Title

Studies on the Properties of Polymeric Glutenins Conferred by the Dispersion of Wheat Gluten under Acidic or Basic Condition

Author(s)

Murakami, Tetsuya

Citation

Kyoto University (京都大学)

Issue Date

2017-03-23

URL

https://doi.org/10.14989/doctor.k20430

Right

学位規則第9条第2項により要約公開; 許諾条件により要約は2018-03-22に公開

Type

Thesis or Dissertation

Textversion

none
Studies on the Properties of Polymeric Glutenins Conferred by the Dispersion of Wheat Gluten under Acidic or Basic Condition

—Abstract Version—

Tetsuya Murakami

2017
INTRODUCTION

Wheat flour can form a viscoelastic dough and a viscous batter when mixed with water. Dough is used for making bread, noodles, and cookies, while batter is used for cakes and coatings of various foods. These properties are attributed to gluten proteins in flour that hydrate and consequently form a network. The physical properties of gluten are so unique that no other plant protein possesses them (1).

Traditionally, gluten proteins have been divided into almost equal fractions according to their solubility in alcohol-water mixtures, typically 60-70% ethanol (2-4). The soluble fraction is gliadins and the insoluble fraction is glutenins. The major portion (about 80%) of the gliadin fraction consists of monomeric proteins with molecular weight in a range from around 30,000 to 55,000. Disulfide bonds are either absent (ω-gliadin) or present as interchain crosslinks (α/β-, γ-gliadins). The smaller portion (about 20%) of the gliadin fraction contains oligomeric proteins (under 100,000-500,000) linked by interchain disulfide bonds (3-7). This fraction has been called high molecular weight gliadin, aggregated gliadin or ethanol-soluble glutenin (8,9) and was shown to consist of α/β- and γ-gliadins (probably with an odd number of cysteines) and low molecular weight-glutenin subunits (LMW-GS). The glutenin fraction that is insoluble in alcohol-water mixtures consists of varying size with molecular weights ranging from about 500,000 to more than 10 million. They are mainly formed by LMW-GS and high molecular weight-glutenin subunits (HMW-GS) linked by interchain disulfide bonds (4,10-13). Regarding the physical properties, monomeric gliadin is responsible for viscosity and extensibility of the dough and polymeric glutenin is responsible for dough strength and elasticity (4,14,15).

Gluten isolated from flour and subsequently dried is commercially available as an ingredient to improve the quality of a variety of foodstuffs (16-20). Wet gluten containing approximately 75% protein (on dry matter basis) can be prepared by washing flour dough or batter to remove starch and water-soluble materials, such as albumin, globulin, and fiber. Gluten powder is produced from wet gluten that has been dried and then pulverized. Gluten powder is used in the manufacture of bread, noodles, cakes, cookies, sausage, fish cakes, cream, and coatings of various foods to enhance their appearance, texture, workability, and yield.

There are two main types of gluten powders utilized in the food industry worldwide, namely, flash-dried gluten and spray-dried gluten. Their industrial production process is shown in Figure 1. Flash-dried gluten is manufactured by drying wet gluten using a ring dryer, while spray-dried gluten
is produced by dispersing wet gluten in either acidic or basic (ammonia) solutions and then drying the dispersed gluten using a spray dryer (21). Spray-dried gluten prepared either in the presence of acid or ammonia exhibits dough properties that differ from those of flash dried gluten corresponding to general gluten. Spray-dried gluten is much more adhesive and extensible than flash-dried gluten. Moreover, the use of spray-dried glutens with interesting properties has been increasing for a number of applications. Nonetheless, only a handful of studies have characterized the molecular makeup of these compounds to date (22-25). Clearly, there is a need for further molecular characterization of spray-dried glutens to develop new applications for the food industry.

The author hypothesized that the unique rheological properties of the spray-dried glutens are attributed to the molecular characteristics of gluten proteins in a dispersion that is acidic or basic. In this study, gluten powders were prepared by dispersion under acidic or basic (ammonia) condition followed by lyophilization instead of a spray drying, and their viscoelastic dough properties and molecular characteristics were examined. This thesis deals with molecular characterization of gluten proteins that is responsible for the expression of their rheological properties in dough.

ABSTRACT

CHAPTER 1
Dispersion in the presence of acetic acid or ammonia confers gliadin-like characteristics to the glutenin in wheat gluten

Spray-dried gluten prepared via dispersion of gluten in the presence of acid or ammonia has unique dough properties that differ from those of flash-dried gluten corresponding to general gluten. The characteristic changes were detected in the dispersion process used for the preparation of spray-dried glutens. The glutens prepared by dispersion under acidic (acetic acid) or basic (ammonia) condition followed by lyophilization had weakened dough properties in terms of both resistance and elasticity, suggesting that these properties closely resembled those of gliadins. Moreover, many of the polymeric glutenins that were essentially unextractable became extractable with 70% ethanol like gliadins in the acetic acid- and ammonia-treated glutens.

CHAPTER 2

Molecular analysis of the polymeric glutenins with gliadin-like characteristics that were produced by acid dispersion of wheat gluten

The molecular characteristics of the polymeric glutenins with gliadin-like characteristics were elucidated when gluten is dispersed under acidic condition. When the gluten was treated with acid dispersion, its polymeric glutenins changed very little in molecular size distribution. However, the polymeric glutenins rich in HMW-GS, including y-types and/or 1Dx5, which essentially existed as strong aggregates, would be highly positively charged by acid dispersion and then disaggregated by ionic repulsion, regardless of their molecular size. This characteristic change occurred in more than half of the polymeric glutenins that were essentially unextractable with 70% ethanol. Their polymeric glutenins would stay disaggregated even in the gluten powder owing to the acid remaining after drying, and therefore became extractable with 70% ethanol like gliadins. This molecular behavior of the polymeric glutenins would result in the unique dough properties.


CHAPTER 3

Molecular analysis of the polymeric glutenins with gliadin-like characteristics that were produced by ammonia dispersion of wheat gluten

The detail will be published later.

CHAPTER 4

Structural changes in wheat gluten induced by dispersion in the presence of acid or ammonia

The detail will be published later.

REFERENCES


