FoodDrinkEurope - Fedima

Technical Toolkit & Guidelines to increase Whole Grains in Bread

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1. Introduction

1.1 Background

Food and drink are essential to European culture and daily life, providing both nourishment and enjoyment. Dietary balance, which is providing the appropriate variety and quantities of food to support health and well-being, is an ongoing focus. The food and beverage business serves 1.5 billion meals every day across Europe, providing a chance to assist consumers in obtaining or maintaining balanced, healthy, and sustainable diets.

In its 2022 Action Plan for Sustainable and Resilient Food Systems, FoodDrinkEurope established "The Nutrition Action Project" to address nutrition-related concerns in the food and beverage industry. This workstream supports initiatives and collaborations that help food and beverage industries provide nutritious, safe, and tasty meals and drinks. One of the project's aims is to increase food's whole grain content.

1.2 Objective and scope

FoodDrinkEurope, in close collaboration with Fedima (Federation of European Manufacturers and Suppliers of Ingredients to the Bakery, Confectionery and Patisseries Industries) have developed this whole grain toolkit to assist small and medium-sized bakeries in incorporating more whole grains into their bread products.

The toolkit provides a practical guideline for small and medium-sized bakeries on how to use more whole grains in bread development, innovation and reformulation. It also provides background information on whole grain breads. This toolkit will be limited to bread, category 7.1 as described in the guidance document of Regulation (EC) No 1333/2008 on Food Additives, which provides details of the food categories in Part E of Annex II.

Details of the types of bread included for this toolkit can be found in Annex 1 of this document.

2. Basic information

2.1 Whole grain definition

What is whole grain?

At EU level, there is neither a definition for whole grain as an ingredient nor any EU law that regulates whole grain levels in foods. This document refers to the definition of whole grains from the Definitions Working Group of the global Whole Grain Initiative[1]. It states: "*Whole grains shall consist of the intact, ground, cracked, flaked or otherwise processed kernel after the removal of inedible parts such as the hull and husk; all anatomical components, including the endosperm, germ, and bran must be present in the same relative proportions as in the intact kernel.*"

[1] Kamp, J.-W. v., Miller Jones, J., Miller, K., Ross, A., Seal, C., Tan, B., & Beck, E. (2021). Consensus, Global Definitions of Whole Grain as a Food Ingredient and of Whole-Grain Foods Presented on Behalf of the Whole Grain Initiative. Nutrients, 14, 138

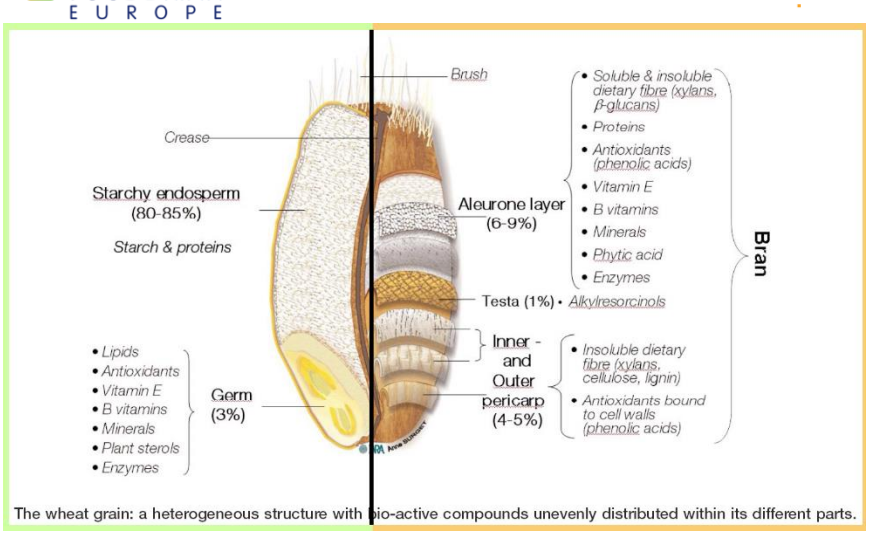

Figure 1. Anatomical structure of a whole wheat grain[2], [3]

Benefits of whole grains

Whole grain consumption has been linked to improved health[4]. However, most Europeans do not eat enough whole grains[5]. According to recent analyses, switching to whole grains may be one of the most significant nutritional improvements. Whole grains provide fibre, protein, vitamins, minerals, antioxidants, and phytochemicals. Consuming them has consistently been associated with a lower risk of colorectal cancer, cardiovascular disease, and type 2 diabetes. Whole grain consumption has also been linked to a reduction in body weight, total cholesterol, and systolic blood pressure[6]. The FoodDrinkEurope Guidelines: Whole Grains & Fibres - The Basics provide additional information on the health advantages of whole grains. Economic health modelling studies demonstrate that in Western populations (USA, Canada, Australia) a partial substitution of refined grains with whole grains can result in significantly lower

[2] Hemery, Y., Rouau, X., & Lullien-Pellerin, V. (2007). Dry processes to develop wheat fractions and products with enhanced nutritional quality. Journal of Cereal Science, 46(3), 327-347. https://doi.org/10.1016/j.jcs.2007.09.008
[3] Surget, A., & Barron, C. (2005). Histologie du grain de blé (Histology of wheat grain). *Industrie des Céréales, 145*, 3-7
[4] Reynolds, A., Mann, J. C., Winter, N., Mete, E., & Morenga, L. T. (2019). Carbohydrate quality and human health: a series of systematic reviews and meta-analyses. *Lancet, 393*(10170), 434-445
[5] Commission, E. (2017). Joint Research Centre - Health Promotion and Disease Prevention - Knowledge Gateway: Whole grain
[6] Micha, R., Khatibzadeh, S., Shi, P., Andrews, K., Engell, R., & Mozaffarian, D. (2015). Global, regional and national consumption of major food groups in 1990 and 2010: a systematic analysis including 266 country-specific nutrition surveys worldwide. BMJ Open, 5(9), e008705

healthcare costs for type 2 diabetes[7,8], cardiovascular diseases[7,8,9] colorectal cancer[10] even with rather pessimistic scenario's when only 5% of refined grains is substituted with whole grains. Analysis of the NDNS food consumption survey showed that higher whole grain intake was significantly association higher with higher quality diets, specifically consuming more fibre, potassium, calcium, iron, magnesium, fruits/vegetables, pulses/nuts, and oily fish, and consuming less free sugars, total fat, saturated fat, sodium, and red/processed meat[11].

2.2 Nutritional contribution of whole grains

Whole grain intake in Europe

Data on whole grain intake in Europe are limited. This is because whole grains do not have a consistent definition across the EU and lack research as a food group; many studies limit their scope to the intake of fibre. Table 1 provides whole grain intake numbers for some European countries and the United States[12]. It is important to note that whole grain intake values vary based on specific foods and methodologies used in studies. Therefore, the whole grain intake numbers are indicative and should not be compared between countries.

Table 1: Whole grain intake in different populations[7]

(Medians and 5th, 95th percentiles; mean values with their standard errors)

		Age group (years)		Mean intake (g/d)		Median intake (g/d)		
Countries	Sex (*n*)	Median	5th, 95th percentile	Mean	SE	Median	5th, 95th percentile	Source (year data collected)
Norway	F (1797)	48	42, 55	51	36	44	0, 120	[17](1995–2000)
Sweden	F (1617)	50	40, 60	41	32	35	0, 120	
	M (1372)	60	40, 60	58	50	49	0, 149	
Denmark	F (1994)	56	51, 64	37	32	31	0, 92	
	M (1922)	56	51, 64*	48	42	41	0, 116*	
France	Both (1171)	3–17		4	0·3	0	20·5*	[18](2010)
	Both (1389)	>18		5	0·3	0	26·4*	
UK	F (729)	1·5–17		15·3	15·0	11	4, 42	[19](2008–2011)
	M (773)	1·5–17		20·1	20·4	15	5, 29	
	F (880)	>18		23·6	22·8	19	6, 35	
	M (691)	>18		28·9	31·1	20	3, 42	
Germany	F (275)	6–12		22	22·9	14·7	0, 57†	[20](1997–2008)
	M (280)	6–12		27	29·5	17·9	0, 66†	
	F (165)	13–18		24	28·7	16·3	0, 56†	
	M (170)	13–18		33	43·7	19·2	0, 84†	
Ireland	Both (594)	5–12		18·5	18·2	12·7	68·5‡	[21](2003–2006)§
	Both (441)	13–17		23·2	29·5	13·4	97·9‡	
	Both (1051)	18–90		36·3	34·0	29·0	118·9‡	[22](2008–2010)
USA	Both (3124)	2–18		16·2	0·57			[23](2009–2010)
	Both (5918)	≥19		23·2	0·85			

* Medians and 95th percentiles.
† Medians and 10th, 90th percentiles.
‡ 50th and 97·5th percentiles.
§ 2003–2004 for age 5–12 years; 2005–2006 for age 13–17 years.

[7] Abdullah, M.M.H., et al. Cost-of-illness analysis reveals potential healthcare savings with reductions in type 2 diabetes and cardiovascular disease following recommended intakes of dietary fiber in Canada. *Frontiers in Pharmacology* 2015; 6: 167. doi:10.3389/fphar.2015.00167

[8] Abdullah, M.M.H., Huges, J., Grafenauer, S. Healthcare cost savings associated with increased whole grain consumption among Australian adults. *Nutrients* 2021; 13: 1855. doi.org/10.3390/nu13061855

[9] Murphy, M.M., Schmier, J.K. Cardiovascular Healthcare Cost Savings Associated with Increased Whole Grains Consumption among Adults in the United States. *Nutrients* 2020; 12: 2323. doi:10.3390/nu12082323

[10] Abdullah, M.M.H., Hughes, J., Grafenauer, S. Whole Grain Intakes Are Associated with Healthcare Cost Savings Following Reductions in Risk of Colorectal Cancer and Total Cancer Mortality in Australia: A Cost-of-Illness Model. *Nutrients* 2021; 13: 2982. doi.org/10.3390/nu13092982

[11] Kutepova, I., Rehm, C., Joy Smith, S. (2025). Whole grain intake remains unchanged in the United Kingdom, 2008/2012 – 2026/2019. British Journal of Nutrition. DOI 10.1017/S0007114525104091

[12] Seal, C. J., Nugent, A. P., Tee, E. S., & Thielecke, F. (2016). Whole-grain dietary recommendations: the need for a unified global approach. *British Journal of Nutrition, 115*(11), 2031-2038. https://doi.org/10.1017/s0007114516001161

Table 2: Mean daily whole grain intake in different EU countries.

Country	≥20 years male	≥20 years female
Germany	127	133
Netherlands	85	87
Sweden	79	80
Denmark	72	74
Finland	70	72
Malta	66	69
Portugal	66	69
Luxembourg	66	67
Austria	64	68
Greece	64	66
Ireland	64	65
France	38	39
Cyprus	30	32
Bulgaria	24	26
Latvia	24	26
Estonia	24	26
Lithuania	21	23
Slovakia	19	20
Slovenia	18	19
Romania	16	18
Poland	16	17
Czech Republic	15	16
Spain	12	13
Belgium	12	12
Italy	12	12
Croatia	3	3
Hungary	1	1

Mean daily intake of whole grain foods (g/day):

Recommendations for whole grain intake

The EU and various national dietary guidelines recommend increasing the consumption of whole grains. These recommendations typically fall into three categories:

1) Non-specific: encourage eating more whole grains or choosing whole grain options
2) Semi-quantitative: based on servings of cereal foods with whole grain proportions
3) Specific: setting a target daily amount of whole grain intake

In most European countries, national dietary guidelines include a recommendation for whole grain intake.

Table 3: Summary of recommendations for whole grain intake in Europe

Qualitative	Semi-quantitative	Quantitative
Prefer, choose, favour, opt for, include or consume whole grain products" *(e.g., Austria, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, Germany, Greece, Iceland, Latvia, Lithuania, Luxembourg, Malta, Slovenia, Spain and Switzerland, Malta, Poland, UK)*	"It is recommended to consume 5-8 servings of a variety of cereals per day, with the largest quantity being whole grain." *(Greece)*	"Eat at least 125 g of whole grain cereals per day." *(Belgium)*
	"Prefer wholemeal bread and other whole grain products. Replace at least half of the white bread with wholemeal." *(Bulgaria)*	"Eat whole grain foods at least twice a day." *(Iceland)*
"Replace or swap refined products with whole grain ones" *(e.g., Belgium, Hungary, Poland and Sweden)*	"Go for whole grain varieties wherever possible; choose whole grains at least twice a day." *(Ireland)*	"Eat at least 3 servings of whole grain cereal products daily (90g/day)." *(Poland)*
	"Swap refined grains with whole grains and consume at least one serving of whole grain food as bread, pastry or side dish a day." *(Hungary)*	"Eat at least 90 grams of whole grains per day." *The Nordic Council (comprising of Denmark, Finland, Iceland, Norway, Sweden, Estonia, Latvia and Lithuania)*

While these recommendations are often linked to dietary fibre intake targets, the benefits of whole grains go beyond fibre alone, contributing to overall diet quality and health.

Contribution of bread to whole grain intake

Intakes are based on Global Dietary Database data. (Total intake of whole grains includes breakfast cereals, bread, rice, pasta, biscuits, muffins, tortillas, pancakes etc. A whole grain food is defined as a food with ≥1.0 g of fibre per 10 g of carbohydrate).

Table 4 provides a global view on whole grain intake via bread in different countries in Europe. In this table information on bread and whole grain intake comes from different sources, but methodologies are different and therefore it is hard to compare between countries. Despite the table provides an insight in which countries whole grain bread types are more often consumed compared to others as well as what part of the bread in a country is whole grain. It needs to be noted that whole grain is not an ingredient that is calculated in the majority of food consumption surveys. Probably the closest marker of whole grain intake will be the amount of fibre provided by bread.

Table 4: Whole grain intake by bread in different EU countries

Countires	Wheat bread and rolls, brown or wholemeal	Crisp bread, rye wholemeal	Crisp bread, wheat, wholemeal	Rye bread and rolls, wholemeal	Total estimates of intake of bread containing whole meal	Total bread intake (kg/yr)	% contribution of whole grain bread intake to total bread intake (kg/yr)
	kg/yr	kg/yr	kg/yr	kg/yr	kg/yr		
United Kingdom	41,2	0,1	0,0		**41**	**168**	25%
Czechia					**0**	**150**	0%
Denmark	24,2	0,4	1,2	33,8	**60**	**148**	40%
Hungary	20,6			10,1	**31**	**138**	22%
Romania	20,2	0,2		5,1	**26**	**137**	19%
Netherlands	65,5	0,9	0,4	1,5	**68**	**130**	53%
Germany	0,4		0,3	7,3	**8**	**123**	7%
Serbia	17,9			1,5	**19**	**120**	16%
Montenegro	18,3			2,1	**20**	**117**	17%
Poland	5,0			5,1	**10**	**117**	9%
Bosnia and Herzegovina	20,5			1,5	**22**	**114**	19%
Ireland	42,6	0,2	0,1	0,5	**43**	**107**	41%
France	5,9	0,1	0,1	0,1	**6**	**106**	6%
Belgium	38,8		0,2		**39**	**104**	37%
Slovenia	28,4			0,7	**29**	**103**	28%
Portugal	6,3			0,4	**7**	**100**	7%
Finland	8,8	3,2	0,2	32,0	**44**	**87**	51%
Sweden	12,0	6,8	0,7	51,7	**71**	**87**	82%
Latvia	0,3	0,0		36,5	**37**	**86**	43%
Greece	4,0			7,0	**11**	**85**	13%
Croatia	8,9	0,0	0,0	0,9	**10**	**81**	12%
Austria	6,9			2,6	**9**	**80**	12%
Italy	12,0				**12**	**74**	16%
Spain	4,9			0,1	**5**	**68**	7%
Cyprus	10,5				**11**	**49**	21%
Estonia	1,0	0,1		0,7	**2**	**42**	4%

2.3. Opportunities and challenges of whole grain flours / kernels

2.3.1. Whole grain bread success stories

Public-private partnerships have been successful in encouraging consumers to eat more whole grains through coordinated communication efforts.

For example, the Danish Whole Grain Partnership, which brings together 27 partners from government, health organisations, industry, and retail, created a dedicated logo to designate whole grain foods. Since its launch, the number of products carrying the logo has grown from 190 in 2010 to 1,097 in 2019. The campaign has achieved wide recognition: 68% of Danes are familiar with the logo, and 80% of them say they use it go guide their food purchases. As a result, the average whole grain intake in Denmark increased from 36g to 82g per 10 megajoule (MJ) by 2019.

In the Netherlands whole wheat is popular: In 2020, 2021 and 2022, whole wheat bread ranks as the most consumed type of bread (47%). As a strong product, whole wheat has the potential to both stimulate bread sales and boost the health of the Netherlands. That is why the Dutch Bakery Centre has set the goal within the current campaign 'Bread, good story' to increase this percentage to 53% by the end of 2023.

Netherlands: Broodcampagne 2024 (Bread campaign 2024): A 360-degree media campaign with as goal to strongly promote whole grain bread to the Dutch consumer. It was done in week 4 and reached over 1 million consumers with positive messages on whole grain bread.

Commenté [TH1]: Question to Fedima: Has this goal been achieved in 2023?

Commenté [TH2]: Question to Fedima: Has WG bread intake increased as a consequence.

2.3.2. Business opportunities

Consumer trends and business

Moving from more refined to more whole grain bread can offer significant business opportunities for SMEs due to increasing consumer demand for healthier and more balanced food and drink choices. There is rising health consciousness among consumers, who are actively looking for options with higher fibre, vitamins, and minerals, making whole grain bread more appealing.

Depending on the country there is more or sometimes less opportunity to move to more whole grain breads. This depends on the current level of whole grain bread consumption and acceptance by consumers of whole grain bread.

Although the trend is slow, it is expected that whole grain bread consumption will grow year on year compared to refined bread.

Impact on production when changing from refined to whole grains

Supply chain: Switching from refined to whole grain ingredients typically has minimal impact on the overall supply chain, as the primary difference lies in sourcing different raw materials. However, it also requires identifying reliable suppliers that meet quality and safety standards, while considering factors such as ingredient availability, consistency, and specific storage conditions.

Cost of production: Whole grain ingredients are typically slightly more expensive than refined grains. In the production of whole grain bread, generally more bread improvers are added to get more acceptable bread for consumers.

Potential impact on product characteristics

Increasing whole grain content in breads presents some technical challenges. These are outlined below, along with possible solutions to support smoother production:

- *Grain selection and processing equipment:* Whole grains vary in compositions (e.g., fat, fibre, and moisture levels), which can influence processing behaviour, texture, and shelf-life. These differences may require adjustments to mixing, to achieve the desired product quality

- *Moisture management:* Whole grains absorb more water. This needs to be considered when producing whole grain bread.

- *Taste and shelf-life:* Whole grains can have a slightly bitter flavour and a shorter shelf life than refined grains due to the potential for rancidity. Shelf life can be extended by preventing oil oxidation in the germ.

2.3.3. Impact on production when changing from refined to whole grains

When changing from refined to whole grain flour in the production of bread, several aspects must be considered. Recipes need to be adapted to the use of whole grain flour. Several aspects need to be considered in the adaptation of the recipes. Whole grain flour absorbs more water due to the fibre content. Use of dough conditioners and/or vital wheat gluten may be needed. Furthermore, in yeast-proofed bread production the proofing time needs to be adapted, or the amount of yeast needs to be reduced.

Despite the use of dough improvers and vital gluten, the dough will be less elastic and less extensive with a reduced gas retention and denser structure due to the higher dietary fibre content of whole grain flours. In addition, the gluten structure, that is responsible for retaining the gas production from the yeast or sourdough, will be partly destroyed by the large particles of the dietary fibres in the whole grain flour. The dough will need shorter kneading time to improve the gluten development. Proofing time needs adaptation as well because fermentation in whole grain flour dough is generally faster when using the same amount of yeast in the dough due to the existing enzymes and nutrients in whole grain flour that are also used by the yeast.

One and another may also affect the necessary equipment. Mixers need to be able to handle a stickier and less elastic dough. Because in general whole grain dough is stickier, non-stick surface or addition flour or oil may be needed when dividing the dough into required pieces. Proofing times, temperature and humidity may need adaptation and therefore the timing and moisture content in proofing cabinets need to be fine-tuned. Dividers may need adaptation for whole grain dough. In the stage of the moulding and panning it is necessary to take care that the dough is less extensible and more fragile, especially when no dough conditioners and/or vital wheat gluten is added. Fine tuning of conditions in the end stage of proofing / fermentation is essential to have an optimal result that can be baked off. Baking will take longer amongst others due to the higher water content of the dough. Browning of the bread during baking will develop differently. A slightly lower oven temperature is often recognized. Be aware that the loaf will have less oven spring than a white loaf. Steaming at the beginning of baking is essential for good oven spring and a crisp crust. Because whole grain flour generates more dust and residues, equipment may require more frequent cleaning to prevent buildup of contamination. Table 5 summarises the potential adaptations in production and processing in the baking of higher whole grain bread.

Table 5: Potential adaptation in production and processes.

Component	Change	Why
Mixer	May be	Stronger mixer may help improve hydration and dough development
Fermentation / proofing	Adjustment	Focus on timing, temperature and humidity
Dividing / moulding	May be	Dough is stickier and more fragile
Oven	Adjustment	Modify time and steam
Cleaning	No	More cleaning due to extra dust and bran
Packaging	Adjustment	Change of bread size

A critical note needs to be made with respect to the size of the bakery. For the artisanal baker, the above indicated adaptation may not have a big impact on the total production process. In the small artisanal bakery, the necessary adaptation when switching from refined flour to whole meal flour can easily be done when an automized production line is not installed. However, when a complete bread baking line is installed, this needs to be fine-tuned. Recipes, mixing and kneading time, proofing time, time spend in the oven including the temperature must be fine-tuned for whole grain flour-based breads. When packing of the final product is automized as well, also this part of the production line may need adaptation. This will need specialised support from the ingredient and equipment suppliers.

2.3.4. Potential Impact on product characteristics

Whole grain bread is characterized by a much richer, nuttier and slightly sweeter flavour then refined grain breads, all due to the presence of bran and the germ. Many consumers experience more bitter and astringent notes in whole grain bread. The flavour moves from a simple, mild, neutral flavour in bread made with refined flour to a rich, nutty, earthy, and toasty flavour profile. The germ contains oils and sugars that can impart a slight, inherent sweetness. The aroma is much heartier, grainier, and more aromatic than the simple yeasty or bready smell of white bread. It often smells like toasted nuts and grains. The crust and crumb are much darker due to the bran in whole grain flour and due to higher Maillard reaction potential. The structure of the crumb tends to be more dense and less airy because the bran interferes with the gluten development during the mixing process. This also may cause a gritty and fibrous texture, depending on the grit size.

The use of whole grain flour challenges the baker to make acceptable whole grain bread. The often less accepted taste and texture of whole grain breads. Due to the higher fibre and lipid content, staling is considered slightly slower.

3. Toolkit to increase whole grains in your products

3.1. Current situation of available bread

3.1.1. Categories of bread in the European market

Bread in Europe is extremely varied, reflecting local baking methods, ingredients, and customs. Based on traits including leavening, flour type, form, crust, and cultural usage, European breads can be broadly divided into the following categories:

Leavened versus unleavened bread	• Most European breads are leavened with yeast or sourdough or a combination of both, giving the product a soft crumb and airy volume. • Unleavened bread is found in some traditional and religious contexts
By leavening agent	• Sourdough; often related to natural or spontaneous fermentation which is usually based on lactic acid bacteria. • Yeast, most often saccharomyces cerevisiae species. • Combination of yeast and sourdough. • Chemical leavening by baking soda/powder.
By flour type	• Wheat based is the most common in southern and western Europe • Rye-based is rather common in northern and eastern Europe • Mixed grains, which are often blends of wheat, rye, oats and barley. Nowadays, also ancient grains like spelt, amarant are used. • Corn or chestnut flour; used in very specific regions (ie. Italy)
By crust and crump	• Crusty breads; thick and crunchy crust • Soft-crust breads: thin or soft crust

	• Dense crumb: often rye and/or whole grain breads • Open crumb: light and airy, like ciabatta and focaccia
By shape and form	• Loaf shaped; standard rectangular pan-baked loafs, like British sandwich bread • Round or boule: traditional rustic forms • Flatbreads, like pita, lavas, focaccia • Braided breads like challah and zopf • Rolls and buns like Kaiser roll and milk buns
By sweetness and enrichment	• Savory breads which is the majority of the European breads, can be consumed without or with either sweet or savoury toppings • Enriched/sweet breads; recipes often contain eggs, milk sugar and/or butter, like brioche, panettone, kulich, Frisian sugar bread
By regional/national tradition	• French: Baguette, brioche, pain de campagne • German: Pumpernickel, Vollkornbrot, Brötchen • Italian: Ciabatti, focaccia, pane toscano, panettone • British/Irish: Bloomer, soda bread, baps • Scandinavian: Rye crispbread, tunnbröd, kavring • Eastern Europe: Borodinsky, kalach, obwarzanek • Balkan: Pita, somun, lepinja

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3.1.2. Production methods per bread category

Numerous bread variants exist in Europe and worldwide. Basic ingredients include grain flour, water, yeast and/or another leavening agent, and salt. The mixing of these ingredients is the very first elementary step in the production process. The mixing process does not essentially differ between the bread categories available in Europe. Mixing is a part of the kneading process. The kneading process determines the rheological characteristics of the dough. In wheat-based doughs the development of the gluten network in the dough depends on the mechanical force during kneading. As indicated above, in doughs based on whole grain flours it is advised to add vital gluten to the ingredients to create a bread that is acceptable for consumers. To allow a proper development of the gluten network in a dough based on whole grain flours, kneading time and or speed of kneading needs to be adapted

Fermentation: time of proofing needs adaptation. Because whole grain flour is higher in enzymes and nutrient concentrations, yeast will grow faster in doughs based on whole grain flours then on refined flours. Shortening of proofing time is advised to prevent overproofing.

Baking: Doughs that are based on whole grain flour contain more water due to the additional water absorption in the dietary fibers in whole grain flour. To create a final bread with a comparable water content as breads based on refined flours, baking time needs to be extended.

Crusting: input from FEDIMA is requested

Commenté [TH3]: Although this section covers what the title is suggesting, we think that it is quite redundant as this is already mentioned in chapter "Impact on production when changing from refined to whole grain". We think we can leave it out: Do you agree.

3.2. Determining the opportunities

3.2.1. Analysis of the nutritional composition of your product

It is important to know the composition of your bread. Especially of the 'innovated' bread with increased the whole grain content. For the higher whole grain bread the nutritional composition will need to be analysed for labelling purposes and eventual nutritional and or health claims.

Analysing the nutritional composition of whole grain breakfast cereal requires assessing its macronutrients (carbohydrates, proteins, and fats), micronutrients (vitamins and minerals), and dietary fibre content. All values should be reported on the nutrition label per 100 g.

Mandatory nutrition information for labelling:

The nutrition declaration must include the following **per 100 grams of the product**:

- **Energy value (in kilojoules (kJ) and kilocalories(kcal))**
- **Fat (g)**
  - **of which saturates (g)**
- **Carbohydrate (g)**
  - **of which sugars (g)**
- **Protein (g)**
- **Salt (g)**

To have your products analysed, specialized companies like Eurofins, SGS, Intertek, can support product analysis. Most of these companies can also provide services on food safety and sensory analysis. A complete nutrient profile may range between €500 and €2500 per sample. Such an analysis involves advanced methods and includes macronutrients and micronutrients analysis.

Due to the absence of an accepted, harmonised regulation at the EU level for whole grains, there are differences across Europe in what companies can communicate on whole grain content.

Currently, front-of-pack labelling does not permit whole grain-related health or nutrient content claims (e.g., "source of" or "high in"). However, it is possible to indicate the quantity of whole grain per serving or per 100 g of product on the label, provided it is based on dry weight.

However, whole grain foods have higher dietary fibre levels. Dietary fibre can be claimed front of pack with source of fibre if the bread contains 3g to 6g dietary fibre per 100 gram bread and with high fibre when the fibre content is higher than 6 g per 100 gram bread.

Calculating the whole grain amount of your product:

When increasing the whole grain content of a product, it is important to know the amount of whole grain that a finished product contains. The whole grain content is based on the product recipe. For example, if 50% of a bread recipe (by dry weight) consists of whole grains, then its whole grain content is 50%. A 30g slice (dry weight) of this bread would then provide 15g of whole grains.

3.2.2. Determine options for adaptation of your product

3.2.3. Opportunities

3.2.3.1. Fermentation Technology:

Fermentation technology is a strong technique in the manufacturing of bread, having several benefits such as higher nutritional value, greater digestibility, distinctive tastes, and extended shelf life. Fermentation is the use of microorganisms (e.g., bacteria, yeast, or fungus) to break down carbohydrates, proteins, and lipids in whole grains, resulting in biochemical changes that improve the quality of the final product.

1. Improving Nutritional Value

Fermentation breaks down anti-nutritional elements such phytic acid, which binds to minerals (iron, zinc, calcium) and hinders absorption. This boosts the bioavailability of vital nutrients. Fermenting microorganisms like lactic acid bacteria (LAB) can generate B vitamins (e.g., folate, riboflavin) and vitamin K, improving cereal nutrition. Fermentation can also create prebiotic substances (e.g., oligosaccharides) that aid gut health.

2. Improving Digestibility

Fermentation breaks down starches and fibres into simpler sugars, making the cereal easier to digest. In gluten-containing grains like wheat, fermentation can partially break down gluten proteins, reducing their allergenic potential and making the cereal more suitable for sensitive individuals.

3. Developing Unique Flavors

Fermentation produces organic acids (e.g., lactic acid, acetic acid) and aromatic compounds that contribute to the unique tangy, sour, or savoury flavours. Using specific cultures, fermentation can reduce the bitterness of certain whole grains.

4. Extending Shelf Life

Fermentation is a natural way of preservation. The organic acids and antimicrobial compounds produced during fermentation (e.g., lactic acid, bacteriocins) act as natural preservatives, inhibiting the growth of spoilage microorganisms and pathogens. The process can reduce the water activity in bread, further enhancing its shelf life.

5. Functional Health Benefits

Depending on the used culture, fermentation can increase the levels of antioxidants in whole grains, which help combat oxidative stress in the body. Often fermented breads have a lower glycaemic index, which is positive, due to the breakdown of starches into slower-digesting carbohydrates.

3.2.3.2. Enzyme technology in breads

Enzyme technology can be used to innovate bread production, improving nutrition, texture, and processing efficiency. Enzymes are natural proteins that catalyse certain biochemical reactions. Their capacity to modify components in a controlled and sustainable way has made them more useful in food preparation. Enzyme technology may boost breads' nutrition by enhancing digestibility, mineral bioavailability, and lowering anti-nutritional factors

1. Improving Nutritional Value

Phytase: Whole grains have phytic acid, which binds to minerals including iron, zinc, and calcium, limiting bioavailability. Phytase enzymes break down phytic acid, releasing minerals and boosting cereal nutrition.

Beta-Glucanase: Oats and barley contain beta-glucans, which are healthy fibers but can make the cereal too dense or gummy. Beta-glucanase enzymes partially break down these fibers, improving texture while retaining some of their health benefits.

2. Enhancing Texture and Mouthfeel

Amylase: Amylase enzymes break down starch into simpler sugars, which can change the taste and texture of the bread.

Protease: Protease enzymes break down proteins in the grains, softening the texture. This is especially helpful for whole grains like wheat or barley, which can be tough.

Xylanase: Xylanase enzymes break down hemicellulose, a component of the grain's cell wall, improving the dough's elasticity and the final product's texture.

3. Optimizing Processing Efficiency

Cellulase: Breaks down cellulose in the grain's outer layers, improving the efficiency of milling and reducing processing time.

4. Enhancing Flavour

Maltogenic Enzymes: These enzymes produce maltose and other sugars during processing, enhancing the natural sweetness and flavour.

Lipase: Lipase enzymes break down fats into free fatty acids, which can contribute to the development of desirable flavours during toasting or baking.

5. Reducing Anti-Nutritional Factors

Enzymes like Phytase and Protease: As mentioned earlier, these enzymes reduce anti-nutritional factors like phytic acid and protease inhibitors, making the cereal more digestible and nutritious.

3.2.3.3. Addition of nutrients/bio-active substances

Fortification is the practice of adding vital and bioactive ingredients to a product therefore increasing their health advantages. Beyond simple nutrition, this strategy offers functional health advantages and helps correct dietary deficits. Whole grains are naturally high in fibre, vitamins, and minerals, but fortification can supplement key nutrients such as iron, vitamin D, and B vitamins. Some nutrients found in whole grains are bound by antinutrients (such as phytic acid), making absorption difficult. Fortification helps to overcome this constraint. Including

bioactive substances can help improve gastrointestinal health, immunity, cognitive function, and overall well-being. Key essential nutrients used in fortification are iron, calcium, vitamin D, B-vitamins (B1, B2, B3, B6, B12, folic acid) and zinc. Furthermore, dietary fibre and prebiotics, such as beta-glucans, inulin, fructo-oligosaccharides and resistant starch can increase the already high level of dietary fibre content. Probiotics, omega-3 fatty acids, polyphenols and carotenoids are also frequently used for fortification.

Methods used to fortify are dry blending, encapsulation, extrusion cooking and spray coating. Fortification needs extra attention for stability of the added nutrients. Some fortified nutrients can alter the sensory properties. Certain compounds (e.g., iron) need careful selection to ensure absorption without affecting taste. Nutrient levels must meet levels set by food regulations.

3.3. Building a plan to change to more whole grains in bread

3.3.1. Know your market

Before innovating bread with more whole grains, it's essential to understand the market(s) you want to be active in. This includes analysing/understanding consumer preferences, market trends, competition, and economic conditions.

A first step for deciding to start with the production of higher whole grain bread is examination and understanding of the local market. Estimate, where possible, the size of the whole grain bread market in terms of revenue, volume, and growth rate. Be aware and understand key consumer trends (e.g., whole grain, low-sugar, high-protein, low sodium, health benefits, organic, convenience). Based on this information it will be possible to make a decision on which and how much whole grain bread can be sold.

3.3.2. Determination of investment needs

When changing from refined to whole grain bread, some level of investment may be needed. Start with conducting a cost analysis to understand the financial impact of the transition and set appropriate pricing for the new products.

Whole grains (e.g., whole wheat, rye) may be more expensive than refined grains. They may also require different storage conditions to maintain freshness and prevent spoilage.

It may be necessary to adjust logistics and distribution plans to accommodate any changes in production schedules, storage requirements and shelf-life considerations. Existing production lines may need to be retrofitted or upgraded to handle the different physical properties of whole grains. The whole grain ingredients can lead to increased wear and tear of machinery and may require a different and potentially more intensive cleaning process.

3.3.3. Short term opportunities

Transitioning from refined to whole grain breakfast bread can be relatively straightforward. Start with introducing partly whole grain breads. These changes typically require minimal adjustments to existing production lines.

A complete switch from refined flour to entirely whole grain is not immediately necessary. Instead, take small steps by blending whole grains with refined in existing recipes. For example, mix whole wheat flour with refined flour or add whole oats to the cereal base. This approach requires only minor adjustments to equipment or processes while gradually introducing whole grains to consumers.

3.3.4. Planning long term product development

For a successful change from refined to whole grain breads, a gradual substitution of refined to whole grains is suggested. This involves a stepwise change in the mix of refined versus whole grains, allowing consumers time to adapt to changes in taste and texture. For small artisanal bakeries, the necessary adaptation when switching from refined to whole grain flour can easily be done in the case an automized production line is not installed. However, when a complete bread baking line is installed, this needs to be fine-tuned, and support from the supplier of the equipment is needed. Also, choose which bread type is the most practical to make more whole grain. When consumers are used to and like the higher whole grain bread, a new increase of whole grain in the recipe can be considered.

A practical starting point is to develop a range of whole grain type breads using existing equipment. Over the long term, if you want to innovate different types of whole grain breads, investment in high-quality equipment and ingredients (e.g., whole wheat, oats, quinoa, etc.) may be required.

Product developers could focus on refining formulations to achieve the right balance of taste, texture, and nutritional value. It is important to incorporate ingredients that align with consumer trends. Regularly gathering feedback can help to improve the product into the right direction, while staying updated on industry developments could help support timely adjustments to the production process accordingly.

Annex 1. Products that are included in the Whole Grain Toolkit and products that are NOT included in the Toolkit

Included bakery wares	Products which are prepared mainly with cereal flour or cereals and may have undergone a treatment, e.g. baking, steaming, extrusion. Includes categories for bread including:	
	Bread and rolls	Bread prepared solely with the following ingredients: wheat flour, water, yeast or leaven, salt, like e.g. wheat bread, rye bread, whole meal bread, multi grain bread, malt bread, pumpernickel bread, rolls (hamburger rolls, whole wheat rolls, milk rolls), bagels, pita bread, Mexican tortillas and steamed breads. This category includes bread-based products, e.g. croutons, bread stuffing, prepared dough
	Pain courant français	Bread prepared essentially with the following ingredients: breadmaking flours (wheat flour, rye flour, meslin flour), water, yeast and/or leaven, salt. Other food ingredients can be added for a technological purpose in accordance with the national general principles.
	Fehér kenyerek	White bread, consisting of 100% of wheat-flour, produced with yeast or yeast substitute, manufactured through kneading, forming, rising and baking of the dough
	Félbarna kenyerek	Semi-white bread, consisting of 85% semi-white wheat-flour and 15% light rye-flour, produced with yeast or yeast substitute, manufactured through kneading, forming, rising and baking of the dough
NOT included bakery wares		
	Fine bakery wares	sweet, salty and savoury products such as cookies, cakes, muffins, doughnuts, biscuits, macarons (i.e. round products made typically with almonds, icing/powdered sugar and egg whites), rusks, cereal bars, pastries, pies, scones, cornets, wafers, crumpets, pancakes, gingerbread, éclairs, croissants, as well as unsweetened products such as crackers, crisp breads and bread substitutes, including prepared doughs* [or mixes for their preparation*]. It also includes sponge cakes, essoblaten and wafer paper and edible paper ('edible paper' does not refer to a paper but to a food placed on the market under the name 'edible paper' usually consisting of dried starch sheets or made of rice or potato starch of various thickness or texture and consumed as such). In this category a cracker is a dry biscuit (baked product based on cereal flour), e.g. soda crackers, rye crisps, matzo.
		(excluding pre-dusts, and doughs which are covered by category 6.6).