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GLUTEN PRODUCTION : ANALYSED IN TERMS OF VOLUME EXPANSION, EXTENSIBILITY AND RHEOLOGICAL CHARACTERISATION

Teuku Rihayat[1*] Puteri Helvina[1]
Department of Chemical Engineering, Lhokseumawe State Polytechnic, Lhokseumawe City
*Email : teukurihayat1007@gmail.com

ABSTRACT

Gluten is the protein in flour that gives the viscoelastic properties of dough. There are still inadequate understandings of the knowledge concerning gluten during the dough mixing and the unique properties that gluten posses. Gluten production was examined in terms of quantity and quality of gluten. Quantity of gluten was measured in terms of wet and dry gluten content. Wet gluten content was determined by weighing the gluten obtained from the dough washed under running tap water. The wet gluten was dried using air oven drying method to obtain dry gluten content. In terms of quality, the gluten was analysed in terms of volume expansion, extensibility and rheological characterisation. The volume expansion analysis was performed by frying the wet gluten in hot oil at 170^{o}C in deep fryer for 15 minutes. The volume of fried gluten was measured using mustard seed displacement method and the difference between the volume of fried gluten and the volume of wet gluten is measured as volume expansion of gluten.

Keywords : Gluten, rheological, wheat

1. INTRODUCTION

Gluten is the protein in flour that gives the viscoelastic properties of dough. During mixing of flour with water, the gluten fibrils formed spontaneously and extended from their surfaces into the surrounding water. As mixing proceeds, more proteins become hydrated and gluten tends to align and stretch into long chain network. When the starch was removed from the flour-water dough with water, a viscoelastic mass called wheat gluten was obtained. Even though the research on gluten quality has been covered for several years until now, the knowledge in this area is still in need of further work due to the lack of understanding of what really happen during the dough mixing and the unique properties that gluten posses.

The uses of wheat-gluten in industry have been intensely applied as commercial products in food (as breakfast cereals, crab analogues, meat substitutes) and non-food industry (as pet food, natural adhesives, biodegradable films) due to the unique cohesive properties of gluten (Day *et al.*, 2006). Wheat gluten has been first developed as meat substitute many years ago in China and is called *seitan*. *Seitan* becomes surprisingly similar to the look and texture of meat when cooked, making it a popular meat substitute (Hackett, 2007). It has low amounts of fats and carbohydrates, being almost nothing but protein (Anon., 2007d). It is most popular in China, East and other Southeast Asian countries. Nowadays, *seitan* has becoming one of the most popular vegetarian foods other than soy, tofu and mushrooms. In 2003/2004, the market for meat-free food is reported to have a growth about 6% per annum and is predicted to grow further in 2008/09 (Anon., 2007f). An increase number of vegetarians, strict and part-time, are reported since people prefer lighter and healthier food (Kuntz, 1995). They are not simply avoiding eating meats but most of them are looking for a healthier alternative for meat and also low-cost protein source. In Malaysia, more people are making the switch to a meat-free existence due to various reasons – cholesterol consciousness, a yearning to be fashionably thin, recent food safety scares or newfound concern for cows and other living creatures (Kaur, 2002). *Seitan* is given an advantage where it is easy and simple to be prepared, even in household, only by mixing the dough and wash it under running tap water to get the gluten. Adding some seasonings to the gluten to enhance the flavour, it is ready to be fried and consumed.

In recent years, the subject of gluten extensibility and its relationship with baking quality has become one of the common subjects covered in this area. So far, however, there has been little discussion about the relationship between the gluten quantity and its quality and also the gluten extensibility and its volume expansion. Therefore, this thesis is focusing into this little area and determines the correlation between the quantity and quality of gluten and also between the gluten extensibility and the volume expansion of fried gluten. There are still inadequate understandings of the knowledge concerning gluten during the dough mixing and the unique properties that gluten posses. The results from this thesis might be useful in the understanding of gluten properties and characteristics for food industry and researchers.

Gluten as meat substitute has become one of the popular choice for vegetarian. Its quantity and quality are the two measurements which ensure that it is acceptable to consumers. The main objective of this study is to determine the production of gluten in terms of quantity (wet and dry content) and quality (volume expansion, extensibility and rheological properties) by studying the: effect of processing parameter such as mixing time, effect of flour quality i.e. protein content and effect of additional ingredients such as water and salt levels.

2. RESEARCH OBJECTIVES, BENEFITS AND LIMITATIONS

The primary objective of this study is to investigate gluten, the protein in flour responsible for the viscoelastic properties of dough. Specifically, the research aims to determine the production of gluten in terms of quantity (both wet and dry content) and quality (including volume expansion, extensibility, and rheological properties). This will be achieved by examining various factors, such as processing parameters like mixing time, the quality of flour (i.e., protein content), and the effects of additional ingredients, such as water and salt levels.

The study highlights the benefits of contributing to a deeper understanding of gluten properties and characteristics, which are crucial for the food industry and researchers. The findings may aid in improving the quality and functionality of gluten-based products, particularly as meat substitutes, which are gaining popularity among vegetarians and health-conscious consumers. By determining the relationship between gluten quantity, quality, extensibility, and volume expansion, this study may lead to advancements in product development, offering alternatives that cater to the growing demand for healthier food options.

Despite its significance, the study acknowledges certain limitations. While research on gluten quality has been ongoing for years, gaps still exist in understanding the precise mechanisms during dough mixing and the unique properties of gluten. Additionally, the study's focus on specific processing parameters may not encompass all variables affecting gluten production and quality. Moreover, external factors such as regional differences in flour quality and consumer preferences could influence the applicability of the findings across different markets. Overall, while this research aims to fill existing knowledge gaps, it is essential to consider these limitations when interpreting the results.

3. RESEARCH METHODS

3.1 Materials

The materials used in this study were wheat flour of two types; strong and weak flour, salt and water. The details on raw materials and flour analyses are presented in this section.

Flour

Two types of wheat flour, Diamond N and SP-3, were supplied by Malayan Flour Mill Sdn. Bhd., Pasir Gudang, Johor Bahru. Later in this thesis, Diamond N and SP-3 is referred as ‘strong’ and ‘weak’ flour, respectively, based on the protein content of the flour. Table 1 shows the analysis of the flour.

The flour used was from the same batch of productions as per manufacturing batch number provided by the supplier. This was to avoid any possible effect of variation due to different batch of production conditions. The flour was kept in a freezer at temperature about -20^{o}C and tightly fastened in the sack once the sack was opened to maintain the flour moisture and other properties. It is important to avoid the flour from drying up after the sack was opened since it can affect the dough mixing characteristic. Prior to mixing, the flour was weighed 200 g and packed in air-tight containers.

Table 1: Flour analysis for strong and weak flour

TEST	FLOUR TYPE	
	Strong	Weak
Flour moisture, % (AOAC, 925,10,1990)	13.99	13.20
Protein, (N x 5.7) % (AOAC, 979,09,1990)	12.33	8.81
Ash, % (AACC, method 08-01)	0.56	0.49
Wet gluten, % (Glutomatic index)	32.0	23.7
Colour Grade Manual (Satake series 4)	1.70	0.63
Water absorption, %	63.4	59.5

Water and Salt

Table 2 shows the details of water and salt used for dough preparation. Treated drinking water was used to avoid any effect or reaction from other type of minerals on the protein of flour during flour-water mixing. Salt and water used were also from the same batch of productions as per manufacturing batch number printed on the pack or bottle respectively.

The amount of flour, water and salt used were calculated based on Bakers’ percentage; calculated based on 200 g flour used in this study. The amount of water and salt were determined using equations 1 and 2

Table 2: Details of water and salt used for dough preparation

Ingredients	Manufacturer	Remarks
Water	World Prominence Sdn. Bhd., Kuala Lumpur, Malaysia.	Treated drinking water. Water source: Treated pipe water supply. The temperature of water used was at room temperature.
Salt	Seng Hin Brothers Enterprises Sdn. Bhd., Rawang,Selangor, Malaysia.	Pure dry vacuum salt.

$$\text{Water(g)} = \frac{\text{Water(\%)} \times \text{Flour(g)}}{100} \quad (1)$$

$$\text{Salt (g)} = \frac{\text{Salt (\%)} \times \text{Flour(g)}}{100} \quad (2)$$

4. RESULTS AND DISCUSSION

Dough for quantity and quality analysis was prepared as described in this section.

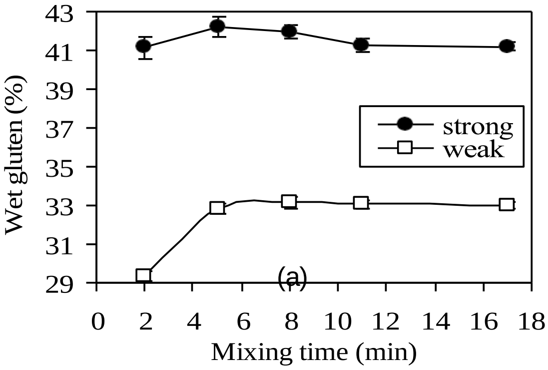
Figure 1 shows the viscoelastic mass of wet gluten obtained from washing of dough. Its physical feel and appearance were different from its dough. It can be stretched and returned back to its original shape in short time and its surface was not smooth compared to dough.

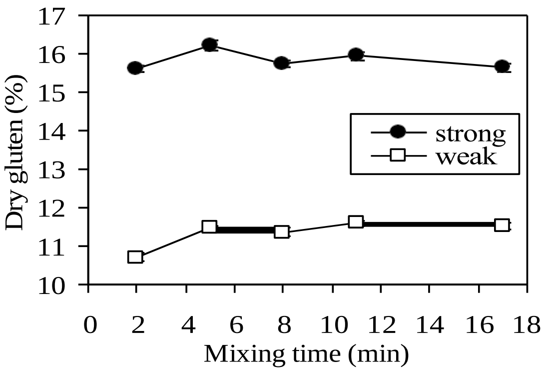
Figure 1: Gluten mass obtained after washing of dough

Some observations were noted during mixing and washing of dough to get gluten. During mixing, dough with high level of salt mixed into cohesive mass at shorter mixing time. Further mixing made it sticky to the bowl and hook. Stickiness was also observed for dough mixed at high water level which in agreement with report from Faubion and Hoseney (1989) that too much water added to the flour will result in slurry but too little water used produces cohesive powder. The combination of optimum water level with addition of salt in the mixing was observed to produce cohesive mass dough at shorter time compared to the one with no salt. One of the observations during washing of dough was that the strong flour dough has longer washing time than the weak flour due to the different starch and protein contents in the flour. Thus, it leads to the next observation where the wash water collected in the container for strong flour was more than for weak to obtain starch-free gluten. Another observation was that the addition of salt reduces the washing time for both flours.

Data was collected from the preliminary experiments and actual runs for wet and dry content analysis. The analysis of wet and dry gluten content consists of the selection of polynomial equation model, verification of the model selected and also analysis and discussion on the effect of mixing time, salt and water levels to the response.

Preliminary experiment was conducted to obtain a profile for the mixing time factor, get a consistency of experimental material, check on the experimental error and practice the technique to produce consistency results for wet and dry gluten content analysis. The profile test was conducted for the mixing time factor only with mixing period range from 2 to 17 minutes. 0 % salt and water level of 63.4 % (for strong flour) and 59.5 % (for weak flour) were used in this profile test. The preliminary experiments results obtained for wet and dry gluten content analyses were presented in Appendix B and also shown in Figure 4.2. Figure 4.2(a) shows that the wet gluten increased up to a peak and then decreased with increasing mixing time for both flours. The dry gluten content (Figure 4.2 (b)) showed similar trend as wet gluten content with mixing time, but less significant. This suggests that as mixing time increases the gluten is more developed and the network of protein linkages are bound stronger (Létang *et al.*, 1999).





(b)

Figure 4.2: Profile for (a) wet gluten content and (b) dry gluten content at various mixing times for strong and weak flour

CONCLUSIONS

The water level gave different effect on the quantity and quality of gluten depending on the amount of salt added and mixing time to develop the gluten. As water level increased, wet and dry gluten content increased with addition of 2% salt but decreased with addition of 8% salt. This shows that gluten content is affected by the water and salt level combination used during mixing of dough. Gluten volume expansion decreased with increasing water level for both flours but gluten extensibility increased as water level increased. However, for longer mixing time the extensibility decreased as water level increased.

This explains that gluten mixed for longer time has weaker strength due to overmixing effect. From the effect of mixing time, it can indicate the development of gluten. The optimum mixing time was indicated by the peak value of gluten volume expansion and also extensibility. This behaviour can be clearly seen in weak flour gluten but not in strong flour gluten. Mixing time, salt and water level affect the rheological characteristics. For strong flour, as mixing time increased, fracture strain increased, fracture stress decreased. With increasing water levels the four characteristics show an increase in value but decreased with increasing salt level.

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