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Effect of wheat flour protein compositions on the quality of deep-fried gluten balls

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Abstract

Wheat flours milled from five different varieties of wheat and collected at an extraction rate of 60% were used as raw materials in this study. The proximate compositions, dough Farinographic and Extensographic properties, and the quality indices of deep-fried gluten balls prepared from these flours were measured. The proteins of these five different wheat flours were extracted and analyzed using the electrophoretic method, and the effect of protein composition on the quality of deep-fried gluten balls prepared from these flours was investigated. In this study, the proteins in each sample were divided into six groups, and the molecular weights of the proteins in these six groups are as follows: (I) 205.0–97.4 kDa; (II) 97.4–66.2 kDa; (III) 66.2–45.0 kDa; (IV) 45.0–36.0 kDa; (V) 24.0–19.7 kDa; (VI) 14.4–6.5 kDa, respectively. The results show that the protein contents of groups I, II, and V are negatively correlated to peak force and Hunter *b* value of deep-fried gluten balls, but positively correlated to Hunter *L* value and sensory evaluation score of appearance. The above results reveal that the high-molecular weight glutenin subunits, ω-gliadins, and albumins/globulins of wheat flour have a profound effect on the quality of deep-fried gluten balls.

Keywords: Deep-fried gluten ball; Electrophoresis; Gliadins; Glutenins; Wheat protein; Wheat flour

1. Introduction

The protein mixture of wheat flour is very complex and contains many molecular species with different sizes, structures, and conformations (Pence, Nimmo, & Hepbum, 1964; Stone & Hamdy, 1964). Proteins in flour can be mainly grouped into three main categories: glutenin, gliadin and albumin/globulin. Some researchers may further divide them into more detailed subgroups which are HMW glutenin subunit, ω-gliadin, LMW glutenin subunit, α-, β-, γ-gliadin and albumin/globulin (Ciaffi, Tozzi, & Lafiandra, 1996; Kasarda, Woodard, & Adalsteins, 1998; Mimouni, Robin, Azanza, & Raymond, 1998). Gliadin has a good extensibility, but lacks elasticity. Glutenin has a better elasticity but a low extensibility (Cheftel, Cug, & Lorient, 1985). Blending both of them in the dough brings a specific elasticity and extensibility, which can then be used in the processing of different flour products. When flour is mixed with water, glutenin swells and incorporates gliadin, and some water-soluble albumins and globulins. Along with mixing processes, a network structure of gluten is gradually developed (Bietz & Wall, 1980; Huebner, 1977). Many studies indicate that gluten plays a key role in determining the quality of wheat flour (MacRitchie, 1992, 1994; Shewry & Tatham, 1997). Gluten proteins substantially control the quality of wheat flour products (Finney, 1943; MacRitchie, 1984).

Deep-fried gluten balls are a traditional food in Taiwan. They are made using wheat flour as a raw material. At first, the flour is washed with water to obtain wet

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gluten, which is then cut and shaped into balls and fried in oil to obtain deep-fried gluten balls (Chang, Chen, & Wu, 1996; Chen, Chen, Wu, & Chang, 1998). While the flour is mixed with water, the network structure of gluten is gradually formed during concomitant stirring (Bietz & Wall, 1980; Huebner, 1977). The network structure of gluten is co-stabilized by disulfide bonds, hydrogen bonds, and hydrophobic interactions (Huebner, 1977; L'asztity, 1972). Much research reports that the elasticity and the extensibility of the dough prepared from wheat flour are determined by the quantity and quality of the proteins in flour (He & Hoseney, 1992). In this study, the flours from different varieties of wheat, which were milled on a laboratory mill and collected at an extraction rate of 60%, were used as raw materials. We prepared deep-fried gluten balls from these flour materials and analyzed their quality. In addition, we extracted proteins from flours, analyzed the protein compositions using electrophoresis, and discussed the relationships between quality of deep-fried gluten ball and flour protein composition.

2. Materials and methods

2.1. Experimental materials

Wheat flours used in this study were provided by Chiafha Co., Ltd. (Ching-Shuei, Taichung, Taiwan). Five sources of flour are American hard red spring wheat (AHRS), American hard red winter wheat (AHRW), American soft white wheat (ASW), Australia prime hard wheat (APW), and Canadian western red spring wheat (CWRS). The wheat was milled on a laboratory mill (Buhler MLU-202, Type 71-14-R4b). Each flour sample was obtained by mixing the flours from B3, B2, B1, C1, C2, and C3 milling streams of the mill at an extraction rate of 60%. The frying oil is soybean oil, purchased from a local oil-manufacturing plant in Taichung.

2.2. Analysis of dough rheological properties

Dough rheological properties, farinograph and extensograph, were determined by AACC methods 54-21 and 54-10 (AACC, 1983), respectively.

2.3. Protein extraction

According to the methods provided by Danno (1981), Singh, Donovan, Batey, and MacRitchie (1990) Chang, Shyong, and Chang (1997), flour was suspended in a 0.05 M phosphate buffer (pH 6.9) containing 2% SDS with a solid/liquid ratio of 1:20. The suspension was treated with a sonicator (Ultrasonic Processor XL, Misonix Inc., USA) for 5 min at a 38 W output. During sonication, a 25 °C water bath was used to cool the suspension to prevent its temperature from exceeding 50 °C. After sonication, the suspension was stirred with a magnetic stirrer for 2 h and then centrifuged at 12,000*g* for 20 min. The supernatant was collected as our protein extract liquid.

2.4. Protein analysis by SDS–PAGE electrophoresis

Our approach followed the method provided by Gupta and MacRitchie (1991) with a minor modification. The equipments used here were an Electrophoresis apparatus Model AE-6450 (ATTO, Japan) and a power supply PS500XT with a 2.5 A input (Hoefer scientific instruments, USA). Ten μl of the protein sample liquid was added with 10 μl lysis buffer containing 0.5 M Tris (pH 6.8), 2% bromophenol blue, 10% SDS, 75% glycerol, β-mercaptoethanol, and distilled water. The sample was then loaded in a 15% acrylamide gel (gel concentration: stacking gel 4.5%, resolving gel 15%). Electrophoresis started at 70 V and was tuned up to 140 V after a tracer dye entered the resolving gel. This voltage was held until the tracer reached the bottom of the gel before the power was turned off. The gel was then immersed in coomassie blue for 2 h and the color was stripped by a solution containing 7% methanol and 7% acetic acid.

2.5. Quantification of protein composition

The color-stripped gel was scanned by a TLC scanner (Camag, Sweden) at 597 nm. The scanned peaks were categorized into six groups according to their molecular weights, which were indicated by standard proteins. Relative protein content in each group was determined by the ratio of the peak's area in each group over the peak's area in the overall six groups.

2.6. Preparation of wet gluten

The method developed by Oda, Yasuda, Okazaki, Yamauchi, and Yokoyama (1980) was used to prepare wet gluten (Oda et al., 1980). The flour was washed with water to remove starch. The obtained wet gluten (water content was around 67%) was then immersed in the water for 30 min before cutting and shaping into balls.

2.7. Frying of gluten balls

The frying of gluten balls was modified from the method of Chen et al. (1998). One hundred grams of wet gluten balls were fried continuously through three consecutive deep-frying pans. Each pan (34 cm i.d. × 26 cm h) contained about 10 l of soybean oil. The frying time in the first, second and third pans were 120, 90, and 70 s, respectively. The temperature of the first, second, and third pans were 135 ± 3, 157 ± 3, and 190 ± 3 °C, respectively.