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Glycemic and insulinemic responses in women consuming extruded amaranth (*Amaranthus cruentus* L)

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Abstract

Amaranth is a pseudocereal, the nutritional and functional values of which have attracted much interest recently. Amaranth has become popular among patients with celiac disease because it does not cause allergic reactions in the intestinal mucosa. However, the high prevalence of diabetes mellitus among these patients is well known. This study investigated the starch digestibility of an extruded amaranth product. The digestion behavior was observed by the glycemic and insulinemic responses of 11 women to the amaranth product, in comparison with the responses to a reference food (white bread). The responses of women to amaranth gave rise to a mean glycemic index of 107 and an insulinemic curve that indicated greater capacity to stimulate insulin production. This digestion profile was probably due to the drastic processing that the amaranth grain had been subjected to, which provided suitable conditions for enzyme attack. Because of its fast digestion, such amaranth snacks are recommended for athletes and, when consumed by diabetic patients with celiac disease, should be assessed in a dietary program.

Keywords: Starch digestibility; Glycemic index; Celiac disease; Extrusion; Human

1. Introduction

Amaranth is the third most important staple crop for pre-Colombian people. Recently, interest in amaranth has increased because of its nutritional and functional values [1-3]. Amaranth is one of the few cultivated plants from which the leaves are used as a vegetable and the grain as a cereal [1]. Snack foods with good acceptance and high nutritive value have

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been developed by extrusion cooking of the defatted flour obtained from milling the grain [4]. The extrusion cooking process is based on starch gelatinization and protein denaturation using high pressure and high temperature [5]. As well as its high acceptability [4], such amaranth snack foods also present characteristics such as cholesterol-lowering effects in hypercholesterolemic rabbits [6], protein of high biologic value, and high bioavailability of calcium, zinc, and magnesium [7].

Over the last few years, amaranth has become popular among patients with celiac disease because it does not cause allergic reactions in the intestinal mucosa [8]. However, the high prevalence of diabetes mellitus among these patients, and vice versa, is well known [9,10]. Therefore, there is a need to study the starch digestion and absorption of amaranth snack foods because the consumption of amaranth products has been increasing among patients with celiac disease.

Several intrinsic and extrinsic food factors are involved in the duration and extent of glycemic and insulinemic responses, such as the free sugar type, starch granule characteristics, food processing conditions, and other food components present that may affect starch digestion and absorption [11-13]. In 1981, Jenkins et al [14] introduced the concept of *the glycemic index*, which allows the classification of foods according to the rate of glycemic response in comparison with a reference food [11].

To study the effect of consuming extruded amaranth on physiological response, the glycemic index and insulinemic response among women were determined in relation to a reference food (white bread).

2. Methods and materials

2.1. Amaranth

The amaranth species used was *Amaranthus cruentus* L, var BRS-Alegria, provided by Embrapa Cerrados (Centro de Pesquisa Agropecuária dos Cerrados, Planaltina, DF, Brazil). After milling, the seeds were defatted using n-hexane in Soxhlet apparatus. The amaranth flour needs to have low final lipid concentration so that it presents good frictional characteristics in the barrel and the screw extruder.

2.2. Extrusion

The extrusion was carried out in a laboratory-scale, single-screw extruder, model RXPQ labor 24 (Inbramaq–Indústrias de Máquinas Ltda, Ribeirão Preto, Brazil). The following conditions were set, in accordance with parameters proposed by Chávez-Jáuregui et al [4], but with some modifications, as follows: 400-rpm screw rotation; temperatures of 20, 20, 20, 40, and 50°C, respectively, in heating zones 1 to 5; a barrel with a continuous helical groove; 1:1 screw compression ratio; and a screw with constant depth flights, regular path, and 2 feeding entries. These conditions reproduced the energy transfer during the process and allowed the attainment of a final product with characteristics similar to those observed by Chávez-Jáuregui et al [4]. After extrusion, the product was flavored by adding 0.5% salt, 4% flavorings, and 12% canola oil. The canola oil acts as a vehicle to fix the flavor. After flavoring, the snacks were sealed in polyethylene bags and stored in an aired and dry place until their use.