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Mesquite (*Prosopis alba*) flour as a novel ingredient for obtaining a "panettone-like" bread. Applicability of part-baking technology

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A R T I C L E I N F O

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A B S T R A C T

Mesquite flour is obtained by grinding the pods of *Prosopis spp.*, a leguminous tree widely distributed in several American countries. This flour contains valuable nutritional and functional components (minerals, fiber) that can contribute to food enrichment. In the present work, mesquite flour (MF) (150–350 g/kg) was blended with wheat flour (WF) (850-650 g/kg) to obtain composite sweet breads. The replacement with MF diminished the resilience (up to 33%) and increased the adhesiveness (up to 20%) of doughs. Higher values of dynamic moduli were obtained when MF level in composite dough was increased. Consequently, leavening was hindered by the presence of MF and thus lower maximum volumes were attained. Concomitantly, when comparing to the bread without MF, lower heights (up to 41% less) and firmer crumbs (up to 60%) were obtained after baking. Crumb microstructure showed smaller and more irregular alveoli with thicker walls when mesquite flour was added. However, sensory analysis revealed a good degree of acceptability for these composite breads, particularly at 250 g/kg replacement level. Part-baking technology was successfully used in formulations with MF since after eight weeks of frozen storage (−18 °C) no changes were observed in the texture parameters of breads in comparison with non-frozen bread.

1. Introduction

Mesquite flour (MF) is a sweet and aromatic product obtained by grinding the whole ripe fruit of mesquite tree (*Prosopis spp.*). It is high in dietary fiber, minerals and sucrose, and has a slightly lower content of proteins than flours from cereals such as wheat and corn. Other flours can also be obtained from mesquite by grinding the seeds or the rest of the pods (Bigne, Puppo, & Ferrero, 2016b; Felker, Takeoka, & Dao, 2013). Mesquite is used mainly as flour to obtain a wide range of regional food products such as alcoholic (by fermentation of whole pods) and nonalcoholic beverages, leavened and non-leavened breads and cakes (mixed with other cereal flours) and is also used as coffee and chocolate substitute (Barba De La Rosa, Frías-Hernández, Olalde-Portugal, & Castañeda, 2006; Bravo, Grados, & Saura-Calixto, 1994). The amino acidic composition of mesquite proteins is nutritionally complementary with that of cereal proteins (Felker & Bandurski, 1977). Taking the latter into account and also its high content of fiber and minerals, this flour has a good potential to be used in healthy cereal-based formulations.

MF was previously tested in simple bread formulations. MF addition in non-sweet breads modified their sensory characteristics and technological quality (specific volume, crumb texture and porosity). However, the fiber content was significantly increased by MF addition allowing obtaining fiber enriched breads (Bigne, Puppo, & Ferrero, 2016a). Taking into account the particular color and flavor conferred by MF, it was considered that these characteristics would make it a good ingredient for sweet bread/cake formulations. Sweet bakery comprises a large number of products due to the great variety of ingredients that can be used in it. The panettone is an Italian festive sweet cake that belongs to a wide range of biologically leavened sweet cakes. It is characterized by its richness of sucrose (300–400 g/kg of wheat flour-WF) and fat matter (200–300 g/kg of WF). Its water content is about 250–350 g/kg, and part of this water amount is contributed by eggs. Traditionally, candied fruits and raisins are also added. The customary breadmaking procedure includes two mixing and at least two leavening (of several hours) steps. This leads to obtaining a product of high specific volume (similar to that of traditional breads) with a light and soft crumb (Pagani, Lucisano, & Mariotti, 2014). The complexity of the formulation and the preparation procedure (several steps and long leavening periods) of this kind of product makes its wide and continuous supply difficult. Part-baking, a bake-off technology (BOT) could contribute to facilitate the provision and availability of the fresh

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product in minimally equipped sale points with the advantage that the supply is on demand.

BOTs include frozen doughs and part-baking techniques. In the first case the dough is typically prepared and frozen in the central factory before being distributed to the sale points where it is thawed, leavened and baked. In the second case the steps of leavening and baking (partial baking) are also centralized, and the product is distributed partially baked and frozen to the sale points, where the process is completed with a final baking (Bárcenas, Benedito, & Rosell, 2004; Giannou & Tzia, 2007).

The objectives of the present work were: (a) test MF as ingredient in a composite sweet bread (based on the traditional panettone formulation) employing different levels of wheat flour (WF) replacement, (b) analyze the applicability of part-baking technology in these formulations.

2. Materials and methodology

2.1. Materials

WF type 000 (Molino Campodónico SA, La Plata, Argentina) with a composition of (g/kg) 121.1 of proteins, 13.2 of lipids, 137.4 of moisture, 0.70 of ash, 37.4 of total dietary fiber was utilized. MF of fully mesquite pods was acquired from local producers (INTI ATUN, Santiago del Estero, Argentina) of the province of Santiago del Estero, in the northwest region of Argentina. MF has a characteristic sweet aroma and a light-brown color typical of "white" mesquite species (*Prosopis alba*), and had the following composition (g/kg): 77.5 of proteins, 13.3 of lipids, 103.4 of moisture, 26.7 of ash, 219.0 of total dietary fiber, 447.7 of sucrose, 32.2 of fructose, and 10.3 of glucose. The composition of flours was determined in our laboratory according to AACC approved methods 46-12, 44-19, 8-1 and 32-05 for proteins, moisture, ash, and total dietary fiber, respectively (AACC, 2000); lipids were determined by extraction using a Soxhlet device, and soluble sugars were determined by HPLC. For dough and bread formulations margarine (Dánica, Buenos Aires, Argentina), fresh yeast (Calsa, Buenos Aires, Argentina), fresh eggs, and sodium chloride (Celusal, Vicente López, Argentina) were also used.

2.2. Panettone-like breads with MF

2.2.1. Formulation and breadmaking procedure

The formulations evaluated are summarized in Table 1. The basic formulation was obtained through preliminary assays taking as reference the one reported by Benejam, Steffolani, and León (2009) with some modifications in the amounts of water, margarine, salt and fresh eggs, and using fresh yeast instead of dehydrated yeast. The quantity of WF, which was partially replaced by MF at four levels: 0, 150, 250 and 350 g/kg (formulations MF0, MF150, MF250 and MF350 respectively), and sugar, reduced according to the increase in the level of mesquite flour, were modified among formulations. The latter was done taking into account the high level of sugars present in MF (mainly sucrose, as mentioned in Section 2.1) in order to maintain a constant ratio of sugar/total flour (250 g/kg) in all the formulations. The breadmaking process was simplified and involved a single leavening step. The traditional process for panettone breadmaking requires several fermentation steps, and natural sourdough is commonly used (Pagani et al., 2014).

Table 1
Formulations for doughs with different mesquite flour contents.

Component	Formulation (g/kg of total flour)			
	MF0	MF150	MF250	MF350
WF	1000	850	750	650
MF	0	150	250	350
water	240	240	240	240
sugar	250	168	113	58
margarine	200	200	200	200
liquid egg	170	170	170	170
salt	10	10	10	10
fresh yeast	30	30	30	30

WF: wheat flour; MF: mesquite flour; MF0, MF150, MF250, MF350: formulations with 0, 150, 250 and 350 g of mesquite flour/kg of total flour.

The fresh yeast was suspended in 100 ml of water at 30 °C with 10 g of sugar and added to the rest of the ingredients into a planetary kneader (Kenwood, Treviso, Italy). The flour/s, salt, melted margarine and the rest of the sugar were premixed for 1 min. Then the suspension of yeast, the liquid egg and the rest of the water were added and mixed for 30 min at 90 rpm. The dough obtained was allowed to rest for 10 min at room temperature covered with a polyethylene film to prevent dehydration. Two hundred g dough pieces were cut and manually formed, and placed in cylindrical molds (100 mm of diameter and 120 mm height) that were put in a fermentation cabinet (Brito Hnos., Los Polvorines, Argentina) at 30 °C during the optimal fermentation time for each formulation. Those times were 320.5 min, 293.7 min, 285.7 min and 231.1 min for doughs MF0, MF150, MF250 and MF350 respectively, and were determined as described in Section 2.2.3. After fermentation process, the leavened dough were baked for 40 min at 180 °C in an electric oven (Ariston, Fabriano, Italy), obtaining fully baked breads (FB) (see Table 2).

2.2.2. Rheological characterization of sweet composite doughs

Doughs prepared as described in Section 2.2.1, without yeast incorporation (to prevent leavening during the measurement), with different WF replacements by MF were rheologically characterized by small and large deformation tests.

2.2.2.1. Small amplitude oscillatory tests. Fresh dough discs were analyzed in a controlled stress rheometer RS600 (Haake, Waltham, MA, USA) with rough surface parallel plates. A gap of 2 mm between plates was used. Strain sweep tests were performed to obtain the linear viscoelastic range, and then frequency sweep tests were performed (0.005–100 Hz) at 25 °C. Measurements of G′, G″, and tan δ were obtained at a frequency of 1 Hz. Assays were performed by triplicate.

2.2.2.2. Texture profile analysis (TPA). A Texture Analyzer TA.XT2i (Stable Micro Systems, Godalming, U.K.) provided with a 245.3 N load cell was used. Discs of 30 mm diameter and 10 mm thickness were subjected to two consecutive compressions up to 40% of the initial height using a flat probe (SMSP/75) of 75 mm diameter and 1 mm s^{-1} crosshead speed. Measurements of force as a function of time were recorded, and texture profiles were analyzed to obtain the parameters of hardness (maximum force at the first peak), springiness (ratio between the distance corresponding to the second compression and the original compression distance), resilience (ratio between the area corresponding to the withdrawal of the first compression and the area of the first compression), and cohesiveness (area of the second peak with respect to the area of the first peak). Twelve assays were performed for each formulation.

2.2.3. Fermentation curves - determination of optimal fermentation times

Rounded pieces of 50 g of dough prepared as previously described (Section 2.2.1) were placed in graduated cylinders and leavened in a chamber at 30 °C and 50–60% relative moisture. The increase in volume of the dough was recorded across time, and data were plotted with OriginPro 8 (Origin Lab Corporation, Northampton, USA) software and fitted with Boltzmann sigmoidal function (eq. (1)) as described by Bigne et al. (2016a). The dependent variable ΔV corresponds to volume increase (cm^3), the independent variable t is the time (min), and parameters A, ΔV_{max}, B and C are fitting constants. Parameter ΔV_{max} corresponds to the maximum increase in volume. Optimal fermentation