Enrichment of bread by adding oat flour and using transglutaminase enzyme

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ABSTRACT

In Iran, as well as many other countries, the staple food of the people is bread. Since most of the bread is made from wheat flour, enrichment and improvement of its nutritional quality is valuable. In recent years, many studies concerning compensation of nutritional deficiencies of traditional bread are carried out. One of the best and cheapest ways is using mixture of wheat flour with other cereals flour in producing bread. One of the cereals that can be used to enrich breads is oat.

The objective of the present study is to investigate the effects of transglutaminase (TG) on rheological and baking properties of bread. TG greatly improves the crumb texture of baked loaves and provides a potential solution to a common consumer complaint. TG also reduces the required work input and substantially improves the water absorption of the dough. Each of these effects would lower processing costs for commercial baking and higher quality of bread.

Keywords: Component; Transglutaminase Enzyme; Bread; Enrichment; Oat flour

I. INTRODUCTION

The bread making process involves the leavening of viscoelastic, extensible, gas-retaining dough [1]. The properties of this dough are attributed to the gluten proteins, which are hydrated and developed. Dough development is difficult to characterize; it is more than a simple blending process and requires special kind of mixing to produces a good gluten network. Bread making practices require oxidizing improvers to assist development and stabilize the developed structure. Oxidizing flour improvers are believed to have beneficial effects due to the oxidation of cysteine residues in gluten proteins to form disulfide bridges which crosslink and strengthen the protein [2].

In general, enrichment can be defined as adding improver and nutrition to flour and bread. The overall quality of bread can contain the size, tenderness of texture, color and flavor. Luckily, enrichment can significantly improve all of mentioned factors. Some of these roles are categorized in following paragraphs.

Role A) improving the volume and tenderness of bread: the volume and tenderness of the bread depend on protein of flour (gluten), in a way that losses of bread can be minimized by increasing in protein levels and at the same time its quality would enhance substantially.

Role B) improving the taste and smell of bread: by adding enzymes color, odor and flavor of bread can be improved. Enzymes, if strong enough, cause degrading gluten increasing fermentation time and ripping of the texture. Moreover, some important amino acids are created that they participate in browning reactions or Millard so smell and flavor of bread improve.

Role C) raising the nutritional value of the flour: another important application of enrichment is enhancing the nutritional value of flour and produced bread. Enrichment is a method for returning nutritional compounds again without changing the quality of yield bread [3].

II. ENRICHED BREAD

Wheat protein is poor from amino acids lysine, tryptophan and valine. In addition, grinding wheat into flour and baking it cause reducing certain amino acids such as lysine, alanine, and valine [4]. The aims of bread enrichment are:

- To compensate lost nutrients during process by adding them to the bread in cooking stage.
- To add nutrients to the bread due to insufficiency of them in bread
- To put nutrients available for the majority of people considering the existing deficiencies and shortcomings

The enrichment of bread means: increasing the nutritional value and improving its quality and organoleptic properties. It should be noted that firstly, the consumers should prefer enriched bread and secondly, the price increase should not be very noticeable [5].

III. Oats and its application in enrichment:

Oat is a cereal grain whose origins can be traced back to about 2000 B.C. in the Middle East and areas surrounding the Mediterranean Sea. Oat bran, possibly by virtue of its β-glucan content, exerts potentially beneficial physiological activity when consumed as part of the human diet. Chronic disease conditions, such as diabetes, atherosclerosis and digestive problems, appear to be improved by inclusion of more fiber in the diet [5].

The important nutritional attributes of oats relate to the lowering of blood cholesterol and sugar. Oat contains a high percentage of desirable complex carbohydrates which have been linked to reduced incidence of different kinds of cancers. The presence of total and free sugars in oats is very low in comparison with other cereal grains [6].

Whole-grain oats have the greatest percentage of fat among the major cereals with a good balance of the essential fatty acids, which are primarily unsaturated [5]. The high content of oleic and linoleic acid result in a favorable polyunsaturated to saturated fatty acid ratio of 2:2.

Oat flour also has antioxidant properties. In an equal weight basis, the purified oat antioxidant has effectiveness equal to that of commonly used commercial antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) [5].

Lipase, the major enzyme in oats, causes the rapid release of free fatty acids in damaged or milled oats which can result in off flavors. In industry, the action of lipase is controlled by heating the oat grains [7].

Oat also contains high amounts of biotin, thiamin, niacin and pantotenic acid. Oat flour has been shown to be a complex collection of volatile flavor components [7].

Oat protein quality is lower than animal protein, but it is more desirable than the other crops' protein. Oat protein has a high biological value and considering the fact that the Avenin-protein ratio does not change, its biological value remains constant by increasing protein amount. Some types of oat contain 20% protein. By eating oat, protein needs of infants can be provided. The products, enriched with oat isolated protein, are evaluated more favorable in sensory characteristics [8].

Emulsifier activity of oat protein is similar with wheat gluten and higher than soybeans proteins. Hydration capacity of oat protein is similar with soy protein and higher than gluten. Nitrogen heterocycles, formed from Maillard reactions and lipid oxidation products are the key compositional types of flavor volatiles. Heat induced from reactions of precursors native to the oat groat is primarily responsible for the development of oat flavor during its normal processing into commercial food products. Oat product's flavor stability depends upon lipid composition and resistance to oxidation. The flavor instability of oats correlates directly with the appearance of low molecular weight lipid oxidation products and specifically with pentanal, hexanal, 2, 4 decadien-1- als, and 3, 5- octadien-2-ones. In processing of oats for human food use, the hulls are removed and the interior portion is generally consumed. The main steps in oat processing are cleaning, hulling, steaming and flaking. Steaming of grains is one of the important steps for denaturing of enzymes. Otherwise, there would be a bitter taste in oat products. The two factors that differentiate oats from most other cereal ingredients are their whole-grain identity and their thermal processing requirement, which serve to limit their application potential [5].

In food industry, oat flour has shown positive effects on dough properties yielding a higher water absorption and dough development time and lower dough stability and extensibility compared with the wheat flour [9]. Oat's starch has properties of softening bread crumb. Oat bran, as a fiber source, enhances absorption of water in producing bread. Oat flour with high-protein increases dough development time. Adding oat flour to wheat flour in bread production increases water absorption of dough and reduces bread volume, also bread staling is delayed [10]. Oat flour addition at levels of 30% and 40%, also affects the texture of bread and produced undesirably soft bread with a bitter taste. Addition of 10% to 20% oat flour can provide acceptable breads. Furthermore, these breads have improved nutritional values and longer storage time along with acceptable softness and taste [5].

Since oat's protein is gluten-free, so using the oat flour in companion with wheat flour, in bread making, looks better. Therefore, to improve the texture and flavor of bread derived from mixture of wheat flour and oat flour and to compensate for the lack of gluten in oat flour, TG enzyme is used in processing bread. This is done because of the positive effects of this enzyme, compared with oxidative and traditional improvers during the baking process of bread. These effects are due to disulfide cross-linking of TG enzyme [11].

IV. Transglutaminase enzyme and its application in enhancement of bread properties:

TG enzyme, like most enzymes, is used as an aid in the process therefore is not under the scope of the rules and regulations of the additives and there is no need to talk about it. The active form of TG is an enzyme that connect protein compound to each other in food products. This connection, which is called g-l, creates a better texture and resistance of nutrient during the process. These connections are very stable and highly resistant against the effects of factors, such as pH changes and temperature variation. TG (protein-glutamine γ-glutamyl transferase) is a promising enzyme for the food industry as a protein modifier. TG catalyzes the formation of ε-(γ glutamyl-)-lysine crosslinks in proteins via an acyl transfer reaction [2]. This enzyme is an exchange of γ-glutamyl that naturally causes catalyzing of reaction between the groups of ε-amino lysine and a β-carboxyl group in glutamine that results a covalently cross-linking. TG enzyme is used in many industries including dairy, bakery and meat industry [12].

The TG enzyme shows great advantage as a processing aid in the bulk manufacture of bread. Addition of TG to weak and strong wheat flours influenced their rheological properties in different manners and to varying extents. At all levels, TG addition generally results in stronger dough properties, but superior handling properties are observed especially at lower addition levels (less than 0.5%). At lower TG addition levels, the quality of breads made with weak flour can be improved to a quality level that might be achieved with stronger flour. The improving effects are lower for strong flours. TG when added to dough induces synergistic beneficial effects on fresh bread quality and staling kinetics retardation. The binary combination leads to breads with softer and less chewy fresh crumbs, increased initial crumb cohesiveness and resilience, and slower crumb staling kinetics and sensory deterioration during storage, particularly for samples made with white flour [2].

The formation of protein polymers as the result of TG action can modify the rheological properties of gluten. It is found that addition of TG makes it possible to transform very weak gluten into a very strong one due to the effects of TG on rheological behavior. There are not enough Investigations on the effects of TG on empirical rheological properties (e.g., farinograph, extensigraph) and bread quality. Results from farinograph show decreasing of flour water absorption, with increasing TG levels. Dough development time and stability values initially increase with increasing between 0.5 to 1% of TG, but decrease at higher TG levels (1 and 1.5%). Extensibility values decrease significantly with increasing TG levels. Low levels of TG has improved effects on bread quality (crust and crumb characteristics), while higher levels (1 and 1.5%) has detrimental effects. Overall results indicated that TG, even at very low levels, could be successfully incorporated in the dough formulation to improve bread making quality. TG can improve dough elasticity and that it may produce beneficial effects during bread making that are similar to oxidizing improvers. It is well known that oxidants play an important role in the bread making process. Although addition of oxidants at optimum levels to dough normally results in improved dough handling properties and bread quality, excessive amounts might cause deteriorative effects. Since the effect of TG is suggested to be similar to that of oxidizing agents, it is expected that the addition level of TG will also have an effect on dough properties and bread quality [2].

In order to increase the elasticity, water holding capacity and other properties of pragmatism, TG protein in whey, soy, rice, casein, and Avenalin speeds up the forming of heterogonous and homolog polymers [12]. Thus TG enzyme increases improvement in texture of volume bread crumb and water absorption capability and also, at the same time, decreases the amount of required raw materials that all of these have a positive effect on reducing bread price [11].

Recent reports in the medical literature have implicated gut tissue TG in the reaction of celiac sufferers on exposure to wheat protein (gluten). The intestinal inflammation in celiac disease is caused by exposure to wheat gliadin in the diet and has recently been associated with an increase in the level of mucosal activity of TG. These observations are entirely consistent with earlier reports. Treatment of gluten with TG reduces its allergen effects. Thus, in addition to improving the functional properties of wheat-based products, TG may also have potential in the production of wheat-based foods appropriate for celiac sufferers [13].

V. RESULTS AND DISCUSSION

Farinogram curve shows characteristics such as water absorption percentage, dough development time, dough stability time and softening degree of dough. It can be seen in Table 1 that with the addition of 20 and 30% oat flour, flour water absorption increases. B-glucan in oat, due to its structure, has an important role in enhancement of water absorption ability. Generally, fiber-rich flour needs higher amount of water for mixing and has a higher ability in water absorption, this problem is exacerbated when fiber amount increases and this is because of presented hydroxyl groups in fibers which cause more water trapping. In addition, oat starch, in comparison with other crops, absorbs more water [11].

Dough development time is one of the other factors that can be obtained from Farinogram curve. No significant differences are observed in dough development time in mixed flour with wheat flour. Another result derived from Farinogram curve, is dough stability time. With increasing oat flour percentage, dough stability reduces and, in general, it can be understood that dough development time in wheat flour is higher than flour samples. This is due to the lack of gluten in oat flour and as a result, dough stability reduces, so adding oat flour in bread formulation, causes gluten thinning and consequently reducing the stability of the dough.

Softening degree of the dough, 20 minutes after the start of curve, shows that generally by adding oat flour, curve distances of 500 Brabender line and has reached from 70 units Brabender in wheat flour to a 100 units Brabender in mixed flour containing 40% oat, this is also due to the absence of gluten in oat. In this study, because of the use of TG enzyme this distance in the flour samples S1 (wheat + 20% oat + TG) and S2 (wheat + 30% oat + TG) dropped in comparison with wheat flour. Generally, adding oat flour and TG have not reduced baking quality of the dough, while they enhance nutritional and functional properties of bread.

Organoleptic evaluation of bread shows that an addition of 20% oat flour has not considerable adverse effects on people acceptance and produces acceptable bread. These results are in agreement with results provided by Shahedi et al [5].

Table1. Farinograph characteristics results of dough with different percent of oat flour.

Flour	average			
	water absorption (%)	***Stability (min)***	***degree of softening (Brabender)***	***farinograph quality number(FQN)***
Wheat	62.667	1.8667	133.67	36.667
S1	63.4	1.6333	129.67	40
S2	64.5	1.5	158.67	44.667

VI. CONCLUSIONS:

The characteristics of wheat flour and dough are modified to different extents by the addition of oat flour. Oat flour has shown positive effects on dough properties yielding a higher water absorption and dough development time and lower dough stability and extensibility compared with the wheat flour. Oat's starch has properties of softening bread crumb. Oat bran, as a fiber source, enhances water absorption of flour in producing bread. Adding oat flour to wheat flour in bread production was reduced bread volume. In fact, mixture of 20% oat flour with 80% wheat flour in bread production process has minimal adverse effects on the final product.

TG enzyme, as an improver of bread texture and bakery products is used. Low levels of TG (0.5%) has improved effects on bread quality (crust and crumb characteristics), while higher levels (1 and 1.5%) has detrimental effects.

An individualized optimum enzyme level should be estimated for any given flour sample to obtain maximum bread loaf volume and minimum crumb firmness values. This optimum level will, of course, depend on the flour quality of the sample itself. Overall results indicate that TG, even at very low levels (0.5%), can successfully incorporate in the dough formulation to improve bakery quality.

Organoleptic evaluation of bread shows that an increase of 20% oat flour has not considerable adverse effects on people acceptance and produces acceptable bread.

VII. REFRENCES

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