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Addition of quinoa and amaranth flour in gluten-free breads: Temporal profile and instrumental analysis

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ABSTRACT

The objective of this study was to evaluate the influence of sweeteners and pseudocereals in gluten-free bread formulations. The quality parameters evaluated were specific volume, firmness, color, water activity, proximate composition, gross energy and an image analysis of the crumb. The sensory properties were analyzed using the time-intensity method. The bread containing amaranth, quinoa and sweeteners presented specific volume, firmness and water activity similar to those of the control bread, but showed higher protein, lipid and ash contents and a larger alveolar area. In the time-intensity analysis, those containing sweeteners did not differ statistically from the control bread (demerara sugar) for the sweet stimulus, but in relation to bitter stimulus, the bread containing quinoa and the sweeteners sucralose and sucralose-acesulfame showed higher maximum intensity. These results showed that it is possible to develop gluten-free breads with pseudocereals and sweeteners with similar sensory and physicochemical properties to those produced with starch-based formulations.

1. Introduction

The substitution of gluten is a great challenge and the majority of gluten-free breads available on the market is based on starches (Arent & Moore, 2006). Currently the gluten-free food manufacturers are investing in the use of whole grains including corn, rice, sorghum, buckwheat, amaranth and quinoa, since the majority of these are excellent fiber, iron and vitamin B sources (Thompson, 2009). The pseudocereals are considered as potentially gluten-free grains with an excellent nutrient profile, capable of diversifying this rising market (Alvarez-Jubete, Arendt, & Gallagher, 2010).

The production of gluten-free breads has been widely studied recently (Cappa, Lucisano, & Mariotti, 2013; Hera, Rosell, & Gomez, 2014; Martínez, Díaz, & Gómez, 2014; Mohammadi, Sadeghniaa, Azizi, Neyestani, & Mortazavian, 2014; Tsatsaragkou, Gounaropoulos, & Mandala, 2014). The choice of a product by consumers is determined by the interaction of non-sensory factors, as personal health in this case, and sensory factors (Jaeger, 2006). The time-intensity analysis allows one to dimension the sensory sensations perceived over time, and the method provides information about flavor, odor and texture (Lawless & Heymann, 2010). The time-intensity method has been used for the last 25 years as an important tool because it allows comparison of the perception of sensory characteristics in a dynamic manner and can be applied to several food products with different objectives (Giovanni & Guinard, 2001).

Some celiac patients develop diabetes lifelong, and in these cases they must consume not only gluten- but also sugar-free foods. Moreover, the increasing cases of obesity related to sugar intake have led to a greater need for studies with sugar substitutes, the sweeteners. The pseudocereals present as potential substitutes for gluten and they are sources of fiber. In this context, the objective of the present study was to evaluate the influence of sweeteners and pseudocereals in gluten-free bread, by way of a physicochemical analysis, and the time-intensity profile in relation to sweetness and bitterness.

2. Materials and methods

2.1. Materials

Seven gluten and sucrose free loaf samples were prepared by partially substituting the mixture of starches by quinoa and

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amaranth flours, and the sucrose content by sweeteners. The ingredients used were: rice flour (Urbano®, SP, Brazil), potato starch (Yoki®, SP, Brazil), sea salt (Yoki®, SP, Brazil), cassava starch (Amafil®, PR, Brazil), sour tapioca starch (Hikari®, SP, Brazil), amaranth and quinoa flours (R&S Blumos®, SP, Brazil), demerara sugar (Native®, SP, Brazil), dry yeast (Dr. oetker®, SP, Brazil), xanthan gum (SweetMix®, SP, Brazil), pasteurized liquid egg (Fleischmann®, SP, Brazil), canola oil (Cargill®, MG, Brazil), the sweeteners in powder form were: sucralose, stevia and sucralose/acesulfame-K blend (SweetMix®, SP, Brazil) and water.

2.2. Methods

Formulations and loaves were developed in the Sensory Science and Consumer Study Laboratory of the School of Food Engineering, UNICAMP, Brazil. Subsequently the breads were produced in a food industry located in the Jundiaí city – Brazil, called "Grani Amici" and specialized in manufacturing gluten-free loaves.

2.2.1. Gluten-free breads manufacturing

The concentrations of the ingredients water, canola oil, pasteurized liquid egg, xanthan gum, dry yeast and salt were kept constant for all the seven gluten-free bread samples. The concentrations of sweeteners, demerara sugar, quinoa flour, amaranth flour, sour tapioca starch, cassava starch, potato starch, and rice flour, varied according to the formulations (Table 1). These ingredients were obtained from local supermarkets in Campinas city, Brazil, or donated by suppliers and were all gluten-free.

The concentrations of starch (rice flour, potato starch, cassava starch, sour tapioca starch, amaranth and quinoa whole flour) varied and was added until completing 100 g/100 g. The other ingredients were added based on starch and flour content. The loaves were manufactured according to the steps indicated for mixing dry ingredients with liquid ingredients in an industrial mixer (Perfecta®) at medium speed for 3 min, until dough formation. Portions of 420 g of the dough were weighed into loaf tins (170 mm × 7 mm × 6 mm), placed in a proofing chamber (Perfecta®) at 35 °C for 20 min and subsequently baked at 195 °C in a rotary oven (Perfecta®) for 25 min, preheated to 195 °C. The loaves were cooled at room temperature. The loaves were then sliced in to 1 cm, slices packaged in transparent polyethylene bags, identified and stored frozen in a freezer until the day of evaluations. For loaves were not sliced, for specific volume evaluation.

2.2.2. Samples preparation

For samples presentation for assessors, samples were heated in an electric oven (Perfecta®) at 100 °C for 10 min. For the other analyses, the samples were thawed at room temperature.

2.2.3. Physicochemical analyses

The physicochemical analyses of gluten-free bread samples were performed at the Central Laboratory of the Food and Nutrition Department, Food Technology Department (UNICAMP/FEA) and Technology Center of Grains and Chocolates of Campinas (ITAL). Samples were evaluated in three repetitions.

2.2.3.1. Specific volume. The specific volume of the loaves was determined according to AACC methodology (AACC, 2000). The loaves were weighed in a semi-analytical balance and the volume measured by millet seed displacement. The specific volume was calculated from the relationship of volume/weight, and results were expressed as cm^3/g.

2.2.3.2. Firmness. The firmness of the crumb of gluten-free breads was evaluated according to AACC methodology (AACC, 2000) using the TA-XT2 texture analyser and the program *Dimension XTRA, Stable Micro Systems*. The measurement of compression and force was carried out. The test was performed under the following conditions: pre-test speed: 1.0 mm/s, test speed: 1.7 mm/s, and post-test speed: 10.00 mm/s, compression 40%. A cylindrical aluminum probe of 36 mm diameter (P36/R) was used.

2.2.3.3. Color. The crumb color of gluten-free breads was determined using the CIELab system, evaluating the color parameters L* (luminosity), a* (green-red) and b* (blue-yellow) in a Hunter Lab model Color Quest II spectrophotometer (Hunter Associates Laboratory, Reston, VA, USA), The apparatus was calibrated with the illuminant D65, 10° hue angle and the RSIN calibration mode (Minolta, 1994).

2.2.3.4. Water activity. The water activity of the crumb of gluten-free bread samples was determined using the Aqualab analyzer (Decagon, Brazil).

2.2.4. Proximate composition

The analyses of proximate composition of gluten-free bread samples were carried out in order to characterize the bread samples. The moisture content, crude protein content, ash content and

Table 1
Ingredients of gluten and sugar free bread formulations.

	Ingredients	F1 (g/100 g)	F2 (g/100 g)	F3 (g/100 g)	F4 (g/100 g)	F5 (g/100 g)	F6 (g/100 g)	F7 (g/100 g)
Starch	Rice flour	61.64	49.32	49.32	49.32	49.32	49.32	49.32
	Potato starch	13.68	10.95	10.95	10.95	10.95	10.95	10.95
	Cassava starch	20.56	16.43	16.43	16.43	16.43	16.43	16.43
	Sour tapioca starch	4.12	3.30	3.30	3.30	3.30	3.30	3.30
	Amaranth whole flour	0	20	0	20	0	20	0
	Quinoa whole flour	0	0	20	0	20	0	20
	Amount of starch	100	100	100	100	100	100	100
% Base flour	Demerara sugar	2.73	0	0	0	0	0	0
	Sucralose	0	0.003	0.003	0	0	0.002	0.002
	Stevia	0	0	0	0.01	0.01	0	0
	Acesulfame-K	0	0	0	0	0	0.005	0.005
	Salt	2.05	2.05	2.05	2.05	2.05	2.05	2.05
	Dry yeast	2.05	2.05	2.05	2.05	2.05	2.05	2.05
	Xanthan gum	0.35	0.35	0.35	0.35	0.35	0.35	0.35
	Pasteurized liquid egg	37.67	37.67	37.67	37.67	37.67	37.67	37.67
	Canola oil	10.28	10.28	10.28	10.28	10.28	10.28	10.28
	Water at 4 °C	82.25	82.25	82.25	82.25	82.25	82.25	82.25

Note: F1: control; F2: amaranth sucralose; F3: quinoa sucralose; F4: amaranth stevia; F5: quinoa stevia; F6: amaranth sucralose/acesulfame-K; F7: quinoa sucralose/acesulfame-K.