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Effect of Enzymes on Wheat Flour and Nutritional Quality

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Abstract – Wheat (Triticum aestivum) belongs to the family Poaceae or gramineae and genus triticum (Peterson et al, 2006). It was grown in the fertile region of the east, but now cultivated worldwide. It played an important role of religious significance and was part of the sacred rituals of many cultures. Greek, Roman, Sumerian and Finnish mythology had gods and goddesses of wheat. This exceptionally nutritious grain is still considered to be sacred in some areas of China (Proceedings of International Workshop on the importance of Sacred natural sites for Biodiversity Conservation, 2003). Wheat was introduced in the late 15th century when Columbus came to the New World. While wheat was grown in the United States during the early colonial years, it was not until the late 19th century that wheat cultivation flourished, owing to the importation of an especially hardy strain of wheat known as Turkey red wheat, which was brought over by Russian immigrants who settled in Kansas. Earlier, it was just picked wild, wherever it happened to grow. Around 10,000 B.C., people began to grow wheat for food. Gradually people made the wheat easier to grow and eat, by choosing the seeds of the best plants for the next years planting. They learnt different ways of cooking the wheat. They made porridge (like oat-meal) which is easy to cook and other times they made bread, which is harder to cook and needs more fuel, but could be carried around and kept it better than porridge, and tastes better.

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INTRODUCTION

Wheat is rich in nutrients needed by the human body. Starch, protein, fibre, vitamin B, vitamin E and minerals in wheat help to build and repair muscular tissue, digestion and provide energy (Kumar et al, 2011). The whole wheat, which includes bran and wheat germ, provides protection against diseases such as constipation, ischemic heart disease, obesity, diabetes and colon diseases. Wheat protein, which comprises as low as 8% of the grain, has a special benefit as it has eight of the essential amino acids in delicately balanced proportions. A complete internal rejuvenation takes place when wheat protein is metabolized into health-building amino acids.

Whole wheat flour contains about 82% starch, 12–14% protein, and 5–8% pentosans (Pomeranz, 1978; Pritchard et al, 2011). Starch is the major component of the wheat grain and its properties may affect the quality of flour and products derived from it. The starch consists of two types of glucose polymers, the highly branched amylopectin and the linear amylose. Pentosans originate in the endosperm of the cell walls of wheat grains. They play a key role in dough rheology and baking quality, because of their functional properties. They exhibit high affinity for water absorption and viscosity of dough (Rouau & Moreau, 1993).

Wheat flour contains various enzymes such as α–amylase and β-amylase, proteases, lipases, phosphatases and oxidases (Sahlstrom & Brathen, 1997). Amylase acts on starch resulting in increased proportion of low molecular weight fragments characterized by lower rates of retrogradation thus improving the baking quality (Palacios et al, 2004). Fungal α-amylase produces greater uniformity in dough properties and bread quality (Rouau et al, 1994). Pentosanases modify the functionality of pentosans during baking by reducing their water binding capacity thus inducing water redistribution in dough and lower the optimal amount of water needed for maximal gluten yield (Wang et al, 2004). Rouau et al (1994) reported that pentosanases incorporation at an optimal level improved the bread quality. Recently, Prabhasankar et al (2004) reported that addition of enzymes modify the rheological properties of dough and overall quality of parotta, the flat unleavened bread.

In the present study ten wheat varieties were evaluated for their physico–chemical and bread making quality. Further, effect of enzymes like amylases, xylanase, peroxidase and pentosans on the improvement of bread quality and its nutritional and nutraceutical properties were systematically investigated.

OBJECTIVES:

The objectives were as follows:

1. Physico-chemical properties, rheological properties of whole wheat flour and the overall quality of bread prepared from wheat cultivars used in this study.

2. To correlate the physico-chemical and rheological properties to the overall quality of breads.

Role of refined wheat flour components on quality of bread

Wheat dough as such is unique due to its visco-elastic property that makes the product more elastic, chewy and adds to its characteristic flavour. This sheeting property is mainly due to the type of protein present in flours. The quantity of flour protein (Schofield et al, 1992) quality of protein (Finney & Barmore, 1948) amount of gluten (Webb et al, 1971) proportion of gluten proteins (MacRitche et al, 1990; Orth & Bushuk, 1972) and the type of subunits especially high molecular glutenin subunits (Kolster & Vereijken, 1993; Payne et al, 1992; MacRitche, 1992) are all known to influence the quality of refined wheat flour dough and bread. The uniqueness of wheat lies primarily in its unique physical properties that are important to baking, the most important of which is the elasticity of its gluten. The quantity and quality of the gluten produced by any particular genotype of wheat are prime factors in determining the baking quality of the flour obtained from the milling process (Bushuk & Wrigley, 1974). Unlike any grain or plant product, wheat gluten has the ability to form a continuous film that retains carbon dioxide formed either by yeast or chemical leavening. Retention of the gas bubbles during leavening and baking allows expansion of dough and thermal setting of bread (Briggle & Curtis, 1987; Faridi & Finley, 1989). The water soluble proteins play a dual role of contributing to gas formation and modifying the physical properties of the gluten (Hoseney et al, 1969).

Textural properties of bread are attributed to the presence of pentosans in wheat. Water absorption and loaf volume potential in bread are governed by protein content and quality, pentosan content, their extractability and their interactions (Shogren et al, 1987). The pentosans are known to play an important role in water balance of dough (Jeleca & Hlynka, 1971) rheological properties of dough (Michniewiez et al, 1991; Luc Saulnier et al, 1997) retrogradation of starch (Gudmundson et al, 1991) and breadmaking quality (Delcour et al, 1991; Luc Saulnier et al, 1997). These pentosans compete with other constituents of the dough for water added to the flour (Izydorczyk & Biliaderis, 1995) and thus change conditions for gluten development resulting in lower gluten yield and an increased resistance of gluten against extension. This reflects in a lower extensibility of dough and gluten (Wang et al, 2002). Interaction between arabin-oxylans and proteins takes place during bread-making process in which changes in molecular weight distribution are observed (Cleemput et al, 1997). Pentosans also effect the gluten formation both physically and chemically. The physical effect is related to viscosity and likely to deplete attraction between protein particles. The chemical effect is related to ferulic acid mediated cross-linking of proteins and arabinoxylans. Pentosans cause a partial agglomeration of gluten and shift the glutenin macro-polymer particle size distribution in gluten to a higher value (Wang et al, 2004; Wang et al, 2003). Pentosans imbibe and hold water with the cross-linking density of the gel network and thus increase farinograph water absorption and dough development time (Jeleca & Hlynka, 1971; Cleemput et al, 1993; Vanhamel et al, 1993; Izydorczyk & Biliaderis, 1992).

Pentosans exert their functional role by means of their molecular structure, gelling capacity and influence water distribution and water availability and thereby influence loaf volume and in turn bread quality (Courtin & Delcour, 1998). On adding pentosans to dough, water absorption increased and dough development time decreased (Michniewiez et al, 1991) and brought about significant effect on the firmness of bread (Yin & Walker, 1992). Water soluble and insoluble pentosans change the properties of starch gel significantly, even if the amount added is very small. Water insoluble pentosans increase the elastic and viscous component of starch gels, implying that water insoluble pentosans have great capability to hold water and increase the starch concentration in the continuous phase, resulting in increased starch molecule reassociation. Water insoluble pentosans also increase starch rigidity. Water soluble pentosans bring about softening effect on starch gels (Sasaki et al, 2004).

RESULTS:

The results of this study are summarized below.

1. The damaged starch, total protein and total sugar contents in whole wheat flour in ten wheat varieties ranged from 12.3 to 17.6%, 11.6 to 14.6% and 0.84 to 1.41%, respectively.

2. Water absorption of whole wheat flour as measured in Brabender Farinograph, varied from 69.9% to 77.8%.

3. Gelatinization temperature ranged from 63.6ºC to 76.5ºC in the amylograph studies. The wheat variety GW-322 had the highest paste viscosity of 567 BU and cold paste viscosity of 809 BU.

4. Objective measurement of breads, like puffed height varied from 4.7 to 5.5 cm and shear force ranged from 4.2 to 8.5 N.

5. Moisture contents of control breads prepared from GW-322, NI- 5439, MACS-2496 and HD-

2781 varieties decreased by 4.6 – 6.0% on storage for 96 h. However, in breads prepared with enzyme treated dough the decrease in moisture contents was low. The moisture content of bread prepared from fungal α-amylase, bacterial α-amylase and combination of bacterial α-amylase and xylanase treated doughs decreased by 2.4 – 2.7%, 1.4 – 1.8% and 0.4 – 2.0%, respectively on storage for 96 h in all the varieties.

6. Breads prepared from the dough treated with bacterial a-amylase, xylanase, fungal a-amylase and combination of bacterial a-amylase and xylanase had sheer force of 2.4 to 2.8 N, 2.3 to 2.8 N, 3.2 to 3.8 N and 2.2 to 2.5 N, respectively, which were less than the control breads. This indicated that breads prepared from dough treated with enzymes yielded softer breads.

7. The overall sensory quality scores of control breads prepared from GW-322 and NI-5439 were 7.1 and 7.2, respectively, while the overall quality scores of breads prepared from enzyme treated doughs of these varieties increased significantly and their values ranged from 7.6 to 8.0. Thus, the results indicated that chapattis prepared from enzyme treated dough had better pliability and higher overall quality compared to control.

CONCLUSION

Ten wheat varieties were evaluated for their physico-chemical properties and bread making properties. Of these, DWR-162, DWR-39 and GW-322 varieties yielded highly acceptable breads. This was closely followed by those prepared from NI-5439, NIAW-34, K-9644, HD- 2501 and HD-2781. Varieties MACS-2496 and HD-2189 had low overall quality scores. The total protein content in these varieties ranged from 11.6 to 14.6%. The total protein content did not show any correlation to the tearing strength, puffed height or overall scores of the bread. Few studies indicate that wheat varieties having protein content of 9.5 to 10.5% were found to be more suitable for bread preparation. However, no such relation was observed in the present study. The present study indicate that total protein content of wheat alone may not govern the bread quality of a particular wheat variety, rather characteristics of protein and other major constituents of wheat may also contribute to the quality of bread.

Breads are generally consumed fresh, However, due to urbanization there is a need for ready to eat foods. Just like bread, breads are also known to stale on storage. Carbohydrates are the major constituents of wheat and starch constitutes about 80% and pentosans (arabinoxylans) constitute about 5-8% of the whole wheat flour. Changes in structural properties of these constituents may improve the quality characteristics of bread. Breads prepared from dough treated with amylases and xylanase yielded soft textured bread with improvement in overall quality and retained the same quality on storage for 96 h. The improvements in bread quality observed upon addition of amylases and xylanase may be due to changes in starch and pentosan properties, respectively. There is an increase in the soluble starch contents and also alterations in structures of starch granules in breads incorporated with amylases. Thus, the addition of amyalses and xylanase had improved the texture and shelf-life of breads.

In addition to improving the sensory and shelf-life of breads, treatment of amylases and xylanase had enhanced the nutraceutical and antioxidant properties of breads. Treatment of dough with amylases had increased the contents of soluble dietary fibre and polyphenols as well as antioxidant properties significantly, while treatment of dough with xylanase has increased antioxidant properties compared to control breads. Therefore, similar treatment with these enzymes may increase the content of nutraceuticals in other wheat based products also. Enzymes are preferred over chemicals as food additives to improve the quality of food products as they are natural and safe. As reported in the present study, additional benefit of improvement in nutraceutical properties will encourage the use of enzymes in food products.

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