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Sensory attributes and physicochemical features of corn snacks as affected by different flour types and extrusion conditions

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ABSTRACT

The development of functional corn snacks by adding nutritional rich additives is an interesting strategy to promote the consumption of antioxidant rich ingredients, such as polyphenols. Flours made from Jerusalem artichoke tubers, amaranth seeds, and pumpkin flesh were added at level of 10% to corn grits in twin-screw extrusion at the head zone temperatures of 120, 140, or 160 °C and two levels of screw rotation speed (200 and 300 rpm). The use of amaranth seeds flour and in a lower degree of Jerusalem artichoke flour is recommended. Amaranth flour did not change significantly sensory attributes (especially the appearance and texture) of regular corn snacks and significantly increased the total polyphenols content, TPC up to 3449 mg 100 g^{-1} dry matter (dm), particularly when extruded at a temperature of 160 °C and a screw rotation speed of 300 rpm. The effects of Jerusalem artichoke and pumpkin on the structure of the corn snacks were so negative that preclude their used in this industrial application, even though drastic increases in the antioxidant capacity and TPC were observed.

1. Introduction

The interest and habits of the contemporary consumers in the field of food have changed during last decades. Consumers look for food articles which combine interesting appearance, highly acceptable crunchy texture, and appealing flavour but with nutritive or functional ingredients. In particular dietary fibre, protein, micronutrients or compounds with high antioxidant activity, such as polyphenols are the most requested by consumers (Alvarez-Jubete, Wijngaard, Arendt, & Gallagher, 2010; Černiauskienė Kulaitienė, Danilčenko, Jarienė & Juknevičienė, 2014; Peressini, Foschia, Tubaro, & Sensidoni, 2015; Sun-Waterhouse, 2011).

Snacks are one of the most popular foods which are liked by a high percentage of consumers. In this group of foods, extruded products play an important role. They are liked for their specific sensory attributes, such as crispness, interesting appearance and taste, small size, and wide range of shape. The final texture and other quality parameters of extruded snacks depend in a high degree on the type of raw material (ingredients and additives) used. The best ones are starchy materials, such as corn starch, flour, or grits, as well as rice products because of their superior expansion characteristics (Bisharat Oikonomopoulou, Panagiotou, Krokida, & Maroulis, 2013; Jin, Hsieh, & Huff, 1995; Lusas & Rooney, 2001; Mezreb, Goullieux, Ralainirina, & Queneudec, 2006; Silva, Ascheri, Carvalho, Takeiti, & Berrios, 2014). However, it is underlined that corn products are not rich enough in bioactive compounds and need suitable supplementation by adding different functional additives. Consequently, research is focused on the study of novel raw materials to be used to enrich corn extrudates and the optimization of their extrusion conditions. Some of the most popular materials under study include defatted peanut flour (Suknark, Philips, & Chinnan, 1998), corn bran (Mendonça, Grossmann, & Verhé, 2000), chickpea, bovine lung (Chávez-Jáuregui, Cardoso-Santiago,

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Pinto e Silva, & Arêas, 2003), legumes (Pastor-Cavada et al., 2011), or tomato products (Dehghan-Shoar, Hardacre, & Brennan, 2010).

Jerusalem artichoke's (*Helianthus tuberosus* L.) tubers, amaranth's (*Amaranthus cruentus* L.) seeds and pumpkin (*Cucurbita maxima* L.) flesh are materials which have interesting nutritional properties and have not been studied as potential components of extruded snacks (Cardoso Santiago, Moreira-Araujo, Pinto e Silva, & Arêas, 2001). Jerusalem artichoke is a potential source of carbohydrates, such as inulin and its derivatives, fructooligosaccharides (Cieślik, Kopeć, & Praznik, 2005; Kays & Nottingham, 2008), and also contains an important content of polyphenols. The pumpkin flesh is rich in pectins, sugars, carotenoids, polyphenols, and also contains lutein (Zhou et al., 2014). Finally, amaranth's seeds contain high quality proteins and fat, and are rich in squalene, a substance known by its strong antioxidant properties (Szwejkowska & Bielski, 2012).

Extrusion conditions, including temperature and pressure, should provide enough level of starch gelatinization to the final product otherwise the product will not be attractive for consumers. Extrusion technology allows the combination of different raw materials; however, the most important are these affecting structure and texture creation of extrudates and they stabilization. In extrudate snacks processing this compound is the starch. Total starch gelatinization in a dough provides production of snacks with typical porous structure, proper expansion with low density and soft, crunchy texture. The addition of raw materials containing significant amounts of dietary fibre, sugar or fat can impede of starch gelatinization process and thus degrade the sensory as physicochemical properties of ready snacks (Capriles, Soares, Pinto e Silva, & Arêas, 2009; Bisharat, Oikonomopoulou, Panagiotou, Krokida, & Maroulis, 2013; Ding, Ainsworth, Tucker, & Marson, 2005; Mezreb et al., 2006; Peressini et al., 2015).

Because the enrichment of foods with antioxidant compounds seems to be useful to human nutrition and health, it appears worth to optimize the extruding conditions of newly designed extruded corn products enriched with flour from pumpkin, amaranth or Jerusalem artichoke as a natural source of bioactive compounds.

The aim of the present study was to evaluate the effect of the additive nature as well as the extrusion conditions on sensory attributes and physicochemical features of snacks enriched with the addition of 100 g/kg of flours made from pumpkin flesh, Jerusalem artichoke tubers or amaranth seeds.

2. Materials and methods

2.1. Materials

The ingredients used for preparation the extruded snack were: corn grits (control), enriched with flours of Jerusalem artichoke tubers (JAF), amaranth seeds (AF) and pumpkin tissue (PF). All additives were prepared under laboratory conditions with material organically grown on Lithuanian farms at the Agriculture and Food Sciences Institute of Aleksandras Stulginskis University (Kaunas, Lithuania) in 2012. The corn grits used for the experiment were obtained from Polish retail market.

2.2. Preparation of the experimental flours

Freshly harvested Jerusalem artichoke tubers (*H. tuberosus* L.) cv. Sauliai, pumpkin fruits (*C. maxima* L.) cv. Karovita, and amaranth seeds (*A. cruentus* L.) cv. Geltoniukiai were used in this experiment. Tubers of Jerusalem artichoke were brushed, washed and sliced (1.0–1.5 mm thick slices). The peel and seeds from pumpkin fruits were manually removed and the flesh was cut into slices (2–3 mm thick). Jerusalem artichoke tuber and pumpkin slices were uniformly layered on a tray and dried for 24 h at 55 °C in a dryer with forced air flow (Venticell 111–Comfort; MMM Medcenter Einrichtungen, Planegg Germany). The amaranth seeds were dried in the same dryer at 45 °C for 48 h. Afterwards, the dried material was ground on a GRINDOMIX GM 200 knife-mill (Retch, Haan, Germany) and amaranth was additionally sieved through a 200 μm nylon sieve. The obtained flours were packed in airtight containers prior to use; the composition of the final flours are available in Pęksa et al. (2015).

2.3. Preparation of samples used for extrusion

Mixtures of corn grits were prepared with Jerusalem artichoke tubers, amaranth seeds, and pumpkin flesh flours as additives. The level of supplementation was 100 g/kg of the corn grits. The samples of extruded products were prepared in batches of 10 kg.

2.4. Extrusion process

Extrusion of samples was carried out in the laboratory of the Food Technology and Food Service Institute of Łomża State University of Applied Sciences (Łomża, Poland). For extrusion, twin-screw co-rotating extruder of EV0LuM (EV25) by Clextral firm (Firminy, France) was used. Three temperature profiles were evaluated: (i) 120/100/80şC, (ii) 140/120/100şC, and (iii) 160/140/120 °C, die diameter of 4 mm, and screw speed of: (i) 200 or (ii) 300 rotation/min. Based on preliminary experiments there were established constant conditions: water injection on the level of 0.2 l h^{-1} and 7.9 kg h^{-1} feed rate. Each obtained extrudate was granulated into pieces of 1.5 cm diameter and allowed to cool for 60 min in room temperature. Next, snacks pieces were packed into plastic bags and kept in the room temperature for 48 h before analyses. Experiment was conducted in two technological repetitions, and each measurement was run, at least, in triplicate.

2.5. Descriptive sensory analysis

Sensory evaluation with trained panel was used to quantify the intensities of the main organoleptic attributes defining the quality of the corn snacks. A panel of 8 panellists, aged 26–58 years (four females and four males, all members of the Universidad Miguel Hernández de Elche, UMH), with sensory evaluation experience, was intensively trained in descriptive evaluation of corn snacks. The lexicon development and the establishment of definitions and references (Table 1) were based on consensus data obtained from the eight highly trained panelists. The attribute determination and description procedure were adapted from the flavor and texture profile method and were similar to the one used by Vázquez-Araújo, Chambers, and Carbonell-Barrachina (2012) to develop a specialized lexicon on *turrón*, a Christmas confection prepared from honey and toasted almonds. Once all "training" samples were evaluated and no new terms were developed, three samples of commercial corn snacks were randomly chosen to validate the lexicon. In each of the next sessions, one of these "control" samples was presented to the panelists to validate their results.

The study was carried out at UMH facilities (individual booths, samples coded with 3-digit random numbers, and controlled illumination and temperature) during 4 sessions of 1.0 h. Approximately 4 units of each snack were served in one booth at 23 °C together with the appropriate questionnaire; 6 different samples were presented in each of the 4 sessions, allowing the analysis of the 24 samples under analysis. Panellists were asked to rinse their palates with water between samplings to minimize any residual effects and to wait at least 2 min between samples.

In the questionnaire, the panellists were asked to evaluate the