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# Evaluation of the functionality of five different soybean proteins in yeast-leavened pan breads

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ABSTRACT

Soybean (SB) products are a source of proteins that complement the amino acid profile of cereal-based products and consequently improve human health. Four different SB flours (SBF-1 to SBF-4) and a SB concentrate (SBC) were incorporated into refined wheat flour in order to increase approximately 20–25% the protein content. The composite flours were processed into yeast-leavened pan breads. The SB fortified breads were characterized in terms of dough rheological, baking performance, bread crumb texture and color and sensory properties. The different SB proteins affected differently rheological properties of doughs, bread properties and quality. Addition of the SB proteins increased more than 3% optimum dough water absorption and consequently bread yield but decreased between 7 and 13% bread volume. The fortified breads also had a darker crumb. The best SB protein sources were SBF-3 and SBC which had respectively 75.5 and 52% PDI, 24 and 36% NSI, 4.0 and 8.3 water absorption and 50.3 and 36.9% water solubility indexes. These SB-fortified breads averaged 23% more protein and almost twice as much lysine compared to the control. Therefore, these SB proteins can be utilized to produce yeast-leavened breads with higher protein and upgraded protein quality.



## 1. Introduction

Soybeans (SB) are a rich source of high-quality protein and nutraceuticals. The high protein content plus the high amounts of essential amino acids that are lacking in most cereals make these flours ideally suited to fortify cereal-based foods, with only a slight increase in the production cost (Mashayekh et al., 2008; Novotni et al., 2009). Furthermore, soybeans are rich sources of dietary fiber, flavonoids, isoflavones, soyasaponins, other antioxidant compounds and most B-vitamins that exert positive health benefits especially in terms of prevention of most chronic diseases, osteoporosis and cancer (Mahmoodi et al., 2014).

Bread is the main staple in many countries worldwide and is mainly prepared from refined wheat flour. Nutritionally, the wide array of white breads provide energy, proteins, minerals and micronutrients (Shin et al., 2013; Acosta-Estrada et al., 2014), but the nutritional quality of the protein is not adequate due to the low levels of lysine present in wheat flour. The partial replacement of wheat flour by protein rich flours is difficult because they do not contain gluten-forming proteins and therefore are not functional, especially in leavened-bread systems. In an early report, Serna-Saldivar et al. (1988) produced SB enriched pan breads with and without sodium stearoyl lactylate and concluded that this dough conditioner improved volume and texture but not to the level of the control bread. Likewise, Shin et al. (2013) manufactured SB-fortified breads and concluded that they had comparatively denser texture and the peculiar beany flavor. However, SB proteins are potentially suited to fortify bread, biscuits and other bakery formulations especially in terms of enhancing protein quality and quantities of relevant nutraceuticals (Serna-Saldivar et al., 1988; Mashayekh et al., 2008; Ivanovski et al., 2012; Yezbick et al., 2013; Mahmoodi et al., 2014).

Defatted SB flour used in bread making increases absorption and moisture retention, which enlarges the freshness or textural shelf-life of the product. However, if a large amount of SB protein is incorporated into the wheat flour a disruption of the gluten-forming proteins occurs. Therefore, the SB protein interferes with the starch–gluten matrix negatively affecting volume, crumb scores and overall quality attributes and acceptability of enriched breads (Shin et al., 2013; Mahmoodi et al., 2014).

The aim of this research was to assess the effect of addition of four different defatted SB flours or a SB concentrate with

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contrasting functional properties on the rheological dough properties and quality of yeast-leavened pan breads produced by the pup loaf straight or sponge dough processes. Control and SB fortified treatments were compared in terms of chemical composition, amino acids, dough rheological properties, bread texture and sensory attributes.

## 2. Materials and methods

### 2.1. Commercial soybean samples

Five different commercial SB samples were selected to differ in functional properties especially in terms of urease activity, water absorption (WAI), water solubility (WSI), protein dispensability (PDI) and nitrogen solubility (NSI) indexes. Four were defatted SB flours, Industrial de Alimentos (SBF-1), GAF-120 (SBF-2), ADM (SBF-3) and Ragasa (SBF-4) containing approximately 49% protein (N x 6.25 as is basis), whereas the remaining a protein-concentrate (SBC) Provita® containing 67% protein (as is basis). Urease activity (Method Ba 9-58, AOCS, 2011), nitrogen solubility (Method Ba 11-65, AOCS, 2011), water absorption and solubility (Cheftel et al., 1989), and protein dispersibility (Method Ba 10b-09, AOCS, 2011) indexes were assayed. Lysine, tryptophan and sulfur containing amino acids (methionine plus cysteine) in wheat flour and the different SB protein sources were determined according to Official Method 982.30 E (a,b,c) of the AOAC (2006).

### 2.2. Soybean-fortified flours

Each of the five different SBF proteins were composited with commercial refined wheat flour (La Perla, Molinos del Fenix, Saltillo, Coahuila, Mexico) in order to increase the protein concentration to about 20–25%. The experimental SB enriched flours were produced by substitution of 6.0% SBF-1; 6.1% SBF-2; 6.3% SBF-3, 6.2% SBF-4 and 4.5% SBC of the refined bread flour. Protein (N $\times$ 5.7) was determined in the control and experimental composite flour samples using the AACC International (2000) method 46-30.

### 2.3. Dough rheological properties

The dough rheological properties of the control and SB-composite flours were determined with the farinograph (Brabender Instruments, South Hackensack, NJ) and Alveograph (Chopin Instruments, Villeneuve-La-Garenne, France) according to Approved Methods 54-21 and 54-30, respectively (AACC International (2000)).

### 2.4. Straight dough baking

The pup loaf straight-dough bread micro-baking method 10-10.03 (AACC International, 2000) was utilized. The bakers formulation consisted of 6% refined cane sugar (Avance, Avance Comercial de Monterrey, Monterrey, NL, Mexico), 3% vegetable shortening (Inca, Unilever de Mexico S.A de C.V., Tultitlán, Edo. de Mexico, Mexico), 2% refined iodinated salt (La Fina, Sales del Istmo, Coatzacoalcos, Veracruz, Mexico) and 2% dry yeast (*Saccharomyces cerevisiae*) (Azteca® Levadura, Iztapalapa, Mexico, D.F., Mexico). Optimum water absorption and mix times were subjectively determined by observing dough properties or gluten development (film formation, gloss and dough stickiness). Bake absorption, mixing time, proof height, loaf height, oven spring, loaf weight, loaf volume, and loaf apparent density were determined. Proof height and loaf height were determined with a proof height meter (National Manufacturing Co., Lincoln, Nebraska). The difference between these values was recorded as oven spring. Loaf volume was determined by rapeseed displacement (National Manufacturing Co., Lincoln, Nebraska) according to method 10-05.01 of the AACC International (2000).

### 2.5. Sponge dough baking

Sponge dough breads were manufactured in a pilot plant in order to generate loaves for texture and sensory analyses. Sponge doughs were produced by mixing by hand 200 g of refined bread flour, 5 g instant dry yeast and 140 g water. The resulting blend was placed in a plastic container in a fermentation cabinet (National Mfg., Lincoln, NB, USA) set at 28 $\pm$ 1 °C for 4 h. Resulting sponges were mixed with the remainder of the dry ingredients: 300 g bread flour, 30 g sugar, 20 g shortening, 5 g of dry whole milk (Nestle de Mexico, Mexico, D.F., Mexico), 10 g salt, 1 g lecithin (Proveedores de Ingeniería Alimentaria S.A. de C.V. Monterrey, N.L., Mexico), 1 g Sodium Stearoyl Lactylate (SSL), 1 g calcium propionate and 2.5 g dry yeast instant for one min at low speed in a Hobart mixer equipped with the hook attachment. Then, the rest of the predetermined amount of water was added and blended for one minute at low speed. Next, the velocity was switched to medium until attaining optimum dough development. Film formation, gloss and dough stickiness were subjectively determined to estimate optimum mix times. Resulting doughs were weighed before placing them in a fermentation cabinet set at 28 $\pm$ 1 °C and 85% relative humidity. After 10 min resting, doughs were punched thru 0.95 cm roll spacing in preparation for molding and panning in 7.5 cm height metal pans that had the following dimensions on the base and top, respectively: 22.5 and 24.5 cm long and 8.5 and 10.5 cm wide. Baking pans were previously greased with vegetable shortening on the bottom and sides. Panned doughs were proofed for 45 min before baking for 25 min in an oven (Electrolux EOG Gas single oven X 601) set at 190 °C. Upon 30 min cooling at room temperature, breads were cut into 2 cm thick slices, packaged in sealed polyethylene bags and stored at room temperature for 5 days.

### 2.6. Crumb texture and color of sponge breads

The crumb texture of the slices of bread (2 cm thick) was evaluated with a texture analyzer (model TA.XT plus, Stable Micro systems, United Kingdom) according to the bread firmness-compression test method 74-10.02 (AACC International (2000)) with a trigger force of 0.048 N. Cohesiveness, hardness, gumminess, chewiness and elasticity were evaluated at the center of the slice. The parameters were calculated from the resulting texture profile analysis curves. Tests were conducted at days 0 (fresh), 1, 2 and 5 days of bread slices kept at room temperature.

The crumb color of the control and experimental breads was objectively measured on three *slices* with a colorimeter (CR 300, Minolta, Japan). Bread-crumb color parameters $L^*$, $a^*$, and $b^*$ were the average of three measurements at different parts of the slice. Tests were conducted after 1 day storage at room temperature.

### 2.7. Sensory analyses

In-house consumer panels (pilot consumer panels) consisted of forty untrained panelists, evaluated the sensory features and overall acceptability of control and experimental breads in individual booths after 24 h of baking. Bread evaluation was performed in a sensory evaluation laboratory (ITESM-Campus Monterrey) according to the guidelines described by Watts et al. (1989). Each panelist was simultaneously given six coded samples along with a ballot, and was asked to rate color, texture, flavor, odor, and overall quality on a 5-point hedonic scale, where 1 is like very much and