

Oats and Rye: Production and Usage in Nordic and Baltic Countries

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Nutritionists worldwide recommend an increased consumption of whole grain products and dietary fiber. Rye and oats are excellent raw materials for healthy and tasty foods and both cereal types are rich in dietary fiber. The Nordic Innovation Centre (NICE) is the Nordic Council of Ministers' instrument for promoting an innovative, competitive, and knowledge-intensive Nordic business sector. In 2006, NICE founded a three-year project entitled "Wholegrain, rye, and oat—Nordic opportunity," short name "Granity," to promote the use of rye and oats in Nordic and Baltic countries. Granity is a collaborative project between scientists and cereal industries in Finland, Norway, Denmark, and Sweden. One of the aims was to collect information about the production and use of rye and oats. The collected information is presented in this paper.

In 2006, the European Union (EU) used 7 million tons of rye and 8.4 million tons of oats; of which, 41.9% of rye and 16.7% of oats were used for food. In comparison, the EU used 115.9 million tons of wheat; of which, 39.6% was for food.

Of the Nordic and Baltic countries, Estonia has the highest rye consumption (29 kg per person) and Norway the lowest with 7.2 kg per person. All Nordic and Baltic countries are above the EU's average of 6.1 kg per person. To increase the usage of rye, new products are developed, such as rye bread mixes, pasta products, mixtures of rice and steel-cut rye served as a side dish, rye as an ingredient in casseroles and salads, and rye hamburger buns.

The EU oat consumption average is approximately two times lower than for rye. Belarus has the highest oat consumption in the world with 9.0 kg per person, followed

by Latvia (7.0 kg per person), Denmark (5.0 kg per person), and Finland (4.0 kg per person). For oats, new usages include as a constituent in granola bars, waffle and pancake mixes, and oat-based beverages; a thickening agent in soups and sauces; and a meat extender and fat replacer.

Rye Production and Consumption

In 2006, total world production of cereal grains was about 2,228 million tons and approximately 0.5% or 12 million tons of this was rye (2). Rye (*Secale cereale*) is primarily a crop of temperate regions, although it may be used as feed in semi-tropical regions. Most of the rye production takes place in the northern part of the area between the Ural Mountains and the Nordic Sea (4). The Russian Federation, Germany, and Poland each produced 2.9, 2.6, and 2.6 million tons of rye, respectively, followed by two other producers: Belarus (1.0 million tons) and the Ukraine (0.5 million tons). In 2006, the combined production of these five countries represented 80% of the world's production. Rye is the most cold resistant of the common cereal crops and is therefore used instead of other cereals in some areas of Canada, Scandinavia, and Siberia.

Of the total rye production (6,771,000 tons) in the EU, 8.1% was produced by the Nordic and Baltic countries. The Baltic countries Estonia, Latvia, and Lithuania produce 282,000 tons of rye, which is approximately 6% of the total cereal production in these countries. In comparison, rye production in the Nordic countries (Sweden, Norway, Denmark, and Finland) was 2.0% of the total cereal production. Of the Nordic and Baltic countries, Denmark, Latvia, and Sweden have the highest rye production, more than 115,000 tons per year and Norway has the lowest (18,000 tons per year) (1,5). Table I shows that of

- Oats and rye are whole grains that are excellent raw materials for healthy and tasty foods and both cereals are rich in dietary fiber.
- The consumption of oats and rye is low in Nordic and Baltic countries compared to wheat.
- To increase the consumption of oats and rye in Nordic and Baltic countries and other areas of the world, e.g., the European Union, Asia, and North America, new products must be developed and more collaboration between scientists and the cereal industry is needed.

the 7 million tons of rye used in the EU, 42% is used as food. The human consumption of rye increased slightly during the 1990s even though the total rye production decreased. The consumption of rye in the world is approximately 6 million tons or about 50% of total production.

All of the Nordic and Baltic countries have higher rates of rye consumption than the EU (6.1 kg per person) (Tables II and III). The rye consumption in the EU is 15.2 times lower than wheat (Table II). Estonia has the highest rye consumption with 29 kg per person and Norway has the lowest with 7.2 kg per person (Table III). In the EU, Poland has the highest rye consumption with 35.3 kg per person. The most dramatic change in rye consumption is observed for the Baltic states Estonia and Lithuania (Table III). In Estonia, the rye consumption increased from 21 kg per person in 1995 to 29 kg per person in 2003. For Lithuania, an opposite trend was observed with a dramatic decrease from 45 kg per person in 1995 to 13 kg per person in 2003. For other countries, the annual consumption of rye is quite stable, although small fluctuations can be observed (Table III).

Table I. Cereal consumption in the European Union 2006^a

Cereal	Total Usage (1,000 tons)	Human Consumption (1,000 tons)	Human Consumption (Percent of Total)
Wheat	115,900	45,900	39.6
Rye	7,055	2,955	41.9
Barley	52,730	350	0.6
Oat	8,455	1,410	16.7

^a Eurostat (1).

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Oat Production and Consumption

Oats have been grown for thousands of years mainly as an animal feed crop, but during the 19th century, oats won acceptance as part of the human diet. Oats belong to the grass family *Gramineae*. The most cultivated oat species in the world are *Avena sativa* L. (common covered white oat). A variety of *A. sativa* (*A. sativa* var. *nuda* [a naked variety]) is commonly cultivated. This has a hull that is loosely attached to the groat and can be easily removed during threshing. This character gives rise to the term "naked." These varieties have good grain quality, but are more prone to mechanical damage than covered oats. Furthermore, naked oats generally have lower yields compared with covered varieties. Oats can be grown on many different soil types and are therefore considered to be one of the most versatile cereals.

In 2006, 16.7% or 1.4 million tons of oats was used as food in the EU (Table I); the rest was used as feed. In 2003, the Russian Federation had the highest oat production (4,569,000 tons), followed by Canada (3,333,800 tons), the United States (1,669,250 tons), and Poland (1,311,378 tons). Nordic and Baltic countries produced 2,553,000 tons of oats in 2006 and the EU produced 11,520,000 tons, which was 22.2% of the oat production in the EU (1,5). Of the Nordic and Baltic countries, 42% of the oats is produced in Finland, 26% in Sweden, and 11% in Denmark. Although the total production of oats has diminished, its use as food for humans increased slightly during the 1990s. In 2003, the food consumption of oats in the world was about 3.2 million metric tons, which is about 12% of total production (2).

In the EU, human consumption of oats is 2.8 kg per person, which is 3.5 times higher than barley, 2.1 times lower than rye, and 33.2 times lower than wheat (Table II). In Latvia, Lithuania, and Denmark, oat consumption has increased, and for Finland, Sweden, Estonia, and Norway, oat consumption decreased during the last decades (Table IV). Belarus has the highest consumption of oats in the world with 9.0 kg per person. Of the Nordic and Baltic

Table II. Annual cereal consumption as food in the European Union^a

Cereal	Human Consumption (kilograms/person) per Year		
	2004	2005	2006
Wheat	90.8	90.3	93.1
Rye	6.3	5.6	6.1
Barley	0.7	0.7	0.8
Oat	3.1	3.0	2.8

^a Faostat (2).

countries, Sweden has the lowest consumption of oats (1.0 kg per person) and Latvia the highest (7.0 kg per person). Only Finland, Denmark, Latvia, and Lithuania of the Nordic and Baltic countries have higher rates of oat consumption than the EU's average of 2.8 kg per person (Table II).

Oat Products

The processing of oats is essentially done in order to produce oat-based products with attributes that will attract consumers. This involves the main steps: cleaning, heat treatment, dehulling, cutting, and flaking (milling). Oats contain high levels of lipids which can be hydrolyzed to fatty acids by lipolytic enzymes found in the oat grain that cause rancidity due to further oxidation of the final oat product. This is the reason why oats for human consumption are heat stabilized in order to inactivate lipases and to obtain oat aroma. Oats without hull are called groats. During the flaking of oats, steam is added to increase the moisture content in order to soften the groats so that they can form flakes with minimum breakage. The flak-

ing of intact oat groats produces rolled oats that are the thickest of the standard oat-flake products which are about 0.5 to 0.9 mm thick. The thicker flakes require longer cooking periods and maintain flake integrity for extended periods (6). By cutting the groats into pieces, thinner flakes can be produced, usually 0.25 to 0.60 mm thick, and these thinner flakes require less cooking time. Thinner flakes are often used for instant oatmeal. Oat flour can be produced by milling oat flakes or groats using a special hammer mill where exhaust air is drawn through the system to prevent the relatively high-fat flour from sticking to the sieves of the mill. Oat flour is used as an ingredient in a wide variety of food products. Oat bran is the food produced by grinding clean oat groats or rolled oats. The resulting oat flour is separated by sieving, bolting, and/or other suitable means. A fraction such as oat bran is not more than 50% of the starting material and has a total beta-glucan content of at least 5.5% (dry weight basis) and a total dietary fiber content of at least 16.0% (dry weight basis). Due to this, at least one-third of the

Table III. Annual rye consumption as food in the world and in several individual countries^a

Area/Country	Rye Consumption (kilograms/person) per Year				
	1985	1990	1995	2000	2003
World	1.8	1.2	1.4	1.0	1.0
Poland	56.8	32.4	32.0	36.1	35.3
USSR	8.4	3.8	-	-	-
Former USSR	-	-	12.1	8.9	8.9
Finland	20.4	17.7	15.8	15.7	14.8
Denmark	20.4	18.4	15.5	13.2	18.2
Sweden	14.8	11.7	9.0	12.7	12.4
Norway	8.9	9.2	7.4	7.2	7.2
Estonia	-	-	21.0	32.0	29.0
Latvia	-	-	17.0	17.0	16.0
Lithuania	-	-	45.0	19.0	13.0
Germany	21.6	14.4	12.5	10.7	10.7
Canada	0.5	0.5	0.5	0.5	0.6
U.S.A.	0.2	0.4	0.3	0.3	0.30
China	1.0	0.8	0.5	0.2	0.1

^a Eurostat (1).

Table IV. Annual oat consumption as food in several individual countries^a

Area/Country	Oat Consumption (kilograms/person) per Year				
	1985	1990	1995	2000	2003
Poland	1.0	1.0	0	0	1.0
USSR	-	-	1.0	1.0	1.0
Former USSR	1.0	1.0	-	-	-
Finland	5.0	5.0	5.0	3.0	4.0
Denmark	3.0	2.0	4.0	5.0	5.0
Sweden	3.0	4.0	2.0	1.0	1.0
Norway	5.0	6.0	5.0	3.0	2.0
Estonia	-	-	16.0	2.0	2.0
Latvia	-	-	1.0	1.0	7.0
Lithuania	-	-	0	2.0	3.0
Germany	3.0	2.0	2.0	2.0	2.0
Canada	2.0	2.0	1.0	0	0
U.S.A.	2.0	5.0	4.0	3.0	3.0
Belarus	-	-	10.0	9.0	9.0

^a Faostat (2).

total dietary fiber is soluble fiber. To produce oats for instant baby foods, rolled oats are milled and mixed with water, drum dried, and the thin film formed in the extract is milled and put into products.

The primary food products produced from oats are based on heating the cereal materials. Oatmeal is consumed on a worldwide basis, but North America, the United Kingdom, and northern Europe represent the principal markets. Cold plate cereals or ready-to-eat (RTE) products represent the second major use for oat products. The high fat and fiber content of oats limit the utilization of oats in this application, but a number of economically important products have been successfully introduced into the marketplace. Oat products are used as ingredients in a wide variety of bread and other baked products. These ingredients provide unique flavor and moisture retention characteristics, as well as enhance the nutritional benefits of the products. Oatmeal or oat flour is a major component of infant foods. In many instances, this is the baby's first introduction to solid foods (3,6). Oat flour is a major constituent in granola bars and waffle and pancake mixes. It is used as a thickening agent in soups and sauces and as a meat extender and a fat replacer. Beverages based on oats are quite new products.

Oat bran is consumed as a heated cereal and is a main ingredient in many RTE formulations. Additionally, oat bran is used in a wide variety of bread, granola, and cookie products. Oat bran's popularity is due to the recent recognition of the prevention of coronary heart diseases by dietary beta-glucan.

Rye Products

Most of the world's rye grain is consumed by humans as bread, but many so-called rye breads contain only a low percentage of rye. In Finland, Denmark, Russia, and the Baltic countries, whole grain rye bread is the most typical rye bread. Whole grain rye flour contains a lot of enzymes, which under a normal baking process hydrolyzes the constituents of the rye flour. This makes it almost impossible to bake bread with only rye flour. The solution is the addition of sourdough which lowers the pH in the dough and reduces the effects of enzymes. A sourdough is a mixture of whole grain rye flour, water, and starter culture which are left to ferment for 8–18 hours at 30°C. To reduce the fermentation time, a specific lactic acid bacteria mixture or a part of the previous fermentation is added as starter culture. After fermentation, the sourdough contains increased amounts of lactic acid bacteria, sourdough yeast, and different

aroma components. To make the final dough, more rye flour, water, and other ingredients are mixed with the sourdough. After mixing, the dough is rested for a short time, divided, put in pans, proofed, and finally baked. Rye flour does not contain gluten, and it is the soluble fiber fraction in combination with the sourdough technology that makes it possible for the rye dough to keep the gas from the yeast and increase in volume (4).

In Sweden, one-third of rye bread is consumed as the popular hearth bread (40% rye flour). The rye flour that is used has an extraction rate of about 80%, which means that 20% of the rye kernel is taken away during the milling process. Crisp bread is a traditional rye bread product from Sweden that is normally baked using whole grain rye flour and leavened with or without yeast. It is very popular in the Nordic countries because of its light weight and transport-friendly shape. If stored under dry conditions, it will stay fresh and edible for a long time.

As for rye, rye kernels can be used to produce different types of rye flakes, which are used in baking, for cooking porridge, and in breakfast cereals. Rye flakes are an important ingredient in breakfast cereals and the content can be as high as 55%. To have the right structure and mouth feel, rye flakes are precooked and sometimes extruded to increase crispiness and taste. Baking whole grain rye bread using sourdough technology is very time consuming and special equipment is needed.

Therefore, to increase the usage of rye and to make baking easier at home and in commercial kitchens, rye bread mixes containing natural sourdough or sourdough in dry form are produced. In many products, rye adds color and taste. To increase their health profile, two Finnish fast food chains have started adding rye flour to their hamburger buns and created the concept of "rye burgers" (4).

Much more collaborative work is needed between scientists and the cereal industry in order to increase the use of rye and oats. This is crucial in the countries where rye and oats are eaten traditionally, but also within potential new markets in the EU, Asia, and North America.

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