Justo Javier Pedroche Jiménez
Francisco Millán Rodríguez
(coords.)

CHÍA

(Salvia hispanica L.)

THE OLD FOOD OF THE FUTURE

(CIRCHIA2016)

CHIA LINK
Red internacional

Based on presentations made at the II International Conference of the Chía-Link Network held at the Instituto de la Grasa from october 5 to 7, 2016

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RESEÑA ››

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IN VITRO GLYCAEMIC INDEX AND MICROSTRUCTURE ANALYSIS OF BAKERY PRODUCTS WITH CHIA

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SUMMARY: It was evaluated the effect of the addition of chia by-products (seeds, whole and defatted chia flours) in bakery products on in vitro kinetics of starch hydrolysis. Micro-computed tomography scanner was used for microestructure determination of crumb bread. The higher lipid and fibre amounts in chia by-products could restrict enzymatic hydrolysis of starch in bakery products. They also impacted the microstructural organization inside of crumb, which could determine the bioaccessibility and/or bioavailability of glucose. The inclusion of chia ingredients in bread formulation could be an ideal strategy for reducing the glycaemic response in bakery products.

Keywords: Chia, bakery products, glycaemic index, μCT, food microstructure.

RESUMEN: ***índice glucémico in vitro y análisis de la microestructura de productos de panadería con chía.*** Se evaluó el efecto de la adición de subproductos de chía (semillas, harina integral y harinas desgrasadas) en productos de panadería sobre la cinética de la hidrólisis de almidón *in vitro*. Escáner de micro tomografía computarizada se utilizó para la determinación de la microestructura de miga de pan. Las mayor cantidad de lípidos y fibra en los subproductos de chía podrían restringir la hidrólisis enzimática del almidón en productos de panadería. Ellos también afectaron la organización microestructural en el interior de la miga, lo que podría determinar la bioaccesibilidad y/o biodisponibilidad de la glucosa. La inclusión de ingredientes de chía en la formulación de pan podría ser una estrategia ideal para la reducción de la respuesta glucémica en productos de panadería.

Palabras clave: Chía, productos de panadería, índice glucémico, μCT, microestructura de alimentos.

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1. INTRODUCTION

The last years the consumer demand for healthy, tasty and palatable food has been steadily growing. In this context, the introduction of new row materials and ingredients such as ancient Latin-American grains is a good alternative to offer at the consumer a variety in healthy meals.

The incorporation of chia seeds and its by-products in to the meals can be a good alternative to include a new source of proteins, lipids (mainly omega-3), fibre and antioxidants. One of the most important and interesting components is its dietary fibre; its consume can provide many health benefits such as regulation of intestinal transit, reduction of glycemic index and increased satiety, among others (Norlaily *et al.*, 2012, Muñoz; Cobos *et al.*, 2013). Some strategies for reducing the glycaemic response in bakery products are the use of whole grains as well as the addition of external parts of the kernel or sourdough fermentation (Steyn *et al.*, 2004). One of the most important aspects of chia seeds and flours is their high fibre content; its use has important benefits such as the regulation of intestinal transit, reduction in the glycaemic index and its corresponding insulin response, among others (Bushway *et al.*, 1981; Reyes-Caudillo *et al.*, 2008).

The food microstructure is connected with the bioaccessibility/bioavailability of nutrients. The use of non-destructive techniques is a helpful tool to know how the structure is correlated with the functionality of the food products, specifically bioaccessibility. In this sense, using X-ray micro-computed tomography (μCT) which provides a non-invasive, non-destructive and no sample preparation to the analysis, allows an evaluation of internal structural and microstructural features in food (Schoeman, Williams *et al.*, 2016).

The objective of this investigation was to assess the effect of the addition chia by-products in bread formulations on *in vitro* rate of starch digestion/GI and their connexion the bread microstructure.

2. MATERIALS AND METHODS

2.1. Materials

Commercial Spanish wheat flour was purchased from the local market. Chia seeds, whole chia flour, semi-defatted chia flour and low-fat chia flour products were purchased from the ChiaSA Company (Valencia, Spain). The characteristics of the raw materials were published by Iglesias-Puig and Haros (2013). Compressed yeast (*Saccharomyces cerevisiae*, Levamax, Spain) was used as a starter for the breadmaking process.

2.2. Breadmaking process

The control bread dough formula consisted of wheat flour (500 g), compressed yeast (2.5% flour basis), sodium salt (1.6% flour basis) and distiller water (up to optimum absorption, 500 Brabender Units). The ingredients were mixed for 4 min, rested for 10 min, divided (100 g), kneaded and then rested (15 min). Doughs were manually sheeted and rolled, proofed (up to optimum volume increase, at 28 °C, 85% relative humidity) and baked at between 170-190 °C during 18-23 min, according to the formulation (Sanz-Penella *et al.*, 2009). The chia ingredients were added at 10% on flour basis to the bread dough formula, providing the following samples: bread with 10% of chia seeds (PS), bread with 10% of whole chia flour (PWF), bread with 10% of chia semi-defatted flour (PSD), bread with 10% of low-fat chia flour (PLF). Fermentation was monitored by measuring pH, temperature and volume increase of the dough at regular intervals. After the fermentation step, the doughs were baked in an electric oven and cooled at room temperature for 75 min for subsequent analysis (Sanz-Penella *et al.*, 2009).

2.3. *In vitro* starch digestion and GI estimation

To evaluate the *in vitro* rate of starch hydrolysis was employed the method described by Goñi *et al.* (1997) with slight modifications (Sanz-Penella *et al.*, 2014). The rate of starch digestion was expressed as the percentage of total starch hydrolysed at 0, 20, 40, 60, 90, 120 and 180 min. The total starch content was determined by the AOAC official method (1996). Finally, the area under the curve (AUC) from 0 to 120 min and total digestible starch was used to calculate an *in vitro* glycaemic index value normalised against white bread (SigmaPlot software, Version 12.0) expressed as a percentage.

2.4. Micro tomography analysis

The samples were scanned by using a SkyScan 1272 desktop μCT System (Bruker, Belgium). Power setting was selected at 50 kV and 100 μA obtaining a good contrast. The samples were fixed a specimen stage using ortho wax and a set of flat cross section 2-D projected images were acquired rotating 180°. The x-ray projected images were acquired using a digital CCD-camera cooled 11 Mp detector and reconstructed with Nrecon® software and later visualized and processed by CTVox® and CT Analyser® software to quantify internal microstructural details.

3. RESULTS AND DISCUSSION

3.1. *In vitro* glycaemic index

In general, the glycaemic effect of foods depends on the food texture and particle size, type of starch, degree of starch gelatinization, physical entrapment of starch molecules within food, food processing and other ingredients (Pérez *et al.*, 2013). The samples formulated with chia seeds and whole chia flour showed the lowest rate of starch hydrolysis and provided a significant decrease ($P<0.05$) in the total hydrolysable starch amount of bread (Fig. 1, Table 1). Chia by-products supplementation in bread formulations produced a significant decrease ($P<0.05$) in GI, compared to the reference (Table 1). The GI largely depends on the starch granules' accessibility to starch-splitting enzymes. Non-starch polysaccharides and proteins bind to starch granules' surface layers; these lower the starch granules' vulnerability to enzymes (Schuchardt *et al.*, 2016). There are studies reporting that lipids delayed the appearance of exogenous glucose in blood (Englyst *et al.*, 2003). The possibility could be that starch–lipid complexes may have formed during the processing of cereal products, and this could restrict enzymatic hydrolysis (Biliaderis, 1991).

3.2. Micro CT analysis

Food microstructure impacts many physical properties such as textural, rheological and sensorial, and the structural organization inside the foods determine how will be the bioaccessibility and bioavailability of each one of its nutritional components. Fig. 2 represents the 3D images reconstruction of each sample. Fig. 3A shows the structure thickness distribution of the sample made with 10% of whole chia flour and Fig. 3B corresponds to the sample made with 10% of low fat chia flour. In both graphs a clear trend in porous distribution is observed. More and small porous were observed in the crumb bread made with chia seeds, while less porous between 10 and 1000 μm of diameter were observed in the sample made with whole chia flour (Table 2).

Table 2 shows the range structure thickness for all the samples. All the breads show the higher proportion in porous distribution between 10 and 1000 μm of diameter. The control and sample made with low fat flour show similar behaviour in porous distribution, while the sample made with whole chia flour presents the higher dispersion in porous size compared with the other samples showing a 30.9% of porous over 1000 mm of diameter.

4. CONCLUSIONS

The chia ingredients impact the microstructural organization inside the food, which could determine the bioaccessibility and/or bioavailability of nutrients. It seems that the higher lipids content in chia by-products and the higher amount of fibre could restrict enzymatic hydrolysis of starch. Further studies and human trials are needed to gain a better understanding of the potential influence of chia by-product as strategy for reducing the glycaemic response in bakery products.

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TABLES

Table 1. Effect of chia by-products on glycaemic index.

Formulation	Total starch %	GI
Control	76.6 ± 0.7^{b}	100 ± 2^{c}
Seeds	70.1 ± 0.9^{a}	75 ± 2^{a}
Whole Flour	70.6 ± 0.7^{a}	79 ± 5^{ab}
Semi-Defatted Flour	79.9 ± 1.0^{c}	88 ± 4^{b}
Low Fat Flour	78.8 ± 1.2^{bc}	92 ± 5^{b}

Mean ± SD, n = 3. Values followed by the same letter in the same column are not significantly different at 95 % confidence level; GI glycaemic index.

Table 2. Range structure thickness, %.

Bakery products With 10% of chia	10<1000	1000<2000	Diameter μm 2000<3000	3000<4000	4000<5000
Control	91.50	8.50	0.00	0.00	0.00
Seeds	96.68	2.99	0.33	0.00	0.00
Whole flour	65.98	16.47	6.80	6.21	1.42
Semi-defatted flour	89.66	8.52	1.51	0.31	0.00
Low fat flour	91.37	8.63	0.00	0.00	0.00

FIGURE CAPTIONS

Figure 1. Kinetics of starch hydrolysis in bread samples. Bread formulations: 10% of chia seeds (PS), bread with 10% of whole chia flour (PWF), bread with 10% of chia semi-defatted flour (PSD), bread with 10% of low-fat chia flour (PLF).

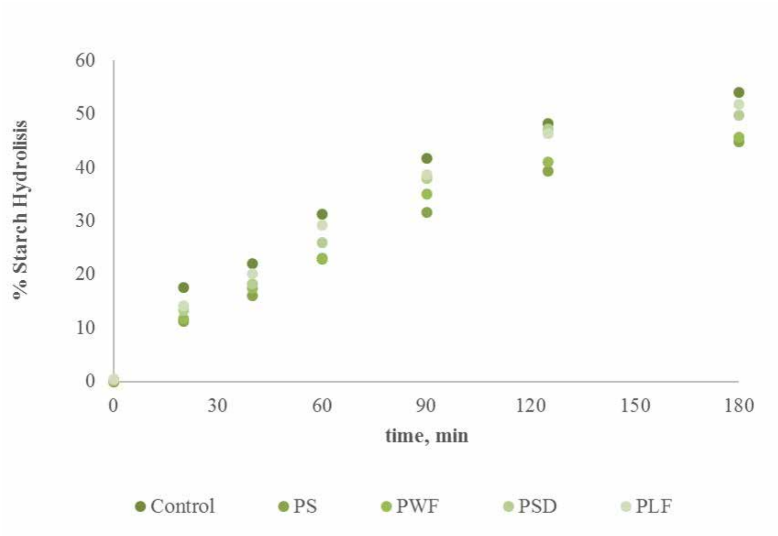

Figure 2. Effect chia by product on bread structure. Bread formulations: 100% wheat flour (Control), 10% of chia seeds (PS10), bread with 10% of whole chia flour (PWF10), bread with 10% of chia semi-defatted flour (PSD10), bread with 10% of low-fat chia flour (PLF10).

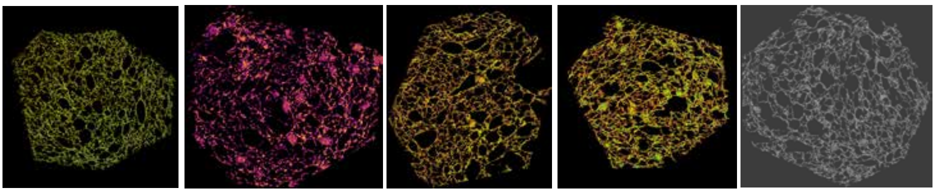

Figure 3. Structure thickness distribution A. bread with 10% of whole chia flour (PWF10); B. bread with 10% of low-fat chia flour (PLF10).