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Products and byproducts of wheat milling process

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Abstract
Wheat crop is India's prime most staple harvest, placed second to rice. It is mostly consumed in the north-west parts of the country. Since it is rich in protein, vitamin and carbohydrate, it provides a balanced diet to the consumer. Wheat milling is the process of grinding whole wheat grain and is converted into flour. Wheat flour is the most important ingredient in home baking and is the framework for almost every commercially baked product and pasta. The grains available for the production of flour, wheat is unique. It is the only cereal grain with sufficient gluten content to make a typical loaf of bread without being mixed with other grains. This study of literature was focused on the wheat morphology and it's composition, wheat milling process, products and byproducts.

Keywords: Wheat, nutrition, milling process, flour

Introduction
Wheat is a farinaceous grass, known botanically as *triticum spp.*, is one of the most consumed cereal grains worldwide and makes up a substantial part of the human diet. It provides more nourishment (calories & proteins) for humans than any other single food crops. According to Statista 2013/2014, the global production volume of wheat amounted approximately 710 million metric tons, which has shown a 7.7% increment from the previous year. It is the second most important food crop in the developing world after rice. In sub-Saharan Africa, 14 countries produce wheat; Ethiopia and South Africa are the two major producers. Along with Teff, wheat and maize represent the three most important cereal crops in Ethiopia. Wheat is one of the various cereal crops largely grown in highlands of Ethiopia. It is produced largely in the southeast, central and northwest parts of Ethiopia (Karin & Leo, 2013) [3].

Morphology and composition of wheat
Wheat grains are generally oval shaped, although different types of wheat have grains that range from almost spherical to long, narrow and flattened shapes. The grain is usually between 5 and 9 mm in length, weighs between 35 and 50mg and has a crease down one side where it was originally connected to the wheat flower. The wheat grain contains 2-3% germ, 13-17% bran and 80-85% mealy endosperm (all constituents converted to a dry matter basis) (Sramkova *et al*. 2009) [9]. The wheat kernel consists of three fractions, the endosperm, bran, and germ, which are compositionally and morphologically very different. Thus, products will have different coarseness, textures, and color depending on the portion of the wheat kernel being used. Refined wheat flour is formed primarily from the endosperm of the wheat kernel. The endosperm comprises approximately 82% of the wheat kernel. The function of the endosperm is to provide energy for the embryonic plant during germination of the wheat kernel. The endosperm contains approximately starch and 10-14% protein (Korolchuk *et al*., 2005) [4]. Compared to the bran and germ, the endosperm contains low amounts of fiber, lipid, vitamins, minerals, protein, pigments and other phytonutrients. This helps give the refined wheat flour its consistent, fine, starchy texture and off- white color compared to whole-grain wheat flour. The bran consists of several cell layers and contains a significant amount of fiber. The bran includes the aleurone layer, which separates the endosperm from the bran layers. The aleurone layer is rich in proteins, vitamins and phytonutrients. The germ is rich in lipids, fiber, vitamins, minerals and phytonutrients. Thus, refined wheat flour, which is made primarily of endosperm is mainly starch and has limited amounts of fiber, proteins, lipids, vitamins, minerals and other phytonutrients (Korolchuk *et al*., 2005) [4].

The bran (outer layers of wheat grain) is made up of several layers, which protect the main part of the grain. In order to protect the grain and endosperm material, the bran comprises water-insoluble fiber. Chemical composition of wheat bran fiber is complex; it contains, essentially, cellulose and pentosans, polymers based on xylose and arabinose, which are tightly bound to proteins. These substances are typical polymers present in the cell walls of wheat and layers of cells such as aleurone layer. Proteins and carbohydrates each represent 16% of total dry matter of bran. The mineral content is rather high (7.2%). The two external layers of the grain (pericarp and seed coat) are made up of dead empty cells. The cells of the inner bran layer- aleurone layer are filled with living protoplasts. There are large differences between the levels of certain amino acids in the aleurone layer and those in flour. Glutamine and proline levels are only about one half, while arginine is treble and alanine, asparagine, glycine, histidine and lysine are double those in wheat flour (Cornell 2003) [1].

Milling process of wheat

The milling process of wheat produces large amount of wheat bran and germ as a byproduct. During milling, the endosperm is broken down into fine particles (white flour) bran and germ are removed. Wheat is a significant agricultural and dietary commodity worldwide with known antioxidant properties concentrated mostly in the bran. Wheat germ, being a byproduct of the flour milling industry, is reported to be one of the most potential and excellent sources of much-needed vitamins, minerals, dietary fiber, calories, proteins, and some functional micro-compositions at a relative low cost (Yiqiang *et al*., 2001 and Shao & LiYu, 2011) [10, 7]. In general from wheat milling industries release a byproduct of (25-40) % and these byproducts utilized for animal feed, bioethanol production, succinic acid production, like a blend for baked products as nutritional improvement, for cosmetics, meat substitute, neutraceutical/ pharmaceutical products and for many more others. Using by-products from wheat milling industries for value addition is accustomed in the developed countries like U.S.A for instance defatted wheat germ helps meet today's demands for full flavor grain-based foods that are rich in protein and fiber (Doty, 2012) [2].

Oil inside the wheat germ extracted using different mechanisms such as the common method organic solvent extraction (Hexane, Methanol, Chloroform- methanol, etc.) which recovers about 90% of the oil, by mechanical pressing, which recovers about 50% (Singh and Rice 1979) [8] or by using super critical extraction methods (85%). The extracted wheat germ oil from the former two mechanisms resulted in having lower free fatty acid and α-tocopherol content; in other word oil obtained by supper critical extraction can overcome these negative factors; in fact, the oils are solvent-free and do not need the traditional refining processes, and extraction yields are similar to those usually need to be refined (Panfali *et al*, 2003) [6]. The wheat grain contains significant level of natural antioxidants, mostly concentrated at the outer part. Wheat is an important agricultural commodity and a primary food ingredient worldwide and contains considerable beneficial nutritional components. Wheat and wheat-based food ingredients rich in natural antioxidants can ideally serve as the basis for development of functional foods designed to improve the health of millions of consumers (Kosik *et. al.*, 2014) [5]. Milling is the process used to grind wheat into flour. Flour is a value-added product derived from wheat, although rarely thought as a value added product today, because we seldom buy whole wheat to grind at home ourselves. The earliest methods of milling wheat was to find a large, sloping stone called a saddle stone and another smaller stone to hold in one's hand. The wheat berries were then ground between these two stones to create a rough form of whole wheat flour. A similar method of using a mortar and pestle was used at this time to grind wheat as well. These processes were very laborious and time consuming, and since the berries were very coarsely ground, they often wore down peoples teeth very rapidly. Methods of milling continued to evolve until the invention of the millstone which consisted of two large horizontal, disk-shaped stones, placed one on top of the other. The top stone turned while the bottom stone remained stationary while grain was fed in between. The millstone was powered by men, horses, oxen, and finally water or wind. Romans were believed to be the first to use water power for milling flour in about 100B.C.in Asia Minor. Windmills were developed nearly a thousand years after water mills. Their use was first recorded in Normandy and Provence, France in 1180 A.D.; Suffolk, England, in 1185 A.D.; and in Syria in 1190 A.D. The automated mill made its first debut around 1785 by Oliver Evans. The mill included screw conveyors that moved flour and wheat horizontally and bucket elevators that lifted the grain and its milled products, called grist. Other new machines cleaned the wheat for a purer flour. By 1808 Evans granted a license to use his mill improvements to Thomas Jefferson. By 1870, mills required fewer than three employees. Water powered two-thirds of all mills and steam powered the rest. In the middle of the 19th century with the development of harder wheat required the use of a new milling process.

In the process, the miller sets the stones wider apart to crack, rather than crush the wheat. The speed of the turning millstones was slowed at the same time. This reduced the heat of friction and ground and separated the wheat into bran and white flour by gradual reduction and repeated grinding and bolting. The flour processed was similar to modern extraction rates of 72-75 percent flour and 25-28 percent mill feed from a given weight of wheat. Three key changes in milling moved it into the modern age by the later half of the 19th century.1) The invention of the steam engine by James Watt in 1769, and its application to American milling in the 1870's.2) The replacement of millstones with two corrugated cylindrical steel rolls. Roller milling was in place in Minneapolis by 1878.3) the use of the middlings purifier, constructed by Edmund la Croix in Minnesota in 1865.

Products and by products of flour

Wheat flour is the most important ingredient in home baking and is the framework for almost every commercially baked product and pasta. The grains available for the production of flour, wheat is unique. It is the only cereal grain with sufficient gluten content to make a typical loaf of bread without being mixed with other grains. For example, for one to make rye bread a certain amount of wheat flour is usually present in the end product. Breads can be made without wheat flour but they are rather rare because the bread will not rise as high and therefore will be very dense.

All-purpose flour is a product of the ground endosperm of hard wheat or a combination of hard and soft wheat kernels. *Enriched all-purpose flour* has iron and B-vitamins (thiamine, niacin, and riboflavin) added in amounts equal to or exceeding that in whole wheat flour color. Chlorine also affects baking quality by "maturing" or oxidizing the flour,

which is beneficial for cake and cookie baking. The bleaching agents react and do not leave harmful residues or destroy nutrients. *Unbleached all-purpose flour* is bleached by oxygen in the air during an aging process and is off-white in color. Nutritionally, bleached and unbleached flour are equivalent.

Bread flour: is ground form the endosperm of the hard red spring wheat kernel. Bread flour is usually enriched and although similar to all-purpose flour, it has greater gluten strength and is generally used for yeast breads

Self-rising flour: is an all-purpose flour with salt and leavening added. One cup of self-rising flour contains 1 1/2 teaspoons baking powder and 1/2 teaspoon salt.

Cake flour: is milled from soft wheat and is especially suitable for cakes, cookies, crackers, and pastries. It is low in protein and low in gluten.

Pastry flour: has comparable protein, but less starch than cake flour. It is milled from a soft, low gluten wheat and is used for pastries.

Gluten flour: is processed from high protein wheat. It is used by bakers in combination with low protein or non-wheat flours. The increased amount of gluten improves baking quality and produces yeast breads of high protein content.

Semolina: is the coarsely ground endosperm of durum wheat. It is high in protein and is used to create high quality pasta products such as macaroni and spaghetti.

Durum flour: is a by-product in the production of semolina and is used for American noodles, some types of pasta and occasionally in specialty breads.

Farina: is the coarsely ground endosperm of durum. It is used to make hot breakfast cereals, most commonly known as Cream of Wheat.

Whole wheat flour: is flour produced from the entire berry of wheat. It includes coarsely ground bran and germ as well as endosperm in the mix. The presence of bran reduces the gluten percentage in the flour mix therefore whole wheat breads are often heavier than breads made from white flour. Whole wheat flour is rich in B-vitamins, vitamin E and protein and contains more trace minerals and dietary fiber than white flour. Since whole wheat flour contains so many minerals, it does not have to be enriched as white flour does. In most recipes, whole wheat flour can be mixed half and half with white flour to increase the gluten percentage. Graham flour is another term for whole wheat flour.

Bleaching agents used in flour

Flour bleaching agent is a food additive added to flour in order to make it appear whiter (freshly milled flour has a yellowish tint) and to oxidize the surfaces of the flour grains and help with developing of gluten. Usual four bleaching agents are organic peroxides, calcium peroxide, nitrogen dioxide, chlorine, chlorine dioxide, azodicarbonamide.

Chlorinated cake flour improves the structure forming capacity, allowing the use of dough formulas with lower proportions of flour and higher proportions of sugar. In biscuit manufacturing, use of chlorinated flour reduces the "spread" and provides a tighter surface. The changes of functional properties of flour proteins are likely to be caused by their oxidation.

Flour treatment agent: Graham flour- an early unbleached whole grain flour,

: Maida flour-a commonly bleached flour in India

Fortified Flour

In developed countries, wheat flour is generally fortified with vitamins B1, B2, niacin, and iron. In some countries calcium and folate are also added. Vitamins A and D can also be added to flour. The levels of vitamin B1 niacin, and iron added to wheat flour is often equivalent to the amount lost in milling, i.e. these micronutrients are restored and the flour is enriched. For other micronutrients such as vitamin B2, the amount added is over and above that lost in milling, i.e. the flour is fortified.

The technology for fortifying flour is simple. First, a premix of the micronutrients to be added is needed The advantage of using a premix over that of adding micronutrients singly is that there is a greater likelihood of ensuring, the correct concentration of micronutrient and an even distribution of micronutrients The fortification process itself is accomplished by adding the micronutrients through a volumetric feeder located towards the end of the milling process. The most commonly used feeder consists of a rotating feed screw that is driven by a variable speed motor. The screw rotates inside a chamber containing the premix and pushes the premix through an outlet spout. The amount of premix added to the flour can be modified by changing the motor speed. The concentration of premix added to the flour can be calculated by weighing the amount of premix deposited by the feeder in one minute divided by the volume of flow passing underneath in the same period of time. The premix can be either fed directly into the flour by gravity or by air convection using a pneumatic system. The homogeneity of micronutrients in fortified flour is largely dependent on the location of the feeder and it is very important that the mixing of the micronutrients with the flour is good.

Whole Wheat Flour

Whole wheat flour is a powdery substance, a basic food ingredient, derived by grinding or mashing the whole grain of wheat, also known as the wheat berry. Whole-wheat flour is used in baking of breads and other baked goods, and also typically mixed with other lighter "white" unbleached or bleached flours (that have been treated with flour bleaching agents) to restore nutrients to the white flours, and body that are lost in milling and other processing to the finished baked goods. The word whole refers to the fact that all of the grain (bran, germ and endosperm) is used and nothing is lost in the process of making the flour. Whole-wheat flour is a full-flavored flour containing vitamins, minerals and protein. It is also a good source of calcium, iron, fiber, and other minerals.

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