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Full Length Research Paper

Distribution of protein components of wheat from different regions

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The distribution of wheat protein components in different regions was researched to provide a theoretical basis on variety selection, quality improvement and food processing. 146 varieties from eight regions were collected to measure contents of protein components (albumin, globulin, gliadin and glutenin) in different regions for the distribution. The largest variation coefficient occurred in contents of globulin, followed by those of gliadin and albumin, while the contents of glutenin varied with the smallest range. The contents of all protein components belonged to normal distribution. It was discovered that the contents of albumin and globulin skewed towards the high value, while glutenin content skewed towards the low value. Differences on the contents of protein components existed in samples from different regions; the regional distribution of four protein components is: the northern region > the southern region > the western region > the eastern region. The contents of protein components of Yannong 19 in different regions were determined, the results displayed that the distributions of four protein components showed the same trends, although the highest contents occurred in Shanxi as compared to the other three regions (Shandong, Jiangsu and An'hui), and there were little differences among them. Geographical conditions can affect the protein components of wheat, and gliadin and glutenin content can affect wheat quality, so we can designate areas where wheat contains more gliadin and glutenin as our high-quality wheat producing areas, of which Shaanxi is a better choice.

Key words: Wheat, protein components, different regions, distribution.

INTRODUCTION

With economic development and health awareness, more people are concerned about not only the high yields of wheat, but also the quality of wheat. Wheat quality includes the nutritional quality and processing quality, which are both closely related to wheat protein content and the ratio of each component; therefore, to determine the merits of wheat varieties quality, protein components must be analyzed. According to statistics, 63% of the total protein consumption in the world directly comes from the cereal food and more than 80% in developing countries(Lin et al., 2007). Wheat protein is very complex, Osborne (1907) first proposed a classification method of wheat proteins, which were divided into four categories according to their solubility in different solvents: water-soluble albumin, globulin soluble in dilute salt, gliadin soluble in ethanol and glutenin soluble in dilute alkali. Albumin and globulin mainly exist in the aleurone layer, embryo and seed coat, known as metabolic proteins or structural proteins, the proportions of albumin and globulin are both 10% in total protein and rich in lysine, tryptophan and arginine, with high nutritional value (Jaswinder et al., 2001). Albumin and globulin include many physiologically active proteins, such as α-amylase, protease inhibitors, regulation enzymes, synthetic enzymes and metabolic enzymes (Fra-mon et al., 1984; Vincenzo et al., 1977; Carbonero et al., 1993).Gliadin and

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Table 1. Variation parameters of protein compositions in different wheat varieties (%).

Protein composition	Average	Minimum	Maximum	Standard deviation	Variation coefficient (%)
Albumin	2.5932	1.4725	3.9610	0.5323	20.53
Globulin	0.7117	0.3576	1.6556	0.2372	33.32
Gliadin	3.0749	1.3673	5.7902	0.7261	23.61
Glutenin	4.4185	2.8180	6.5657	0.7515	17.01

glutenin are present in the endosperm, and are called storage proteins or gluten, which is the main components of wheat protein; the proportions of gliadin and glutenin are both 40% in total wheat protein, respectively. It is generally believed that gliadin determines the dough extensibility, glutenin determines the dough elasticity and the ratio of gliadin to glutenin determines the processing quality (Uthayakumaran et al., 2001; Khatkar et al., 2002; Kuktaitea et al., 2004; Edwards et al., 2004; Tang et al., 2008; Shi et al., 2009). The composition and content of every protein components will affect the processing quality of flour, contents of albumin and globulin have a significant or highly significant negative correlation to loaf volume and bread quality score, and the contents of gliadin and gluten were significantly positively related to loaf volume and bread specific volume. Gluten content was positively correlated to bread quality score, and the alcohol-soluble protein content has no significant correlation to bread quality score, but the addition of alcohol-soluble protein will reduce the volume of bread, enhance the anti-fracture and reduce the resistance against the extension (Susanne and Herbert, 2001; Harmit, 2005; Sapirstein et al., 2007; Khatkar et al., 2002; Peck et al., 2008). Bread volume is relative to the number of disulfide bonds, the number of the folding structural unit in proteins and protein subunits (Zhu et al., 2001; Zhang and Li, 1993). The composition and properties of protein components is closely related to noodle making properties and tensile properties of texture analyzer, such as noodle thickness, the length of noodles, maximum tensile resistance of noodles, tensile length of noodles, tensile energy of noodles, etc., (Kovacs et al., 2004; Wu et al., 2006; Hu et al., 2004; Zhang et al., 1998). Accumulation of wheat protein fractions is complex, which is relative to the genetic characteristics of species and environmental conditions (Uthayakumaran et al., 2003; Graybosch et al., 1995; Yan et al., 2008), which is most important, such as climate, soil, fertilizers, irrigation, etc., (Frances et al., 2006; Daniel and Triboï, 2002; Yan et al., 2007; Jiang, 2006; Saito, 2004; Zhao et al., 2005; Zhao et al., 2003). At present, four kinds of protein components in wheat flour from different regions have not been systematically studied.

In this paper, albumin, globulin, gliadin and glutenin contents were determined in 146 varieties of wheat from different regions, which will provide a theoretical basis for wheat breeding, wheat quality improvement and the food processing.

MATERIALS AND METHODS

Wheat varieties

Grains from 146 wheat varieties were collected from eight provinces (municipalities), including Beijing, Hebei, Henan, Shandong, Jiangsu, Anhui, Shanxi and Shaanxi, among which, two varieties from Beijing, 24 varieties from Hebei province, 16 varieties from Henan province, 32 varieties from Shandong province, 27 varieties from Anhui province, 19 varieties from Jiangsu province, nine varieties from Shanxi province and 17 varieties from Shaanxi province.

Separation of protein components

0.1 g of flour was weighed and put into a centrifuge tube, after which 1 ml of distilled water was added to the extract albumin, before it was fully shook for 30 min and centrifuged for 5 min (4000 turn/min). The supernatant was then extracted from the proteins. Extracted three times, the combined supernatant was placed in 5 ml volumetric flask at constant volume for detection. Globulin, gliadin and glutenin were extracted with 10% NaCl, 70% ethanol and 0.2% NaOH, respectively, the procedure was the same for albumin (He, 1985).

Determination of protein components contents

Briefly, 5 ml protein solution + 5 ml concentrated sulfuric acid + 5 g catalyst (zinc sulfate:copper sulfate = 10:1) were digested at 420°C for 1 h until the fluid was clear, transparent and the color changed from blue to green. The protein content was determined using the FOSS Kjeltec 2300 Kjeldahl automatic analyzer (Sweden).

Data analysis

The average of the sample characteristics, minimum, maximum, standard deviation and variation coefficient was calculated using SAS statistical software, and was drawn by Excel software.

RESULTS

Variation of wheat protein fractions

Contents of four protein fractions and the variation coefficients from 146 wheat varieties are as shown in Table 1. The results indicate that the variation ranges of four kinds of protein components are large, the variation coefficient range from 17.01 to 33.32%, of which the coefficient of variation of globulin content was the largest, followed by alcohol-soluble protein and albumin, the

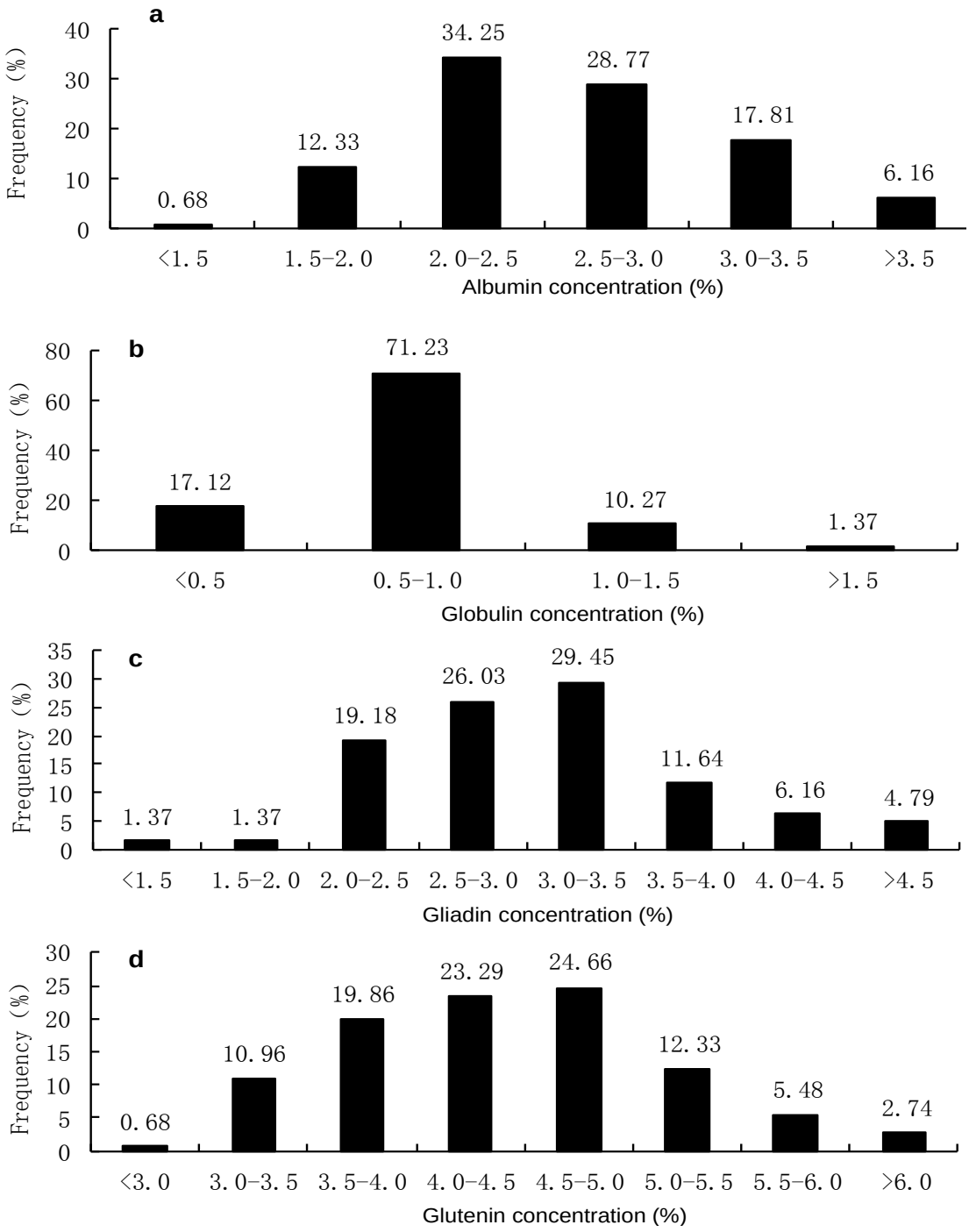

Figure 1. Distribution of protein compositions in different wheat varieties: (a) albumin, (b) globulin, (c) gliadin and (d) glutenin.

variation coefficient of gluten content was the smallest in wheat.

Protein content distribution

Distributions of albumin, globulin, gliadin and glutenin content of 146 samples are as shown in Figure 1. Albumin levels are distributed normally and skewed towards the high value, where the total variation range is 1.4725 to 3.9610% and the peak area of the sample distribution ranged from 2.0 to 2.5%, accounting for 34.25% of the total sample. Close to the peak area at the right (high side), is the second peak area having an

albumin concentration range of 2.5 to 3.0%, followed the first sample peak area whose proportion is 28.77%. The samples whose content ranged from 2.0 to 3.5% accounted for 17.81% of the total samples, while those whose content ranged from 1.5~2.0% accounted for 12.33%; however, the remaining interval included few samples.

Globulin basically showed normal distribution, and it was observed that the total variation range is from 0.3576 to 1.6556% and the peak area of the sample distribution range is from 0.50 to 1.0%, which accounted for 71.23% of the total sample. Close to the peak area at the left (low side), is the second peak area whose range is lower than the 0.5% globulin concentration range, and was followed by the first sample peak area whose proportion range is 17.12%. At the right side (high side) of the first peak area, the sample whose globulin contents range from 1.0 to 1.5% has a 10.27% range; although the samples whose globulin contents were higher than 1.5% were few.

Gliadin levels are the normal distribution skewed towards the high value, the total variation range is 1.3673 to 5.7902%, there are two peak areas of the sample distribution 2.5 to 3.0 and 3.0 to 3.5%, both of which accounted for 26.03 and 29.45% of the total sample, respectively; the proportion of gliadin content from 2.0 to 2.5% accounted for 19.18 and 3.5 to 4.0% accounted for 11.64%.

Glutenin content was basically a normal distribution, the total variation range was 2.8180 to 6.5657%, the peak areas of the sample distribution were 4.0 to 4.5% and 4.5 to 5.0%; which accounted for 23.29 and 24.66% of the total sample, respectively; the proportion of glutenin content from 3.5 to 4.0% was 19.86%, samples from 3.0 to 3.5% was 10.96% and 5.0 to 5.5% was 12.83%.

Geographical differences in protein composition

Average results of albumin, globulin, gliadin and glutenin protein content by region are as shown in Figure 2. Albumin contents in wheat samples from low to high can be divided into three regions, the lowest levels in Anhui (2.38%); Hebei, Henan, Shandong and Jiangsu were the middle levels, ranging from 2.56 to 2.62%; content of Shanxi and Shaanxi were the highest, 2.74 and 2.83%.

Similar to albumin content distribution, the globulin content distribution in wheat samples from low to high was also roughly divided into three regions, the contents of globulin in wheat from Shandong, Jiangsu and Anhui were the lowest (0.50 to 0.57%); Hebei (0.64%) and Henan (0.67%) were the middle levels; the highest contents were Shanxi (0.92%) and Shaanxi (0.83%).

The distributions of wheat gliadin content were divided into four regions from low to high, Shaanxi wheat gliadin content was the highest (3.81%); followed by Shanxi wheat (3.40%); Hebei, Henan and Shandong wheat gliadin contents had little difference (2.93 to 3.25%); Jiangsu and Anhui were the lowest, respectively 2.62 and 2.77%.

Glutenin content distribution, similar to globulin content distribution, was divided into three regions from low to high: glutenin contents from Shanxi and Shaanxi were the highest, 4.76 and 4.80% respectively; Hebei, Henan and Shandong were the middle levels, ranging from 4.34 to 4.64%; Jiangsu and Anhui were the lowest, 3.99 and 3.84%, respectively.

Overall, the protein component contents in wheat from different regions have great differences, and the contents of the four kinds of protein components are arranged in the following order: the northern provinces > southern provinces, western provinces > eastern provinces.

Geographical differences of the same species

Albumin, globulin, gliadin and glutenin content distributions of Yannong 19 variety planted in four regions are as shown in Figure 3. The results indicate that the wheat protein component contents are different as the geographical environment difference, but four kinds of protein distribution was basically consistent, the highest content in Shaanxi, followed by Shandong, Jiangsu and Anhui was the lowest. There were little difference between the contents of protein in wheat from Shandong, Jiangsu and Anhui, because these three provinces are adjacent.

DISCUSSION

The differences observed in the wheat protein content components are caused by many factors. Objective factors include soil nutrient status, light, temperature, precipitation, etc. Human factor is that China's agricultural production is still in the mode of small farmers, which results in the varieties of cultivation practices. In addition, the degradation of wheat varieties characteristics also has a certain impact on the variability of the protein components. In the four protein components, variation of globulin was the largest, because globulin as metabolic proteins has a greater change with the termination of the different metabolic processes; as such, the globulin content is very low with subtle changes which will result in significant differences. The glutenin, as storage proteins, were on the contrary.

Distribution of protein components is basically higher in the north than the south, and the west higher than the east, which may be caused by precipitation and moisture. Dry environmental conditions were conducive to the accumulation of the total protein and protein component.

Albumin content in China's wheat was higher than that in foreign wheat (Yang, 2004), but globulin, gliadin and glutenin were significantly lower. Differences in the content of protein components, especially the gliadin and glutenin which resulted in a qualitatively different component, led to the processing of domestic varieties less than the quality of the foreign varieties. Geographical

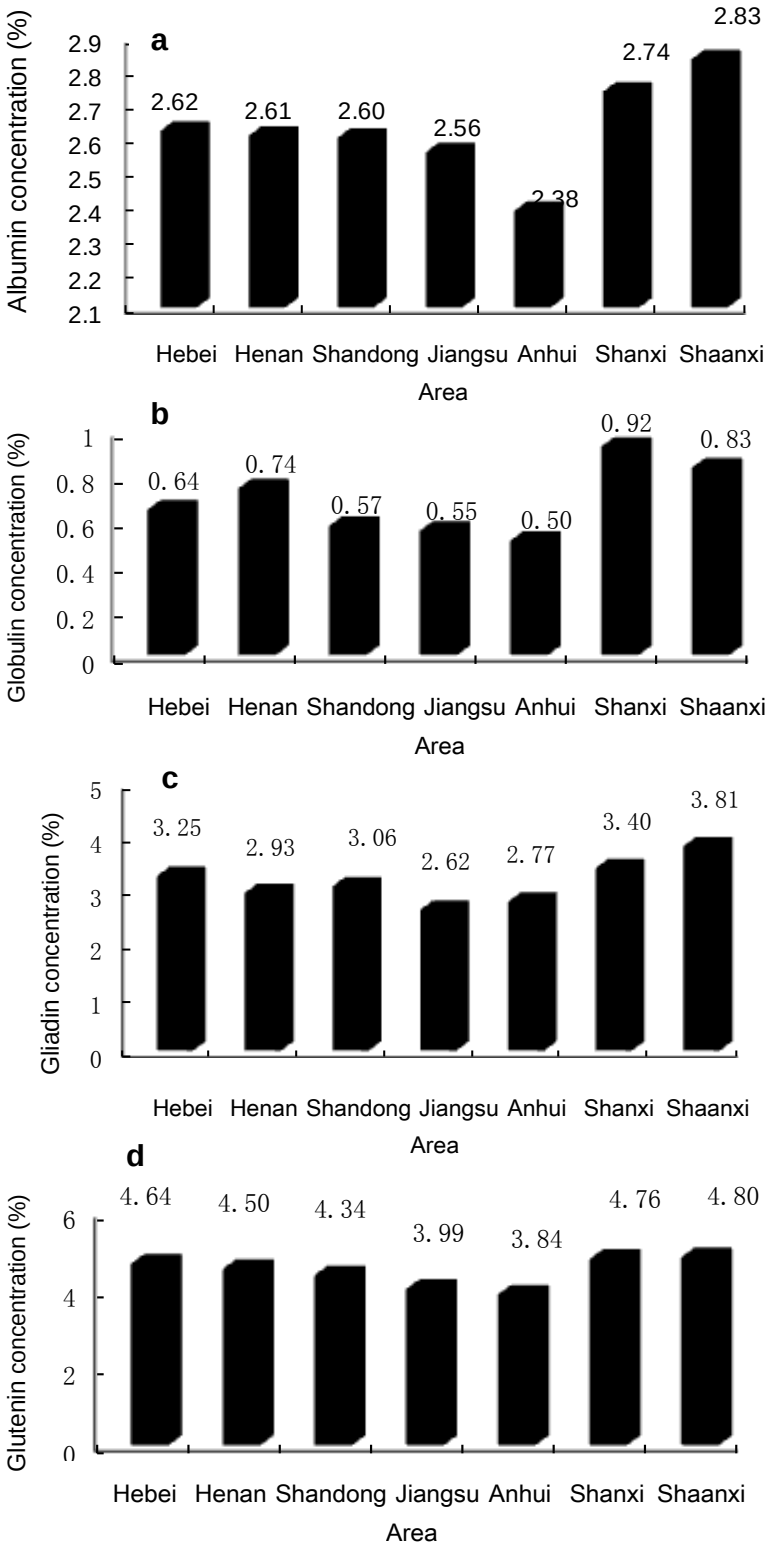

Figure 2. Protein compositions in different provinces: (a) albumin, (b) globulin, (c) gliadin and (d) glutenin.

conditions can affect the protein components of wheat and gliadin and glutenin content affect wheat quality, so we can designate areas where wheat contains more gliadin and glutenin as our high-quality wheat producing

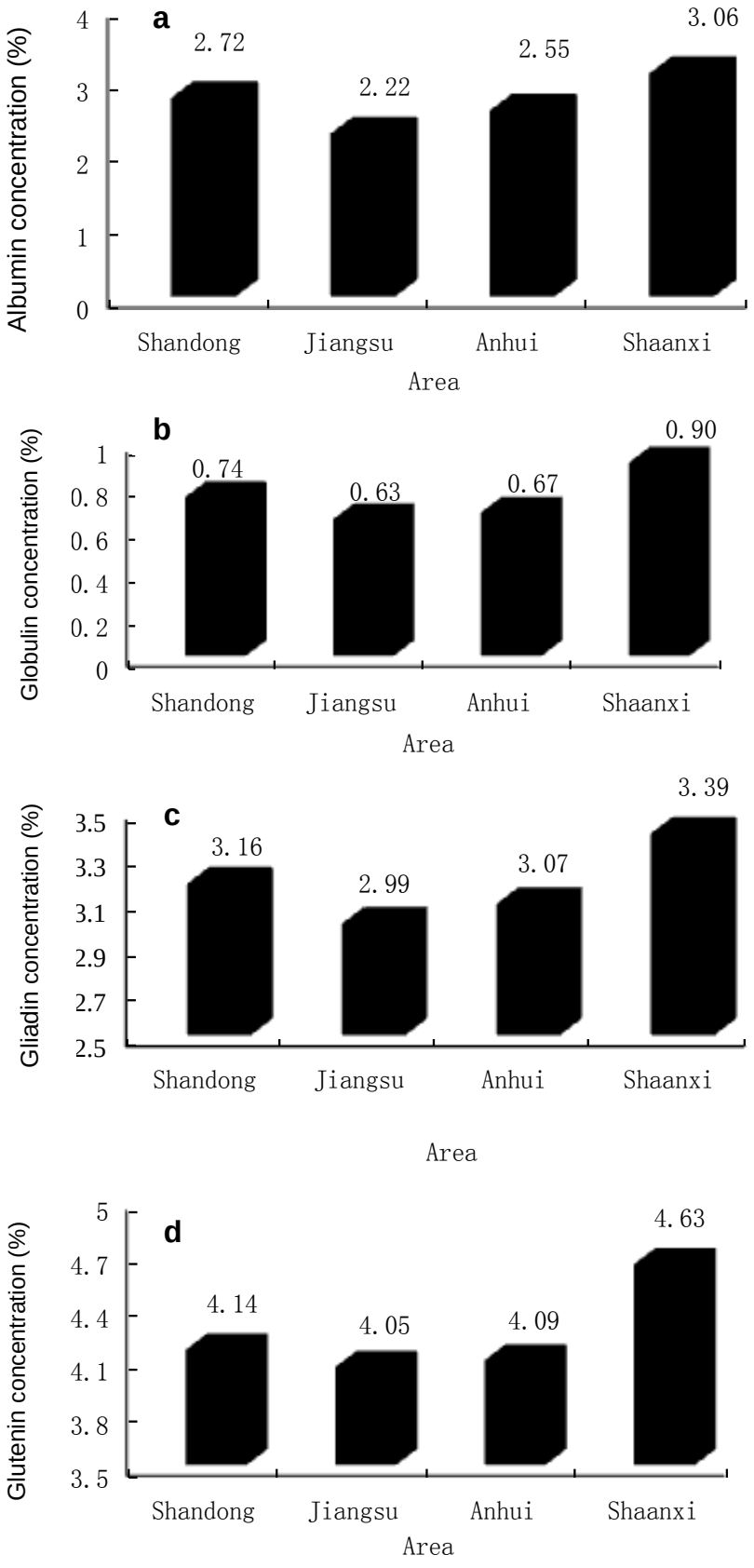

Figure 3. Protein compositions of Yannong 19 in different provinces: (a) albumin, (b) globulin, (c) gliadin and (d) glutenin.

areas, Shaanxi is a better choice.

Conclusions

The distribution of the protein components is as follows: the northern region > the southern region, the western region > the eastern region. Geographical conditions can affect the protein components of wheat, and gliadin and glutenin content can affect the wheat quality, so we can designate areas where wheat contains more gliadin and glutenin as our high-quality wheat producing areas, though Shaanxi is a better choice.

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