Food Uses of Wheat Gluten

MARJA-LEENA SARKKI, Raision Tehtaat,
21200 Raisio, Finland

ABSTRACT

New separation methods for wheat gluten have increased production and made possible the use of mass wheat as a raw material. This widens the use of gluten in the fields where functional as well as baking properties are important. Solubility, swelling, viscosity and nutritional aspects of gluten are reviewed. The current applications of wheat gluten are mainly in baked products, breakfast foods, and meat analogs. Many chemical modifications of gluten have been developed. Modifications are not in use, but the increased gluten production will bring them into use.

INTRODUCTION

Fractionation of wheat into starch and gluten has been known since ancient times, when wheat starch was used in the production of papyrus, and fermented gluten as glue. In the separation processes developed in the seventies, pollution problems of the old production processes have been avoided. This should lead to increased use of gluten for food stuff as well as in technical use.

The Production and Uses of Gluten

Total production of wheat gluten is relatively small, ca. 120,000 tons a year. Only 0.2% of the wheat on earth is processed to starch and gluten. The biggest consumer of gluten is the U.S.A., utilizing 40% of the total production. Growth of convenience foods will provide an increased market for vital wheat gluten. Estimated annual market growth of vital gluten is 8%. Vital and undenaturated gluten is the most desirable and most suitable form of gluten in most uses and because of this, production of chemical gluten modifications has remained small.

Table I shows the main uses of gluten in the three largest producer countries. The main use in the United States and Australia is in the bakery industry, whereas in Japan processed meat, sausages, and fish foods traditionally are gluten utilization areas (1,2).

The Structure and Nutritive Value of Gluten

Wheat contains 10 to 14% protein, and the insoluble protein part of grain is called gluten, which represents about 80% of the grain protein. Gluten is composed from different components with regard to molecular weight and solubility, glutenin and gliadin. Both provide gluten with special characteristics; gliadin extensibility and glutenin elasticity (3) (Figure 1). When water is added to wheat flour, gliadin and glutenin form a tenacious colloidal complex.

The protein content of separated gluten is high, 75 to 80%, but as a typical grain product, gluten is low in lysine. In Table II a comparison is made between the amino acid composition of gluten and the FAO recommendation with regard to essential amino acids (4).

The nutritive value of gluten may also be evaluated (5,6) by the NPU-, BV-, and PER-figures which for gluten are N.P.U. – 38; B.V. – 58; and PER – 1.1. However, gluten is a typical additive in highly processed food, thus other food ingredients balance the necessary amino acids, or when necessary, the lack of these is compensated by supplementing with soy proteins on powdered milk.

Functional Properties of Gluten

Vital wheat gluten retains its characteristics in processing, because the most generally used methods of separation change neither chemically nor physically its characteristics. Only the drying conditions cause slight changes in the protein.

Solubility

The nitrogen solubility of native vital gluten is low throughout the pH range of 4-7. This is important for food systems (Figure 2). In a water solution, gluten forms a strong rubber-like gel. The low solubility of gluten has been attributed to its high molecular weight and the presence of interpolypeptide S-S bonds to the formation at highly stable aggregates by cooperative noncovalent interactions. An increase of ionic strength doesn't seriously affect solubility (Figure 3) (7).

Swelling

Vital gluten binds 1.5 to 2 times its own weight in water. Slight differences may be observed between different kinds

TABLE I

Production and Utilization Distribution of Vital Wheat Gluten in the United States, Japan, and Australia

	United States	Japan	Australia
Total Production, Million kgs	20	20	35
Utilization:			
Bakery industry	69		75
Breakfast foods	12		10
Pet foods	8		5
Meat analogs	4	30	
Processed meat	1	50	10
Hydrolyzed gluten		20	
All other foods	3		

TABLE II

The Contents of Essential Amino Acids of Wheat Gluten (g/16 g Nitrogen)

	Gluten	FAO Pattern
Lysine	1.8	4.2
Threonine	2.6	2.8
Methionine	1.9	2.2
Cystine	2.2	2.0
Valine	4.7	4.2
Isoleucine	4.6	4.2
Leucine	7.6	4.8
Phenylalanine	5.4	2.8
Tryptophan	1.1	1.4

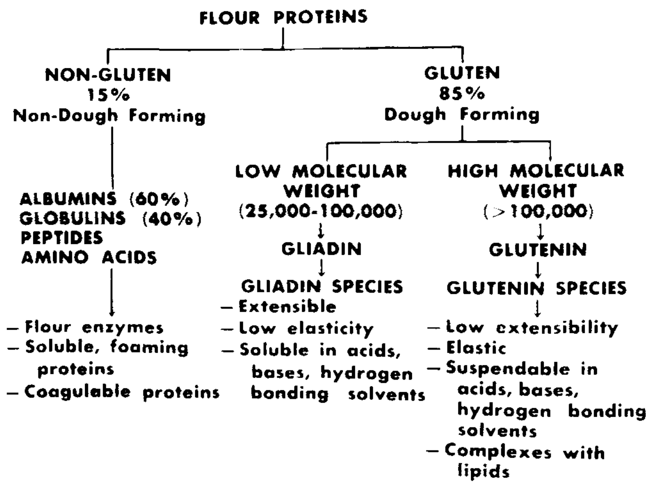

FIG. 1. Properties and composition of wheat flour proteins.

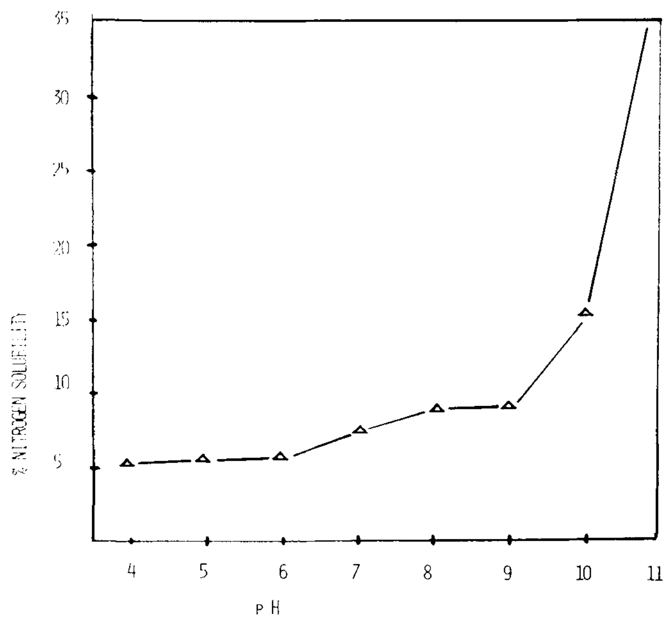

FIG. 2. Nitrogen solubility as a function of pH at ionic strength of 0.2 M NaCl, —△—Vital Gluten.

of grain and different separation processes. Figure 4 shows the maximum amount of water taken up as a function of dry sample weight. Devital gluten has a somewhat increased water uptake. This is due to the destruction of the protein net work and the increase of the amount of active water-binding groups during drying. As can be seen in Figure 5 and Figure 6, ionic strength and pH have very little effect on the water uptake of vital and devital gluten (7).

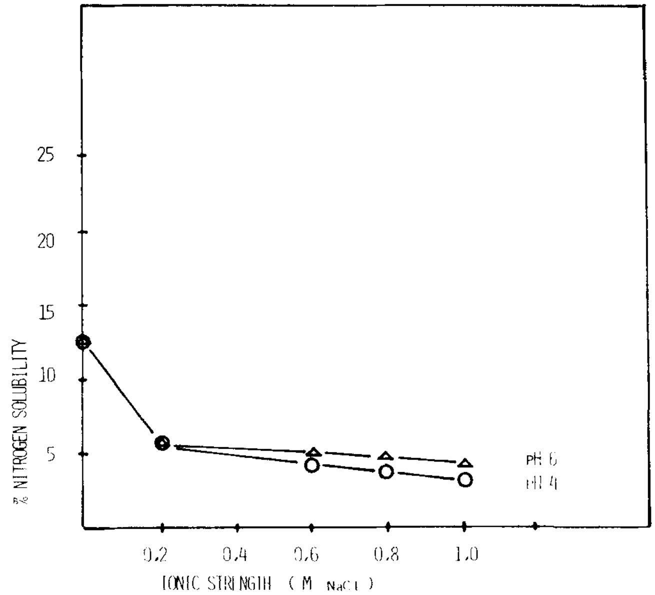

FIG. 3. Nitrogen solubility as a function of NaCl concentration of vital gluten.

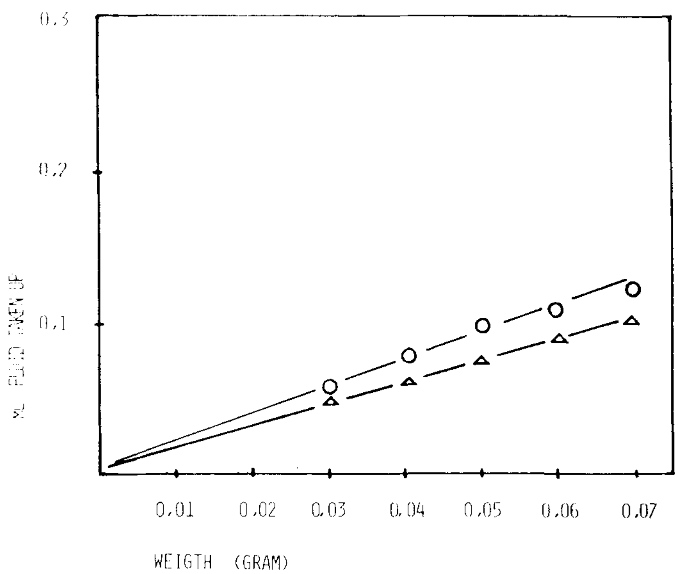

FIG. 4. Swelling as a function of sample weight measured by Baumann apparatus, —△—Vital Gluten, —○—Devital Gluten.

Viscosity Measurements

Swelling of protein molecules in a dispersion results in a viscosity increase. Figure 7 shows viscosity as a function of protein concentration in pure water for vital gluten. In over 10% concentration, the viscosity increases very rapidly due to the strong gel-forming property of gluten. Gluten doesn't disperse in water very easily, but forms large, insoluble gluten agglomerates (7).

Gluten Processing

The new processing methods for gluten are based on a centrifugal separation of starch and protein and on the agglomeration of gluten in a high protein compound, whereas in the older methods, starch is washed from a wheat flour dough with lots of water, and what is left is rubber-like glutinous gluten.

As an example of the new processes, the Raisio-Alfa Laval process can be mentioned. The basic principle of the process is simple and shown in Figure 8. Benefits of the process are: no waste water, processing in big units is

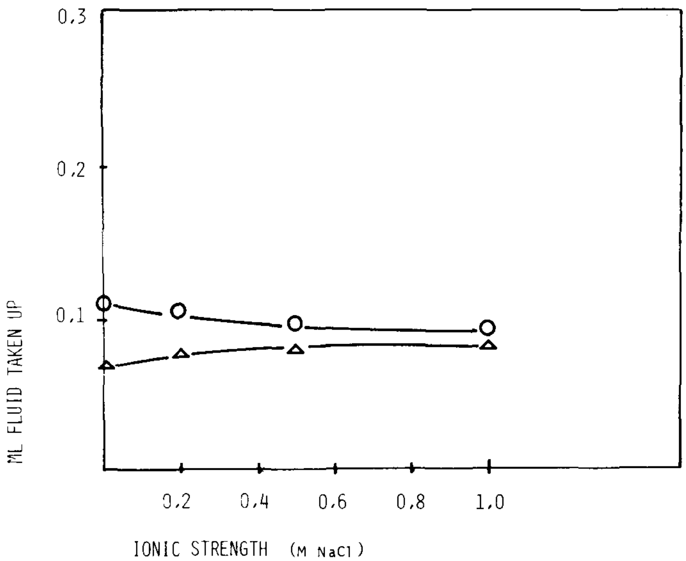

FIG. 5. Swelling as a function of ionic strength. —△—Vital Gluten, —○—Devital Gluten.

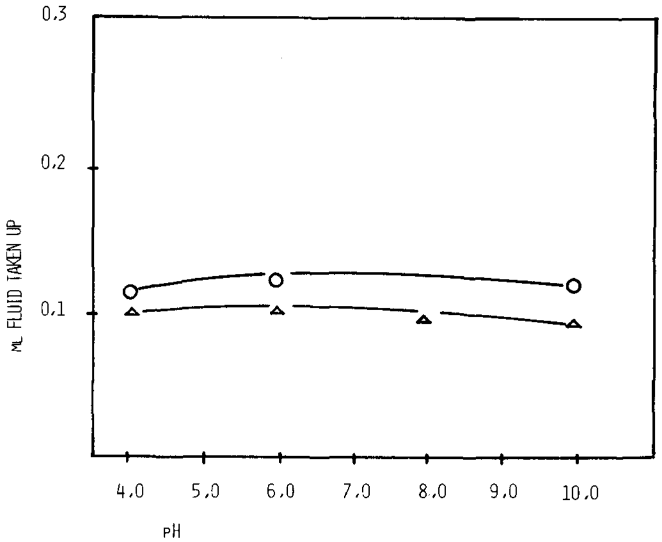

FIG. 6. Swelling as a function of pH Ionic Strength 0.05 M Buffert Sample 0.06G – △ – Vital Gluten, — ○ — Devital Gluten.

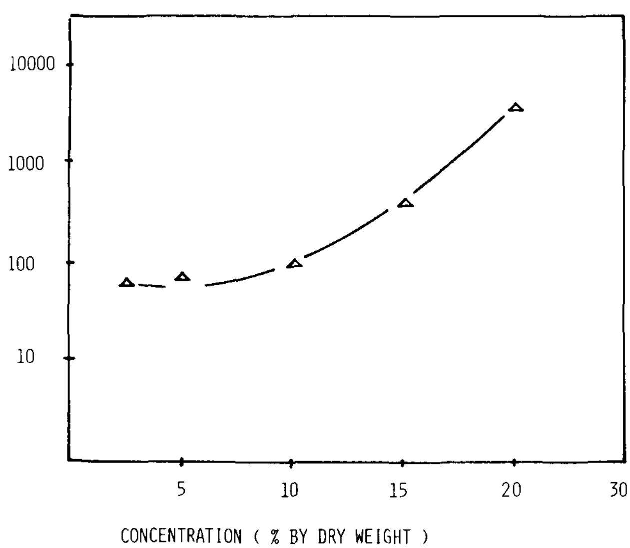

FIG. 7. Viscosity as a function of concentration. —△—Vital Gluten.

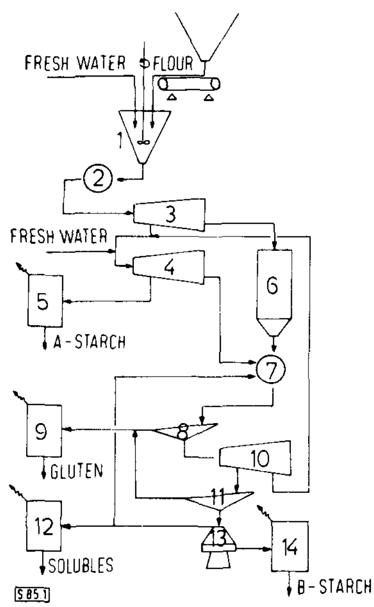

FIG. 8. Process flow diagram of the Alfa-Lava wheat process. 1. Premixer; 2. homogenizer; 3. decfuge; 4. decanter centrifuge; 5. pheumatic dryer; tank; 7. disintegrator; 8. vibrating screen; 9. pneu 10. decanter centrifuge; 11. vibrating screen; 12. 13. nozzle centrifuge; 14. pneumatic dryer.

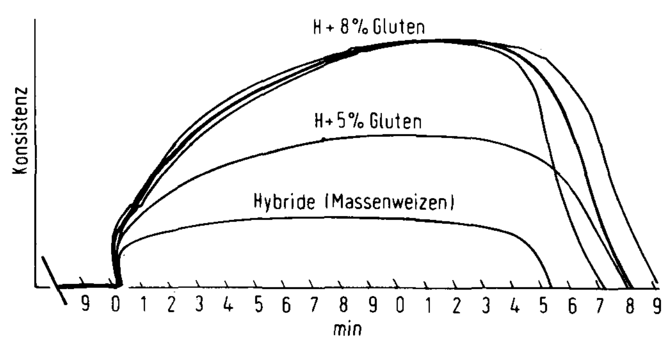

FIG. 9. Baking properties of "Massenweizen" by adding gluten.

possible, good vitality of gluten, no chemicals, and also the chance of processing species of nonbaking wheat varieties, as Triticale and mass wheat species (8).

Use of Gluten in Food

As a protein product processed from wheat, gluten is a natural raw material in baking, where an addition of vital gluten improves the visco-elastic characteristics of dough. The durability and gas retentive power of dough mixtures improve, and the tolerance of inert ingredients of dough increases, but the baking qualifications don't suffer from this. Even from mass wheat unsuitable for baking, the Raisio Alfa Laval method has produced gluten with baking properties.

In Figure 9 visco-elastic properties of mass wheat gluten are shown in the form of an extensogram (8).

The present demands for more wholesome nourishment have increased the use of gluten especially in high fiber breads and in special breads. Gluten is eminently suitable for use in production of meat analogs through extrusion, giving the products a meaty texture when chewed and a fibrous structure (9). In the extrusion products, the synergetic characteristics of gluten and soya have been technologically as well as nutritionally optimally utilized. The same synergy may be applied to other products as well, as for instance in ground meat products (10). Spray-dried mixture of monoglyserides and gluten improves dispersion of gluten in baking. Gluten is used as a good emulsifier and strengthener in cheese products.

Characteristics of gluten may be changed by chemical modification; the water-binding ability and solubility may be improved and thus the use of gluten may be expanded also in food applications. Examples of modificates are phosphorulated gluten, which binds as much as 100 times its own weight in water, and succinulated gluten, the solubility of which is very much higher than that of native gluten (11,7).

Nonfood Applications of Gluten

A number of nonfood uses for gluten have been proposed, as an adhesive gluten already has traditions in glue as well as in paper industries. These applications have economical interest at the moment as compared with the other protein glues. Gluten is also suitable for digestive base of chewing gum (12). The foaming properties of gliadin may be utilized, for instance in foam drying (13). The gluten film-forming properties make it possible to produce edible food films from it (14). Technical applications have not been used in industry yet but they will be brought into use with the growth of gluten production.

REFERENCES

1. Hall, J.B., Cereal Foods World. 22:144 (1977).
2. Burrows, V.D., A.H.M. Greene, M.A. Korol, P. Melnychyn, G.G. Pearson, and I.R. Sibbald, "Food Protein from Grains and Oilseeds. A Development Study Projected to 1980," Office of the Minister Responsible for the Canadian Wheat Board, 1972, p. 120.
3. Pomeranz, Y., L.F. Finney, Food Eng. 45:134 (1973).
4. Pence, J.W., et al., Cereal Chem. 27:335 (1950).
5. "Amino Acid Content of Foods and Biological Data on Proteins," The Food Policy and Food Science Service, Nutrition Division, FAO Rome, 1970, p. 167.
6. Woerman, J.H., L.D. Safferbe, Food Tech. 28:50 (1974).
7. Henriksnäs, H., Åbo Akademi, (To Be Published), 1978.
8. Dahlberg, B.I., Die Stärke 30:8 (1978).
9. Smith, O.B., S.C. Crocco, Food Eng. 47:24 (1975).
10. Svenska Institutet för Konserveringsforskning. Uppdrag 1549. Private study, (1976).
11. Olcoff, H.S. and A. Berkeley, Preparation of Gluten Phosphates, U.S. Patent 2,512,351, 1950.
12. Lutz, H.J., Chewing Gum and Method of Making the Same, U.S. Patent 2,586,675, 1952.
13. Spillers Ltd., Br. Patent. 911,281.
14. Krull, L.H., and G.E. Inglett, Cereal Sci. Today 16:232 (1971).