa flour was metered into the feed section of the extruder with a volumetric feeder from K-Tron Corporation (Pitman, NJ, USA). Water was injected into the feed section of the extruder immediately after the feed port using a triple action piston pump from US Electric Corporation (Milford, CT, USA). Both the feeder and the pump were calibrated prior to extrusion runs to determine the set points required for desired mass flow rates of quinoa flour and water, respectively. The total mass flow rate (flour + water) was kept constant at 300 g/min for all experiments. Temperatures at zones I, II, and III were set to room temperature, 80 and 120 °C, respectively, while the temperatures at zones IV and V were adjusted such that the desired die temperatures could be maintained.

Table 1
Screw configuration and extrusion elements

Extrusion zones[*]						
Feed zone (84 mm)	Zone 1 (196 mm)	Zone 2 (210 mm)	Zone 3 (178 mm)	Zone 4 (98 mm)	Zone 5 (84 mm)	Die zone (28 mm)
SK 42/42	42/21 T	28/28	28/14	20/10	KB 45/5/14	14/14
SK 42/42	42/42	28/28	KB 45/5/14	20/10	KB 45/5/14 LH	14/14
	42/42	IGEL 42	20/20	KB 45/5/20	14/14	
	42/21	28/28	20/20	20/10 LH	14/14	
	IGEL 42	28/28	20/20	20/10	14/14	
	28/28	KB 45/5/28	20/20	20/10	14/14	
		28/14	20/20	14/14		
		28/14	KB 45/5/20	14/14		
			20/10 LH			
			20/10			
			20/10			

KB, kneading block; LH, left-handed (reverse) element; SK, feed element; T, transition element.
[*] IGEL, mild kneading element.