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# Assessing rice flour-starch-protein mixtures to produce gluten free sugar-snap cookies

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The mixture of rice flours, starches and proteins is common in gluten-free bakery products such as bread or cake. The aim of this study was to determine the effects of starch and/or protein addition in rice flour gluten-free cookie quality. For this purpose, the hydration and oil absorption properties of flour-starch-protein mixtures, dough rheology and quality cookie parameters (thickness, final diameter, spread factor, texture, colour and acceptability) were analysed. Generally, protein incorporation increased hydration properties of the mixture and dough consistency, producing cookies with limited spreading in the baking time, lower hardness values and darker colour. In particular, protein addition reduced the width up to 8.4% and the hardness up to 10.60% (control versus 20% of protein inclusion). However, maize starch addition reduced hydration properties and gave rise to cookies with higher thickness and width, but the texture and colour were not affected by the starch. Cookies with higher protein content showed higher acceptability than cookies with higher starch content and no protein addition. Therefore, protein and starch can be used in order to adjust the desired cookie characteristics depending on the cookie formulation and the needs of manufacturers.



## 1. Introduction

Cookies are a baked product that typically has three major ingredients; flour, sugar and fat. There are distinct types of cookies depending on cookie composition, the making of cookie dough and baking parameters. Sugar-snap cookie is a particular type of cookie with high levels of fat and sugar and low water levels characterised by a limited development of the gluten network (Hadnadev, Torbica, & Hadnadev, 2013; Pareyt & Delcour, 2008). In addition, because of the insufficient water content of the cookie dough, most of the starch granules do not gelatinize during the cookie baking process (Pareyt & Delcour, 2008). Due to the minimal gluten development of sugar-snap cookies, there is the possibility to produce gluten-free cookies made from gluten-free flours without any gluten substitute (Donelson, 1988). However, gluten-free flours produce cookies with different physico-chemical characteristics in comparison with cookies made from wheat flour, depending on the cereal origin and the milling process (Mancebo, Picón, & Gómez, 2015).

Most studies that have investigated gluten-free cookies have used different gluten-free flours such as amaranth (De la Barca, Rojas-Martínez, Islas-Rubio, & Cabrera-Chávez, 2010; Gambus et al., 2009; Hozova, Buchtová, Dodok, & Zemanovič, 1997; Tosi, Ciappini, & Masciarelli, 1996; Schoenlechner, Linsberger, Kaczyc, & Berghofer, 2006), buckwheat (Gambus et al., 2009; Hadnađev et al., 2013; Kaur, Sandhu, Arora, & Sharma, 2015: Schoenlechner et al., 2006) and/or rice flour (Chung, Cho, & Lim, 2014; Torbica, Hadnadez, & Dapčević Hadnadev, 2012) or a mixture of these flours with other cereal flours (maize, sorghum or millet) or legume flours (Altındağ, Certel, Erem, & Konak, 2015; Rai, Kaur, & Singh, 2014). However, many commercial bakery products are mainly made from maize starch mixed, greater or lesser extent, with gluten free flours, starches from tubers and/or proteins. It has been proven that the protein and starch proportion in cookies made from wheat flour play an important role in cookie quality, because of their water absorption capacity, their effect in dough rheology and their spread in the baking process (Pareyt & Delcour, 2008). In general, soft wheat flour, which is characterised by a low protein content and weak gluten strength, is preferred in sugar-snap cookie elaboration (Souza, Kruk, & Sunderman, 1994) since they give rise to cookies with higher spread and cookie set time in the baking process (Kaldy, Kereliuk, & Kozub, 1993; Miller & Hoseney, 1997). Thereby,

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starch and protein addition could adjust the expansion in the baking process and gluten-free cookie diameter. It has also been shown that protein content affected dough rheology and texture of cookies, at least in the case of wheat cookies (Gaines, 1990). There are few studies about starch and protein addition in gluten-free cookies. Schober, O'Brien, McCarthy, Darnedde, and Arendt (2003) added starches in gluten-free cookies formulations but they were mixed with three gluten-free flours and only three mixtures were analysed, therefore the effect of starches could not be clearly compared. Sarabhai, Indrani, Vijaykrishnaraj, Milind, and Prabhasankar (2015) studied the effect of protein concentrate (soya and whey protein), however they were added with emulsifiers.

The aim of this study was to determine the effect of the addition of starch and/or protein to rice flour on dough rheology and gluten-free sugar-snap cookies quality.

## 2. Materials and methods

### 2.1. Materials

The following ingredients were employed in this study: rice flour (8.01 g/100 g of protein and 74.35 g/100 g starch) provided by Harinera Castellana S.L. (Medina del Campo, Valladolid, Spain), maize starch (DAESANG, Korea), Nutralys F85M pea protein (80% protein content) (Roquette, Leutrem, France), white sugar (AB Azucarera Iberia, Valladolid, Spain), margarine 100% vegetable (Argenta crema, Puratos, Barcelona, Spain), sodium bicarbonate (Manuel Riesgo S.A., Madrid, Spain) and local tap water.

### 2.2. Methods

#### 2.2.1. Mixture hydration and oil absorption properties

The different flour-starch-protein mixtures were characterised by their hydration and oil absorption properties.

Swelling volume (SV), or the volume occupied by a known weight sample, was evaluated by adding 100 mL of distilled water to 5 g (±0.1 g) of flour sample in a test tube and allowing it to hydrate for 24 h. Water holding capacity (WHC), defined as the amount of water retained by the sample without being subjected to any stress, was determined on the same suspension used to evaluate swelling; the hydrated solid was weighed after removing the excess water and values were expressed as grams of water per gram of solid (AACC method 88-04, 2012). Water binding capacity (WBC), or the amount of water retained by the sample after it has been centrifuged, was measured as described in AACC method 56-30.01 (AACC, 2012). Hydration properties were analysed in duplicate.

The method described by Lin, Humbert, and Sosulski (1974) was used to determine oil absorption capacity (OAC). Flour (100.0 ± 0.2 mg) was mixed with 1.0 mL of vegetable oil. The mixture was stirred for 1 min with a wire rod to disperse the sample in the oil. After a period of 30 min in the vortex mixer, tubes were centrifuged at 3000× g and 4 °C for 10 min. The supernatant was carefully removed with a pipette and the tubes were inverted for 25 min to drain the oil and the residue was then weighed. The oil absorption capacity was expressed as grams of oil bound per gram of sample on dry basis. Three replicates were performed for each sample. OAC was calculated by Eq. (1):

$$OAC(g/g) = Wr/Wi \quad (1)$$

Where Wr is the residue weight and Wi is the sample weight (g, db).

#### 2.2.2. Cookie preparation

All formulations were prepared using the same quantities of ingredients except for water, which was added to adjust dough moisture content to 15.0%, and the proportions of flour, starch and protein added (Table 1). The flour-starch-protein mixture moisture was determined by the AACC 44-15.02 method (AACC, 2012). The following ingredients (as g/100 g on dough basis) were used: flour-starch-protein mixture (43.3 g), sugar (31.2 g), margarine (19.4 g), water (5.2 g) and sodium bicarbonate (0.9 g). The margarine and sugar were then creamed at speed 4 for 180 s in a Kitchen Aid 5KPM50 mixer (Kitchen Aid, Benton Harbor, Michigan, USA) with a flat beater, scraping down every 60 s. The water was then added and mixing was continued at speed 4 for 120 s with intermediate scraping. After mixing, the cream was scraped down. Finally, flour and sodium bicarbonate were added, followed by mixing at speed 2 for 120 s, whilst scraping down every 30 s. After mixing, the dough was allowed to stand for a predefined period of 30 min. The dough pieces were then laminated with a salva L-500-J sheeter (Salva, Lezo, Spain) (gap width 6.00 mm). Cookie dough was cut with a circular cookie cutter (internal diameter, 40 mm) and weighed. Batches of at least 15 dough pieces were baked in an electric modular oven for 14 min at 185 °C. All the cookie elaborations were performed twice.

#### 2.2.3. Dough rheology properties

The rheological behaviour of doughs was studied using a Thermo Scientific HaakeRheoStress 1 controlled strain rheometer (Thermo Fisher Scientific, Schwerte, Germany) and a Phoenix II P1-C25P water bath that controlled analysis temperature (set at 25 °C). The rheometer was equipped with parallel-plate geometry (60-mm diameter titanium serrated plate-PP60 Ti) with a 3-mm gap. After adjusting the 3-mm gap, vaseline oil (Panreac, Panreac Química SA, Castellar del Vallés, Spain) was applied to the exposed surfaces of the samples to prevent them drying during testing. In oscillatory tests, dough was rested for 800 s before measuring. First, a strain sweep test was performed at 25 °C with a stress range of 0.1–100 Pa at a constant frequency of 1 Hz to identify the linear viscoelastic region. On the basis of the results obtained, a stress value included in the linear viscoelastic region was used in a frequency sweep test at 25 °C with a frequency range of 10–0.1 Hz. Values of elastic modulus ($G'$ [Pa]), viscous modulus ($G''$ [Pa]), complex modulus and tangent $\delta$ ($G''/G'$) were obtained for different frequency values ($\omega$ [Hz]). Samples were analysed in duplicate.

#### 2.2.4. Cookie properties

The texture of the cookies was measured sixty minutes after baking on eight cookies from each elaboration, using a TA-XT2 texture analyser (Stable Microsystems, Surrey, UK) fitted with the

**Table 1**
Experimental design of flour-starch-protein mixtures for preparation of gluten-free cookies.

| Trials | Mix (F-S-P) | Rice flour[a] | Maize starch[a] | Pea protein[a] |
|---|---|---|---|---|
| 1 | 100-0-0 | 100 | 0 | 0 |
| 2 | 90-0-10 | 90 | 0 | 10 |
| 3 | 80-0-20 | 80 | 0 | 20 |
| 4 | 70-30-0 | 70 | 30 | 0 |
| 5 | 65-25-10 | 65 | 25 | 10 |
| 6 | 60-20-20 | 60 | 20 | 20 |
| 7 | 40-60-0 | 40 | 60 | 0 |
| 8 | 35-55-10 | 35 | 55 | 10 |
| 9 | 30-50-20 | 30 | 50 | 20 |

Mix (F-S-P): Mixture of rice flour, maize starch and pea protein (g/100 g of flour). Each mixture was performed in duplicate (n = 2).
[a] g/100 g of flour.