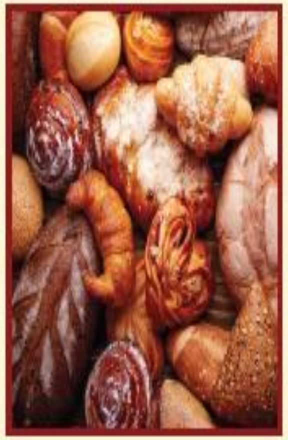



GUIDELINE FOR PROFESSIONALS REGARDING MANUFACTURING FUNCTIONAL BAKERY PRODUCTS FOR PEOPLE WITH DIGESTIVE DISORDERS

Erasmus+

ROMPAN

FBforPDD


GUIDELINE FOR PROFESSIONALS
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Editura EUROBIT
Timișoara, 2022

GUIDELINE FOR PROFESSIONALS REGARDING MANUFACTURING FUNCTIONAL BAKERY PRODUCTS FOR PEOPLE WITH DIGESTIVE DISORDERS

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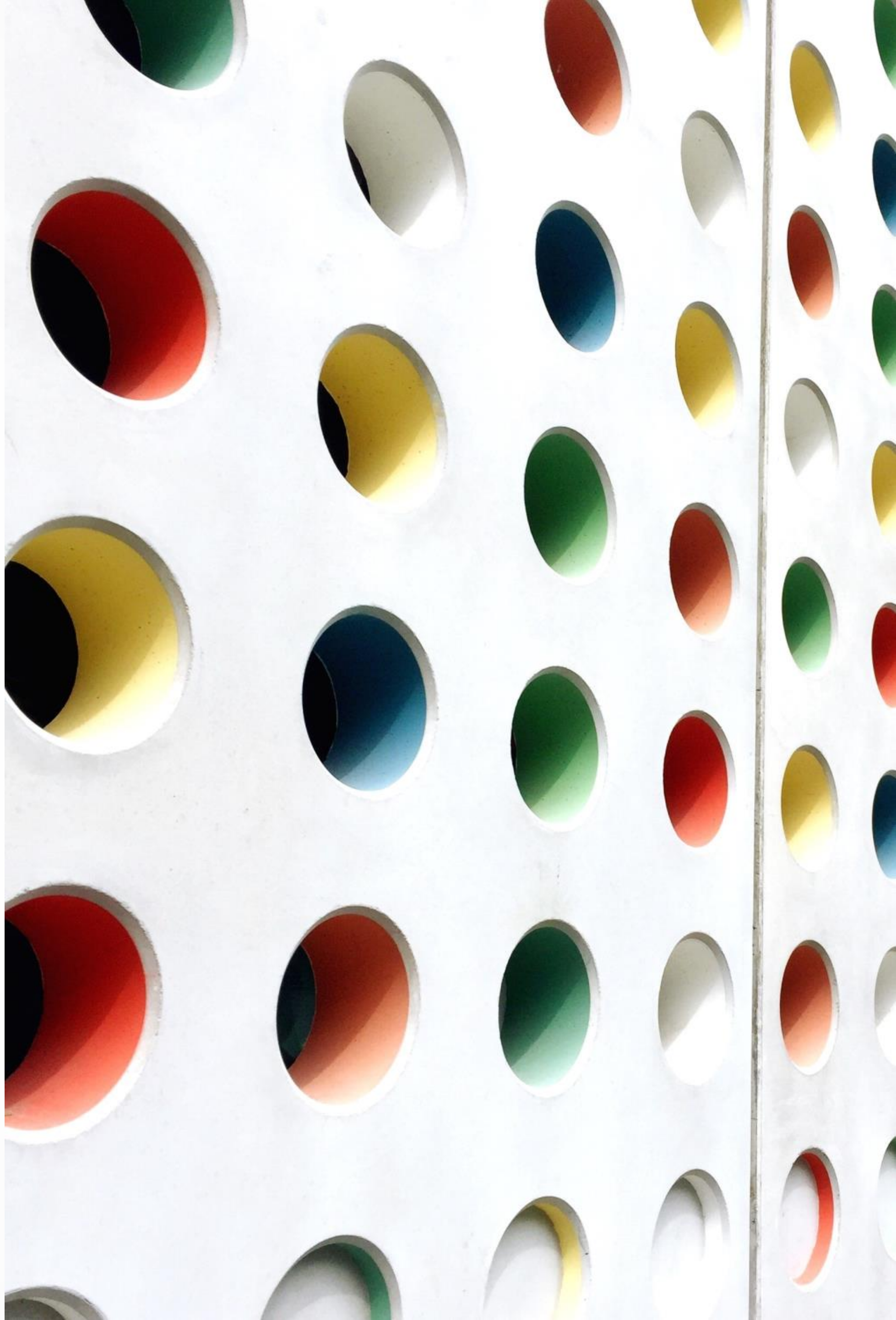
CONTENT

CHAPTER 1.

The importance of functional bakery products consumption



1.1. The benefits of functional products consumption

Functional foods are natural or processed foods that contain biologically active compounds, proven to have a specific health benefit (Bultosa, G., 2016; Ashwell, M., 2002).

They are composed of natural ingredients that provide functional substances or additional ingredients are added to them to achieve beneficial health effects.

For instance, plant-based foods such as fruits, vegetables, herbs, cereals, nuts and beans contain vitamins, minerals, dietary fiber, omega-3 fatty acids, antioxidants and phenolic compounds that play a functional role in the human body against chronic diseases, including cancer, cardiovascular or gastrointestinal tract disease (Arshad, M.S. et al., 2021; Banwo, K. et al., 2021; Lau, T. et al., 2022). Also, food of animal origin, seafood and other marine products are rich in biologically active compounds such as polyunsaturated fatty acids, bioactive peptides, antioxidants, which can be used as functional ingredients in bakery products (Kadam, S.U., Prabhasankar, P., 2010).

Another category of functional foods are those from which certain components are removed so they can be eaten by people with certain diseases (for instance, gluten-free products for people with celiac disease).

Depending on the interventions made on the food in order to increase its favorable effects on health, the following types of foods fall into the category of functional foods:

- natural foods in which one of the components has been naturally enhanced through special growing conditions;
- foods to which a component has been added to provide benefits (e.g. the addition of selected probiotic bacteria with proven health benefit characteristics to improve gut health);

1.1. The benefits of functional products consumption

- foods from which a component has been removed so that the food has less adverse health effects (e.g. the reduction of saturated fatty acids, reduction of sugars);
- foods in which the nature of one or more components has been chemically modified to improve health (e.g. the hydrolyzed protein in infant formulas to reduce the likelihood of allergenicity);
- foods in which the bioavailability of one or more components has been increased to provide greater absorption of a beneficial component;
- and any combination of the above possibilities.

The health benefits of eating functional foods are numerous (Ashwell, 2002; Wu et al, 2017; Green et al, 2020):

- Early development and growth;
- Regulation of basic metabolic processes (energy balance and obesity, diabetes, insulin resistance syndrome);
- Defense against oxidative stress;
- Cardiovascular physiology (lowering the blood pressure, blood lipids, homocysteine levels);
- Gastrointestinal physiology (promoting gut health);
- Cognitive and mental performance, including mood and alertness;
- Physical performance and fitness.

1.2. The role of cereals and cereal derivatives in human health

1.2.1. Nutritional value of cereals and cereal derivatives

Cereals are herbaceous plants of the Gramineae family, cultivated since ancient times for their seeds and are basic foods for the population around the world. Along with cereals, with a similar structure of seeds, pseudocereals (buckwheat, quinoa, sesame, amaranth) have an important contribution in the diet through the intake of macronutrients, dietary fibre, mineral elements, vitamins and phytochemicals.

The main types of cereals in the human diet are represented by wheat, corn, rice, oats, rye, millet, sorghum, triticale and out of these, rice, corn and wheat are the most cultivated globally (Nugent, A.P et al, 2019).

In the group of cereals and cereal derivatives, several categories of products are distinguished:

- cereals and refined cereal derivatives (white flour, white rice, white bread, white flour pasta, bakery/ pastry products prepared with white flour, refined breakfast cereals, etc.);
- cereals and whole cereal derivatives (whole grain flour, whole rice, whole grain bread, whole grain pasta, whole cereals for breakfast, etc.);
- enriched cereal derivatives to which nutrients are added that have been eliminated during processing (e.g. vitamins, fiber added to white bread);
- cereal derivatives fortified with nutrients/micronutrients that are not naturally found in their composition (e.g. iron-fortified breakfast cereals).

From a nutritional point of view cereals and cereal derivatives are distinguished by an important content of carbohydrates and proteins, dietary fiber, vitamins and mineral elements (Poole, N. et al, 2020), as well as the presence of numerous bioactive substances with important roles in health (Benincasa, P. et al, 2019).

Carbohydrates in cereals are of two types: digestible (starch) and non-digestible (dietary fiber and resistant starch).

Digestible carbohydrates range from 40 to 78% (40% in brown bread, 50% in intermediate bread, 75-78% in wheat flour and cornmeal, 77% in rice). Of these carbohydrates, the best representation is made by starch, which is found in a percentage of 95-98%, the rest being small molecule carbohydrates (mono and disaccharides) with an important role in alcoholic fermentation.

1.2. The role of cereals and cereal derivatives in human health

1.2.1. Nutritional value of cereals and cereal derivatives

Indigestible carbohydrates are represented especially by cellulose, pentosans, lignin. They are stored in the shell of the cereals. Therefore, if the product is too refined (husked or with few bran), most of the fiber disappear.

In white bread the amount of fiber can be 2-6 times lower than in whole grain bread.

In oats and barley there are important amounts of soluble fiber called beta-glucans.

Proteins in cereal derivatives have a lower nutritional value than proteins of animal origin because they contain limiting essential amino acids (lysine) or do not contain all the essential amino acids, as is the case with corn (zein, the main protein in corn is poor in tryptophan, isoleucine, lysine and valine).

In the grain of cereals, proteins are found mainly in the aleuronic layer and in the germ, for this reason, refining will also cause a reduction in the amount of protein (in white flour we find a percentage of 10.33% protein compared to 13.7% as we find in whole meal flour) (U.S. Department of Agriculture, 2003).

Lipids in cereals are concentrated in the germ (so they are found in small quantities) and are represented by unsaturated fatty acids (oleic, linoleic and linolenic) with antiatherogenic effect. A greater amount of lipids is found in corn germs. In the germ oil are also found large amounts of vitamin E.

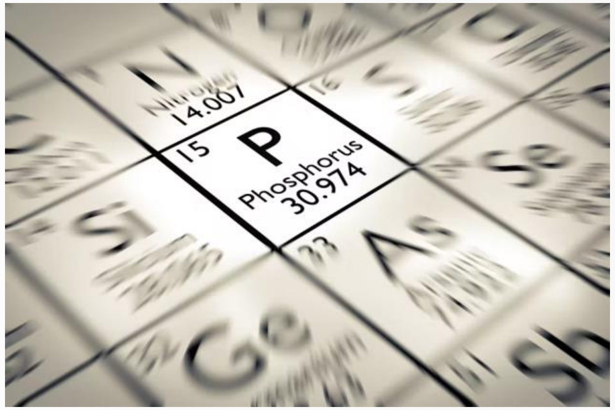
Mineral elements

In cereals and their derivatives there are many mineral elements, both macro-elements (phosphorus-P, calcium-Ca, magnesium-Mg, potassium-K, sodium-Na) and micro-elements (zinc-Zn, iron-Fe, selenium-Se, manganese-Mn, copper-Cu).

1.2. The role of cereals and cereal derivatives in human health

1.2.1. Nutritional value of cereals and cereal derivatives

The main form of phosphorus storage in cereal grains is represented by phytic acid and phytates. The absence of human digestive phytases reduces the use of phosphorus (Ozturk, I. et al, 2012) and the ability of phytates to bind cations places them in the category of the most well-known antinutritive substances in the human diet (Ikram, A. et al., 2021). The formation of insoluble salts with mono and bivalent cations (K^{+}, Mg^{2+}, Ca^{2+}, Fe^{2+}, Zn^{2+}, Cu^{2+}) reduces the bio accessibility of these essential nutrients. Most of the phytic acid is found in bran and germs, so the higher the percentage of bran in flour, the richer it will be in phytates.



In the bakery process, the phytates content decreases due to the action of the phytase in the flour, which becomes active under the influence of heat and moisture. Also, the fermentation of cereal seeds and dough increases the phytase content, thus reducing the phytate content and increasing the bioavailability of phosphorus and minerals (Azeke, M.A et al., 2011). The foods of this group can make a substantial contribution to ensuring mineral balance.

Vitamins

Cereals are a good source of vitamin A (in the form of provitamins A), vitamins of the B complex (except vitamin B12), vitamin E and reduced amounts of vitamin K. They do not contain vitamins C and D.

Vitamin A is found in the form of carotene and carotenoids, with ß carotene, ß-cryptoxanthin, lutein and zeaxanthin in cereals (Trono, D., 2019). Carotenoids are found mainly in endosperm, grinding and degermination do not greatly influence the content in carotenoids.

1.2. The role of cereals and cereal derivatives in human health

1.2.1. Nutritional value of cereals and cereal derivatives

B-complex vitamins

Cereals are a good source of B-complex vitamins except for vitamin B_{12}. These vitamins are found especially in the shell and in the germ, so whole grains have a higher content of B vitamins compared to refined ones.

A quantity of 100 g of whole grain bread can provide between 10 and 24% of the daily requirement of B vitamins, while the same amount of white bread can only provide between 1 and 10% of this requirement. In case of rice, 100g of cooked whole rice provides between 1 and 10% of the daily requirement of B vitamins, while the cooked white rice provides between 0 and 7% of this need.

Vitamin E

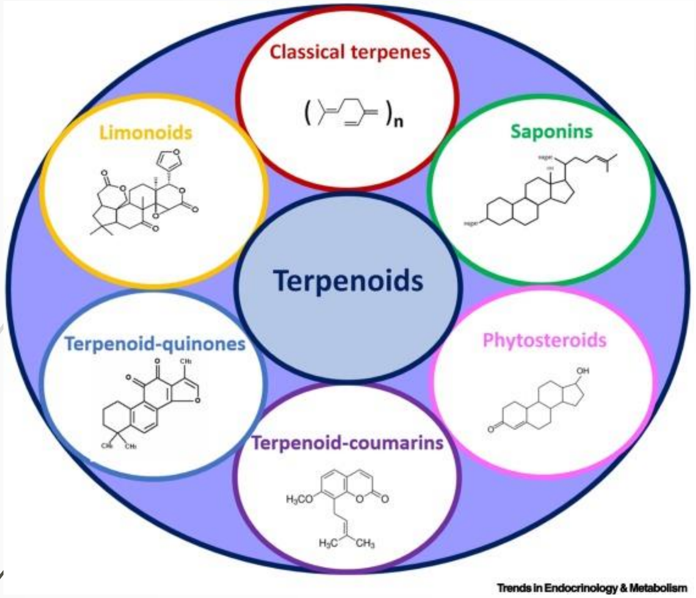
Cereals contain tocopherol and tocotrienol. These compounds are mainly found high in fat layer of the germ, so degermination and grinding determinates the loss of 90-95% of the content of vitamin E.

Fortification of cereal products with vitamins from B group (B2, B9, B12) and vitamin K with the help of bacteria and yeasts, as well as direct fortification with vitamins A, B1, B2, B3, B6, B9, B12, D and E are a method of preventing micronutrient deficiency (Garg, M. et al., 2021).

Biofortification is a long-term solution to improve the nutritional quality of cereals and can be achieved through agricultural practices, genetic engineering, and biotechnologies. This method allows direct biofortification of cereal crops with vitamins A, B1, B2, B3, B6, B9, B12, C and E (Garg, M. et al, 2018).

1.2. The role of cereals and cereal derivatives in human health

1.2.1. Nutritional value of cereals and cereal derivatives



Bioactive compounds

Along with terpenoids (which also include vitamin E), there are other antioxidant substances in cereals, such as polyphenolic compounds, flavonoids, carotenoids (lutein) and lignans (Capurso, C., 2021), also known as bioactive compounds. In wheat, the most abundant phenolic acid is ferulic acid, concentrated especially in bran, aleuronic and germ layer. According to data in literature, bran contains 15-18 times more polyphenolic compounds than endosperm (Fardet, A., 2010). The more whole grains in the bread, the higher the content of antioxidant substances will be.

Numerous scientific evidence support the hypothesis of beneficial effects of the whole grains consumption beyond the provision of basic nutrients, their protective effect against cardiovascular diseases, cancer, type 2 diabetes, being demonstrated by epidemiological studies (Călinoiu, L.F., 2018).

1.2. The role of cereals and cereal derivatives in human health

1.2.2. Benefits of cereals and cereal derivatives consumption

Cereals and cereal derivatives are basic products in the diet of people around the world.

Among the most important advantages of eating cereals we mention:

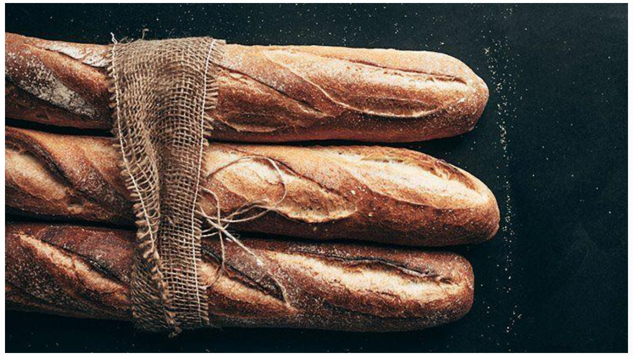
1. Through its high content of carbohydrates it is the most important source of energy, covering 30-50% of the caloric needs. By having as main representative starch, but also dietary fiber, cereal carbohydrates are clearly superior in terms of effects on the health compared to sugary products containing simple carbohydrates.
2. The increased protein content recommends cereals and their derivatives as a good source of protein in vegan and vegetarian diets, during periods of religious fasting and especially in poor countries where the diet is poor in foods of animal origin, the main source of protein.
3. By the natural content of vitamins and mineral elements of whole grains and the fortification of refined cereal derivatives, cereals contribute to the intake of these micronutrients (Fe, Mg, Ca, vitamins of the B complex, vitamin A, vitamin E). They also bring an important amount of bioactive antioxidant substances, with numerous beneficial effects in maintaining health.

4. Through soluble dietary fiber (predominantly in oats and barley) intake and insoluble fiber (mainly present in wheat) intake, cereals contribute to maintaining health both directly, through the functional effects of fiber, and indirectly through the intestinal microbiota.
5. During the germination of cereals, phytohormones are synthesized, about which it has been shown that, against the background of an atherogenic diet, they have the ability to lower the level of hypercholesterolemia and prevent atherosclerosis (Andersson, A.A.M. et al., 2014).
6. Through their nutritional value and energy density, cereals and cereal derivatives play an important role in people's diets being recommended for both healthy people and those with various diseases.

1.2. The role of cereals and cereal derivatives in human health

1.2.2. Benefits of cereals and cereal derivatives consumption

7. Cereals and cereal derivatives, especially those based on whole grains are a staple food in the most valued diets such as the Mediterranean diet, the diet to stop hypertension (DASH).
8. White bread is recommended together with whole grain bread for growing children and pregnant women, the elderly, people with poor nutrition, due to the disposal of excess phytates and in support of increasing the intake of energy and micronutrients.
9. Also, white bread is indicated in acute episodes of diseases in which there is an intolerance to fibrous material such as gastritis, gastric and duodenal ulcers, enterocolitis and ulcero-hemorrhagic colitis, as well as in malabsorption syndromes.
10. Whole cereals and their derivatives are recommended for young people and healthy adults, as well as in the nutritional therapy of metabolic diseases (obesity, metabolic syndrome, type 2 diabetes, dyslipidemia, hyperuricemia, hepatic steatosis), digestive diseases referred to in point 7 during the remission period, cardiovascular diseases, cancer, autoimmune diseases, chronic infections, while taking antibiotics, allergic diseases and neurodegenerative diseases.



1.2. The role of cereals and cereal derivatives in human health

1.2.3. Recommendations for cereals and cereal derivatives consumption in the project partner countries (see Table no. 1.1)

Table no.1.1. Summary of recommendations for cereals and cereal derivatives consumption in the project partner countries (https://knowledge4policy.ec.europa.eu/health-promotion-knowledge-gateway/food-based-dietary-guidelines-europe-table-1_en)

Country	Quantitative recommendations	Qualitative recommendations	Portion size
Ireland	3-5 servings/d of whole meal cereals and breads, potatoes, pasta and rice.	-Whole meal and wholegrain cereals are best (be aware of the caloric difference - some types contain more calories than others). -Enjoy at each meal. -The number of servings depends on age, size, gender, activity levels.	-2 thin slices whole meal bread, -1.5 slices whole meal soda bread or 1 pitta pocket, 1/3 cup dry porridge oats or 1/2 cup unsweetened muesli, -1 cup flaked type breakfast cereal, 1 cup cooked rice, pasta, noodles or couscous, -2 medium or 4 small potatoes, -1 cup yam or plantain.
	Notes: potatoes included		
Italy	-3-5 portions of bread/day, 2 times/day -2-4 biscuits/ 2.5 biscuits crackers -1-2 portions/day pasta or rice* + 1-2 portions of fresh pasta*. * if in soup, it is half a portion	Regularly consume bread, pasta, rice, and other grains (preferably wholegrain), avoiding too much fat condiments. When you can, choose products made from wholegrain flours and not simply with added bran or other fiber (read labels).	1 small bun ("Rosetta") 1 medium slice of bread (50 g) 2-4 biscuits 2.5 crackers of bakery products (20 g) 1 average portion of pasta or rice* (80 g) 1 small portion of fresh pasta* (made with eggs) (120 g). *if in soup, it is half a portion
	Notes: potatoes included (number of portions depending on daily energy requirements: 1,700 kcal, 2,100 kcal, or 2,600 kcal).		
Hungary	3 servings of cereals per day, 1 of which should be wholegrain	Swap refined grain choices for wholegrain bread, rolls, pasta, biscuits or cookies, cereals, brown rice Durum wheat pasta could be a good choice as well	-1 piece of pastry (e.g. cookie or bun) -1 medium slice of bread/cake -12 tablespoons (200 g) of cooked pasta/rice -3 tablespoons of cereals/muesli.
	Notes: potatoes included		
Romania	6-11 servings	Bread, cereal, rice and pasta. Preferably unrefined type, with a low amount of SFA or added sugars. Consume large amounts of grain - this group should be the basis of your diet.	-1 slice of bread -½ cup cereal, rice or pasta (cooked) -1 biscuit

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

Numerous scientific evidence associates the beneficial effect of whole grains with its high fiber content (Huang, T. et al, 2015).

Whole grain derivatives contain the greatest amount of dietary fiber. Thus, whole grain bread has a content of 10% non-starchy polysaccharides – NPS, while white bread only 3% NPS. This difference is due to the fact that the whole grain flour is obtained by grinding the whole grain, so it contains all its component parts: bran, germ and endosperm, which, in the case of refined bakery products, obtained from white flour, are removed in the processing process (Niţescu, M. et al., 2017). Compared to white bread, whole grain bread can contain three times more dietary fiber, vitamins and trace elements, being poorer in calories than white bread, which has a higher starch content. Among cereals, oats and barley contain the most important amounts of dietary fiber, especially β-glucans, of viscous type, soluble in water.

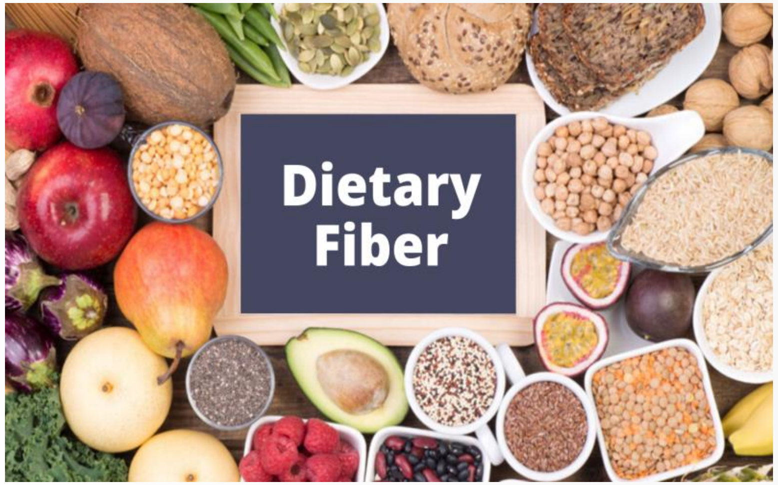
Between 1950-1970, independent observational studies revealed the beneficial effects of eating fiber consumption. The first paper published was that of Eben Hipsley in 1953, which emphasized that pregnant toxemia is less common in women who have a diet rich in fiber. Later, in 1970, Burkitt and Trowell, highlighted the important metabolic effects of dietary fiber and their role in the prevention of cardiovascular disease, diabetes and cancer (Kendall, C.W.C. et al., 2010).

In 2015, based on studies and reports demonstrating the protection brought by the consumption of dietary fiber against coronary heart disease, the US Academy of Nutrition and Dietetics recommended a total daily consumption of fiber of 14 g per 1000 kcal, respectively between 19 and 30 g/day for children and adolescents, 25 g for women and 38 g for men. This recommendation is also relevant for protection against other chronic noncommunicable diseases, such as type 2 diabetes mellitus, different types of cancers, immune disorders. The consumption of dietary fiber can reduce the incidence of colorectal cancer, but also of other types of cancer, along with improving overall intestinal health.

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

Dietary fiber and obesity (Nițescu M. et al., 2019)

The evidence on the benefits of a diet rich in dietary fiber needed to maintain an optimal weight and prevent obesity are very numerous. At the same time, the importance of fiber is also stressed for weight control in people with excess weight (Brownlee, I.A. et al., 2017).



Several mechanisms are described that explain the favorable effects of dietary fiber in weight control (Bozzetto, L. et al., 2018):

- soluble and insoluble fiber increase the intraluminal viscosity in the small intestine and provide a mechanical barrier, in this way there is a decrease in the absorption of glucose and fatty acids and the slowing down of the intestinal transit, which leads to the increase of lipid oxidation and the reduction of adipose tissue reserves;
- the decrease of glucose absorption causes a reduced insulin response, which prevents postprandial reactive hypoglycemia. This makes the feeling of hunger appear not too soon and the food intake to decrease;

Dietary fiber also influence weight through hormonal effects. These effects are mediated by insulin and gastrointestinal hormones (CCK, GIP, GLP-1), which influence glucose satiety and homeostasis, independent of the glycemic response;

- fermentable dietary fiber alter the gut microbial flora. Thus, a diet rich in fiber increases the bacterial species belonging to the taxonomic classes Bacteroidetes and Actinobacteria, characteristic of slim persons and reduce the species from the Firmicutes and Proteobacteria classes, characteristic of obese persons.
- through the colonic fermentation of fiber saturated fatty acids with short chains (acetic, propionic, butyric) appear and contribute to the regulation of body weight by delaying the emptying of the stomach followed by increasing satiety and improving insulin sensitivity, thus modulating the oxidation of glucose and fatty acids.

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

Observational studies have shown an inversely proportional relationship between the amount of fiber in the diet and the abdominal circumference, respectively the percentage of visceral fat (Davis, J.N.et al., 2009).
It is important to emphasize that, in epidemiological studies, the beneficial effects of fiber consumption on weight and reduction of abdominal adipose tissue have been observed both in the case of total dietary fiber, as well as separately for cereal fiber (Du, H. et al., 2010).

Regarding the clinical trials, their results are less consistent compared to those obtained in the epidemiological studies. It has been observed in several studies that there are no statistically significant differences in weight loss when eating whole grains compared to refined cereals.

Dietary fiber, insulin resistance and diabetes (Nițescu M. et al., 2019)

Scientific evidence on the benefits of dietary fiber in relation to insulin resistance is scarce, and the results of some of the studies are inconsistent.
A cross-sectional epidemiological study conducted in the United States, the Insulin Resistance Atherosclerosis Study (Liese, A.D. et al., 2003) found a direct relationship between consumption of whole grain fiber and insulin sensitivity. Randomized clinical trials have had contrary results, with the consumption of whole grains not significantly altering insulin resistance.
The possible mechanisms by which dietary fiber alter insulin resistance are represented by the production of short-chain fatty acids through colon fermentation and the prebiotic effect that some of the fiber have.
If we evaluate the relationship between fiber intake and the risk of diabetes, the evidence is similar to the relationship between fiber and insulin resistance. And in this case, epidemiological studies show an inverse relationship between the consumption of whole grain fiber and the risk of diabetes (The InterAct Consortium, 2015). Another study, Predimed (Martinez-Gonzalez, M.A. et al., 2015), showed the existence of a reverse relationship between the Mediterranean diet (rich in whole grains, vegetables and fruits) and the incidence of type 2 diabetes, after a follow-up of almost 4 years.

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

Dietary fiber and cardiovascular diseases (Nițescu M. et al., 2019)

Over the past two decades, numerous observational studies have drawn attention on the beneficial effect of dietary fiber in the prevention of coronary heart disease (Soliman, G.A., 2019).

Health benefits occur with a consumption of 12-33 g/day for fiber in food and at 42.5 g/day for fiber from supplements (Dahl, W.J., Stewart, M.L., 2008).

The direct protective effect of dietary fiber in the etiology of coronary heart disease is to lower plasma lipids (viscous soluble dietary fiber decrease total cholesterol and LDL-cholesterol and possibly triglycerides as well). Of the fiber, soluble non-starchy polysaccharides seem to be effective, not the insoluble ones, nor the resistant starches (solid evidence demonstrates the cholesterol-lowering effect of oat bran, pectins and natural or synthetic gums) (Threapleton, D.E. et al., 2013).

The mechanisms that explain these effects are related to the digestion and absorption of fats. The effect of soluble fiber in slowing the absorption of fats and cholesterol, the direct inhibition of the synthesis of liver cholesterol by the propionate formed by the fermentation of soluble non-starch polysaccharides in the large intestine and the increase of the fecal excretion of unabsorbed bile acids in the distal ileum and neutral sterols is known. However, cohort epidemiological studies have not shown any link between soluble, viscous fiber and coronary risk. The opposite is true, there are consistent epidemiological evidences that emphasize the benefit of an increased intake of whole grain fiber on the coronary risk, although clinical studies have not shown any metabolic effect thereof (Davis, J.N.et al., 2009).

It has been hypothesized that perhaps other compounds existing in cereals explain this effect (lignans, phytosterols, antioxidants etc.) (Jonson, I.T., 2005).

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

It is believed that other physiological effects of dietary fiber also contribute to cardiovascular protection. Among them, the decrease in TA, especially in the elderly and hypertensive persons, as well as the reduction of inflammatory markers (C-reactive protein).

Referring strictly to the relationship between the fiber intake from whole cereals and bran and cardiovascular risk, a recently published systematic review (Barrett, E.M. et al, 2019) hypothesizes that in the case of whole grains, the beneficial effect of cardiovascular protection would be due to other constituents such as vitamin E, magnesium and bioactive compounds (phytoestrogens). Comparing the consumption of whole grains with the consumption of bran, a slightly higher reduction in the risk of cardiovascular disease was observed in the consumption of bran (Barett, E.M. et al, 2019). In the case of both whole grains and bran, the risk of HTA and coronary heart disease was also low (Flint, A.J. et al, 2009).

Dietary fiber and cancer (Nițescu M. et al., 2019)

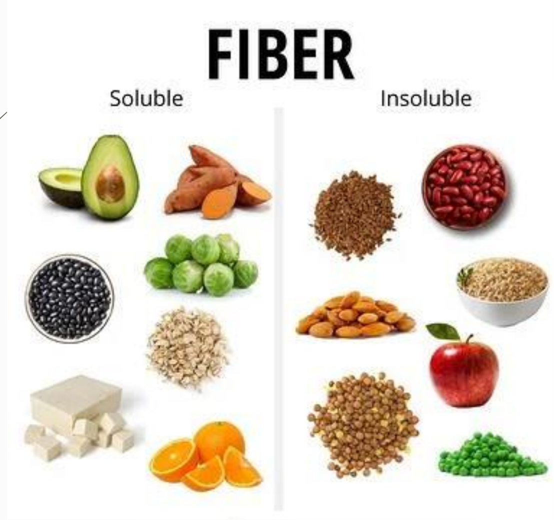
Data obtained in epidemiological studies show that nutrition plays an important role in the prevention of cancer. Among the dietary factors, dietary fiber seems to have a protective effect in the development of cancer, especially colorectal cancer (CR) and breast cancer (McRae, M.P., 2018).

Case-control studies on the incidence of CR cancer conducted in the USA, have found that an intake of 13 g fiber/day from food can reduce the risk of this type of cancer by 31%. Separate analysis of dietary fiber sources revealed a significant reduction in risk (10% for every 10 g of fiber) in the case of cereals, while for legume, fruit and vegetable fiber, no significant reduction was found (Dahl, W.J., Stewart, M.L., 2015).

In Europe, the prospective EPIC study - The European Prospective Investigation into Cancer and Nutrition (500,000 people in 10 countries with high incidence of colorectal cancer), showed that those who consumed on average 33 g fiber/day, had a 25% lower incidence of CR cancer compared to those who consumed 12 g fiber/day. The authors claim that doubling the fiber intake in those with low consumption (12 g / day) can reduce the incidence of cancer by 40% (Dahl, W.J., Stewart, M.L., 2008).

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

The mechanisms by which dietary fiber exert a protective effect against colorectal cancer are numerous, all categories of fiber having beneficial effects.
Insoluble dietary fiber increase the volume of the fecal bowl, through this property they decrease the intestinal transit time and the contact of carcinogens with the intestinal mucosa is reduced. At the same time, a dilution of carcinogens is also taking place. By binding the primary and secondary bile acids, but also other mutagenic agents, the insoluble fiber decreases the concentration of free mutagens in the intestine.



Resistant starch together with soluble and insoluble fiber alter the fecal flora and increase the number of bacteria. Secondary, decreases the concentration of bile acids that have carcinogenic potential, as well as the concentration of colonic ammonia, cytotoxic.
Another mechanism, especially due to resistant starch, is to decrease the fecal pH by producing fatty acids with short carbon chains. Thus, sensitive, potentially pathogenic, pH bacterial species that could produce potentially carcinogenic compounds are inhibited. It also decreases the absorption of toxic alkaline compounds (amines) and the solubility of bile acids.
The fermentation of resistant starch, but also of other non-starchy polysaccharides, by producing butyrate, promotes the normal phenotype of cells, delays the growth of malignant cells and favors DNA repair (butyrate is the preferred substrate of colon cells, providing 70% of the energy needed for them).

Regarding the relationship between total dietary fiber intake and breast cancer, a review published in 2018, which included 4 meta-analyses, showed that the incidence of cancer increases from 7% in people with the highest fiber intake to 15% in people with the lowest intake (McRae, M.P., 2018).
Several mechanisms through which dietary fiber protect from breast cancer and endometrial cancer have been formulated, being known the involvement of prolonged exposure to estrogens in the occurrence of both types of cancer.

1.3. The role of dietary fiber in health promotion and preventing chronic noncommunicable diseases

It seems that dietary fiber bind estrogens to the colon and increase fecal elimination, thereby reducing their concentration in the blood.

On the other hand, fiber reduce the activity of an enzyme β-glucuronidase, which hydrolyzes conjugated estrogens before being absorbed in the colon. Other compounds that are brought together with the fiber in food, such as antioxidants, lignans, phenolic acids, also have protective effects against breast and endometrial cancer.

Another mechanism is explained by the effect of fiber to prevent weight gain. The fact that adipose tissue no longer accumulates, makes adipocytes secrete fewer estrogens, the synthesis of these hormones being proportional to the size of adipose cells.

1.4. The benefits of functional bakery products consumption

The benefits of eating whole grains are well known, they are the main source of fiber, B-complex vitamins (thiamine, riboflavin), mineral elements and polyphenolic substances.

The fiber intake from bread and cereal derivatives varies from country to country, so in the USA and Spain, 32-33% of the fiber intake comes from cereals, while in the Netherlands and Ireland, cereals provide 48-49% of the total fiber intake (Gebski, J. et al., 2019). In some countries bread is the main source of fiber (11-30% of the total intake), the rest of the cereal products having a lower contribution (breakfast cereals 5-8%, pastry 3-11% and pasta 1-4%) (Stephen et al., 2017).

The consumption of foods rich in whole grains and fiber provides only 7% of the total fiber intake. In the American diet, 39% of fiber comes from cereal derivatives that do not contain whole grains, while foods containing refined cereals are widely consumed (Kranz, S. et al, 2017).

Starting from the idea of reducing the deficiency of fiber in the diet, in 2009 the Codex Alimentarius, following long consultations with experts and authorities from all over the world, gave a comprehensive definition of dietary fiber in which it included alongside the fiber naturally present in plants, isolated fiber from plant raw materials and industrially synthesized fiber that have proven to exert beneficial physiological effects. It has been accepted the hypothesis that, similar to vitamins, fiber vary in structure, functions and necessary intake and that each of them, contributes to optimal health if they are present in adequate quantities.

By enriching foods with fiber leads to increased intake, while the caloric value of the diet can be maintained at the recommended level.

In the context in which simple, white bread is still a very consumed and preferred food, enriching it with fiber can be a way to improve the fiber intake of the population. The reformulation of bread for the purpose of enrichment with fiber (resistant starch and bran) must consider especially the sensory qualities so as to have a positive impact on the consumer. As long as consumers negatively perceive the relationship between taste and health, their interest in healthy eating will be limited (Grunert et al, 2010, Gebski, J. et al., 2019).

1.4. Beneficiile consumului de produse de panificatie funcționale

Studies highlight the increase in the nutritional value of plain bread enriched with corn bran, rice bran and sorghum bran, both in terms of fiber content and certain mineral elements (Mounjouenpou, P. et al., 2019; Bourre et al., 2008).

Good results both in terms of sensory properties and metabolic effects (increased satiety, decreased blood glucose and postprandial insulinemia, increased fecal elimination and production of short-chain fatty acids) were obtained by the addition of resistant corn starch (Hi Maize) in bread, pasta, breakfast cereals (Ingredion, 2018).

Torres and collaborators (2019) have demonstrated that by adding soluble fiber and polyphenols from green tea, using an adequate proportion of ingredients and controlling the baking process, bakery products with a reduction in acrylamide content of up to 64% can be obtained. In addition, the addition of soluble fiber reduces the digestibility of starch, implicitly the level of rapidly absorbed glucose. (Torres, J.D. et al, 2019)

Tessari and Lante (2017) in a research conducted on a group of patients with type 2 diabetes found that replacing white bread with bread enriched with soluble fiber (7 g fiber/100g and with beta glucan/starch ratio 7.6/100) reduces a jeune blood sugar and significantly, postprandial blood sugar (Tessari, P., Lante A., 2017). Regular consumption of bakery products enriched with soluble fiber can improve average and long-term glycemic control in the case of type 2 diabetes, along with hypoglycemic treatment.

The question of whether the health effects are equal when it comes to whole grains and refined cereals enriched with fibers is not completely clarified, so the transmission of messages on the consumption of whole grains must remain a priority.

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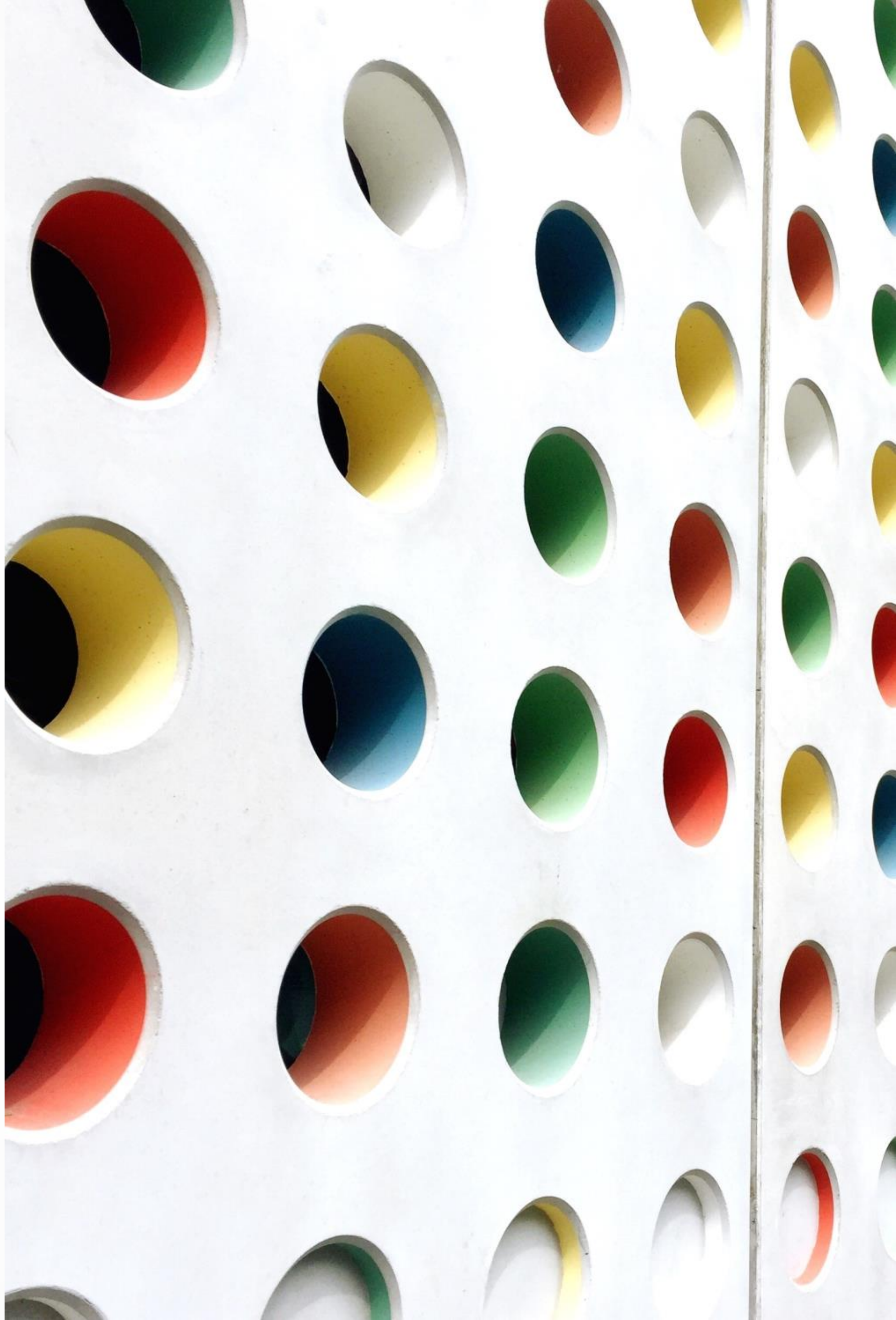
CHAPTER 2.

Types of functional bakery products



2.1. Types of functional bakery products

GENERAL

In order to meet a person's nutritional requirements, enough nutrients must be provided by a proper diet.

In present there are sufficient data that support the fact that certain ingredients and foods have beneficial physiological and psychological effects besides providing basic nutrients.

Nowadays, science of nutrition has moved on from the classical concepts of avoiding nutrient deficiency to the concept of "positive" of "optimum" nutrition.

Lately, the research shifted more on identifying the biologically active components from foods that have the potential to optimize the physical and mental wellness to reduce the risk of illness.

In the 80's in Japan first appeared the concept of functional foods and the sanitary authorities recognized an improvement of the quality of life that can increase the quality of life. This type of foods were developed specially to promote the health and reduce illnesses.

LEGISLATION

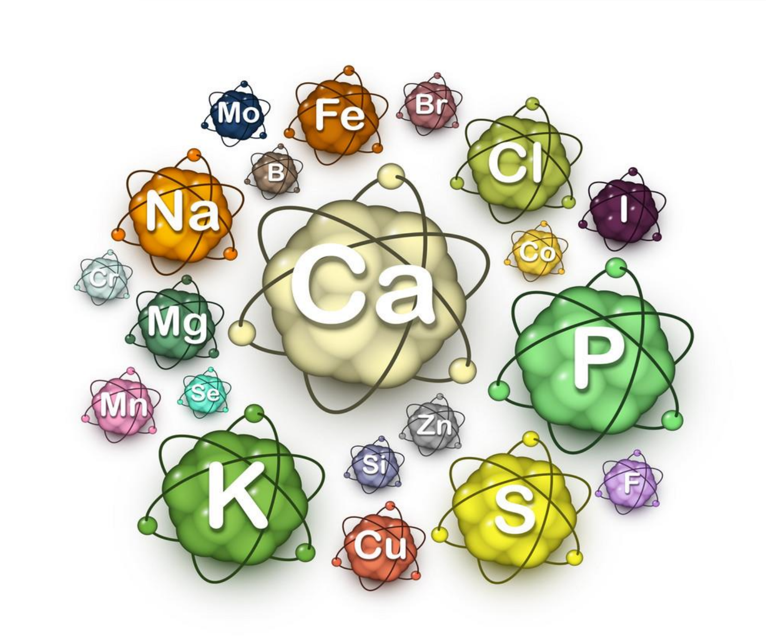
In Europe, in this point there is no legislation defined. Functional foods are considered to be foods destined for consumption

Functional foods have not yet been defined by legislation in Europe, and are generally considered to be foods that are intended for consumption as part of a normal diet and contain biologically active components that help to improve health and reduce the risk of disease.

- **REGULATION (EC) NO. 1924/2006** of the EUROPEAN PARLIAMENT AND OF THE COUNCIL from 20 December 2006 on nutrition and health claims made on foods
- **REGULATION (EC) NO. 1925/2006** of the EUROPEAN PARLIAMENT AND OF THE COUNCIL from 20 December 2006 on the addition of vitamins and minerals and certain other substances to foods.
- **REGULATION (EC) NO. 41/2009** of the Commission from 20 January 2009 on the composition and labelling of foods suitable for people intolerant to gluten
- **Implementing Regulation (EU) no. 828/2014** of the Commission from 30 July 2014 regarding the requirements for the provision of information to consumer on the absence or presence or reduced amounts of gluten in food.

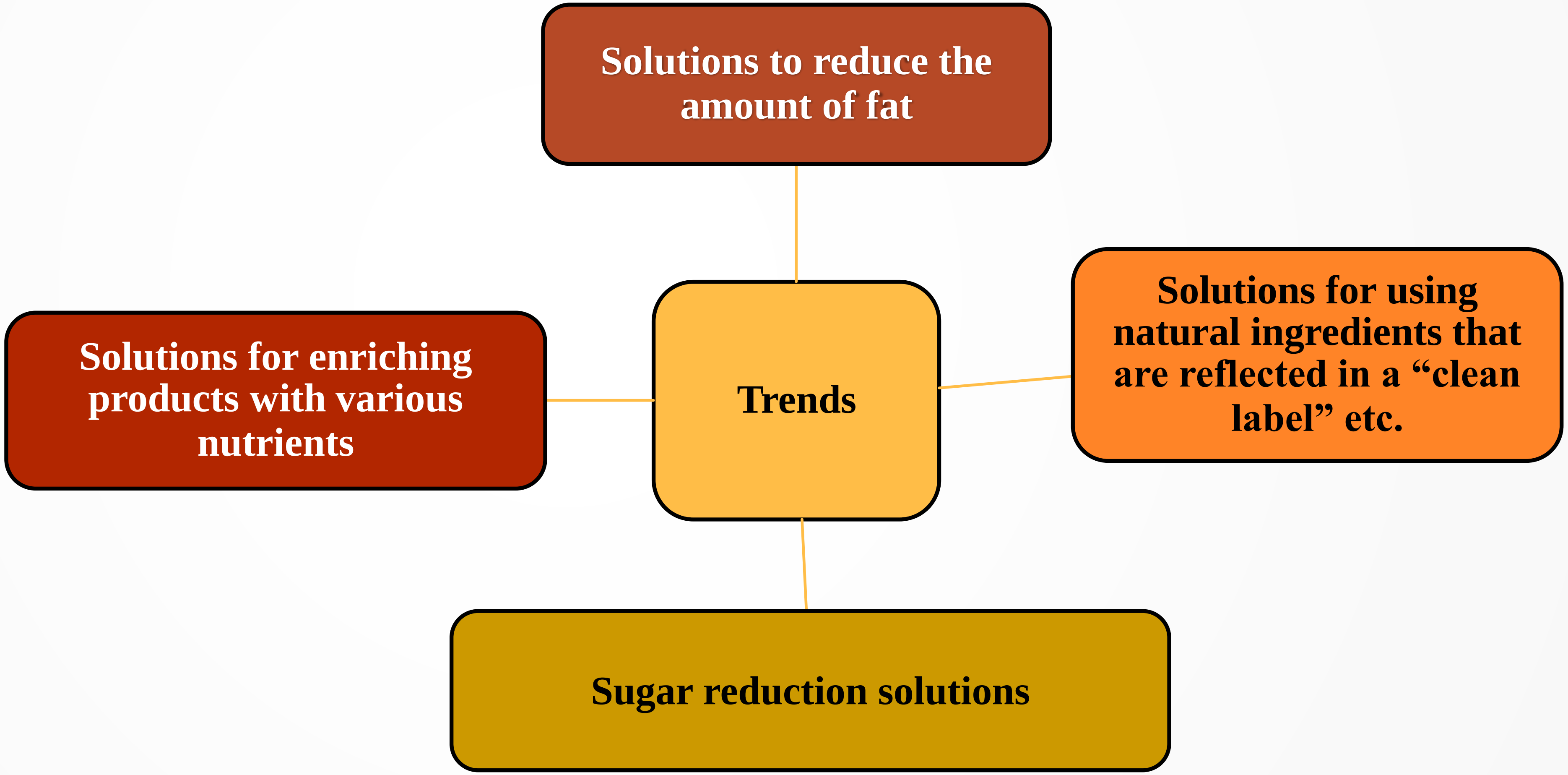
2.2. Analysis of the assortment range of bakery products with a functional role

The food products have been created for people that suffer of certain diseases.
They are also named products for particular nutritional use – PARNUTS.
Their composition is adapted to in order to satisfy the requirements of persons with different diseases.
Products from which certain compounds have been eliminated are part of this category (bakery products without salt, without gluten, low acidity) and certain bakery products in which compunds were added (dietary fiber, microelements, vitamins, etc.) (Rumeus I., 2016)



2.2. Analysis of the assortment range of bakery products with a functional role

For meeting the consumers requirements for various health conditions, specialists in the bakery sector are considering the following trends from a technological point of view:



2.2. Analysis of the assortment range of bakery products with a functional role

Questions	Does lowering sugar help lower the number of calories in a low-sugar bakery product?
Answer	Reducing the amount of sugars will not necessarily reduce the number of calories. This is because the fiber used to replace sugar are carbohydrates and therefore have a caloric content similar to that of sugar. A high caloric reduction can be achieved by reducing the fat content, because fat has a higher caloric content.
Questions	Do the proposed reformulation solutions come with process limitations?
Answer	The research carried out in the bakery units leads to the development of new solutions, which do nothing but develop new technological processes.
Questions	Is the development of solutions based on clean label?
Answer	Yes, the solutions are aimed at developing products with the label as clean as possible, and where there are "E" numbers, they try to be limited to those that are usually already found in the ingredients.

2.2. Analysis of the assortment range of bakery products with a functional role

A) Alergen free products

Types of functional bakery products

B) Products enriched with different compounds (fibers, vitamins, minerals etc.)

C) Products with low salt, sugar, fat, etc.

A) Alergen free products

A1) Gluten free products

A2) Functional bakery products for people with celiac disease

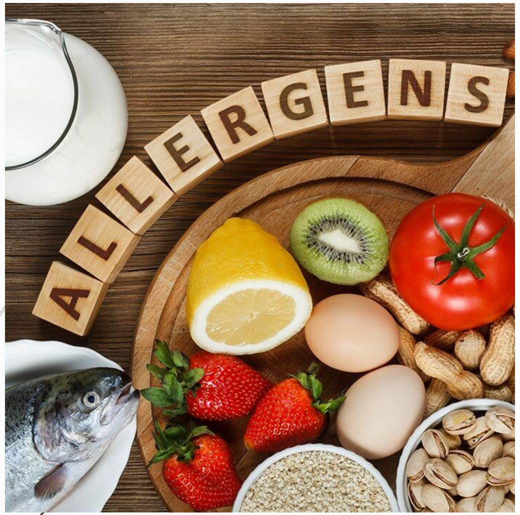
A3) Lactose-free products

Hungary

Romania

Italy

A) Alergen free products



The allergen is an antigen that causes allergic reactions in the human body. Most allergens are proteins, often with carbohydrate side chains (glycoproteins), but less often are pure carbohydrate allergens, small molecule chemicals (isocyanates, anhydrides or formaldehyde), and some metals (eg. chromium and nickel).

A1) Gluten-free products

Gluten intolerance or celiac disease is an autoimmune genetic disease caused by a sensitivity to gluten. In the case of people suffering from this disease, gluten consumption produces a toxic immune reaction. This reaction causes damage to the lining of the small intestine, inflammation and malabsorption of important nutrients such as fats, calcium and iron.

About 1% of the world's population is affected by celiac disease, but unfortunately many people remain undiagnosed even though much progress has been made.

A) Alergen free products

A2) Functional bakery products for people with celiac disease

Celiac disease, also known as gluten-sensitive enteropathy, is an autoimmune reaction of the body to the consumption of gluten, a protein found naturally in grains such as wheat, barley and rye. The autoimmune reaction causes damage to the intestinal villi, which covers the inner walls of the small intestine, leading to chronic malabsorption of various nutrients, especially minerals and vitamins (Koskimaa et al., 2020).

A3) Lactose-free products

One of the most common forms of food intolerance is lactose intolerance. It is characterized by an inability to digest and absorb lactose. It is manifested by gastrointestinal symptoms caused by the consumption of milk and its derivatives.

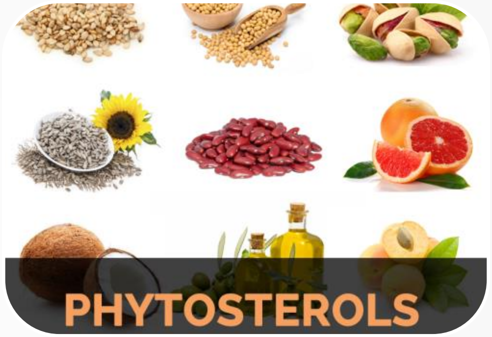
Lactose cannot be absorbed in the intestine as such but must be broken down by the body's own lactase. Problems occur when this enzyme is missing from the body and the non-cleavage process can no longer take place.

B) Enriched bakery products

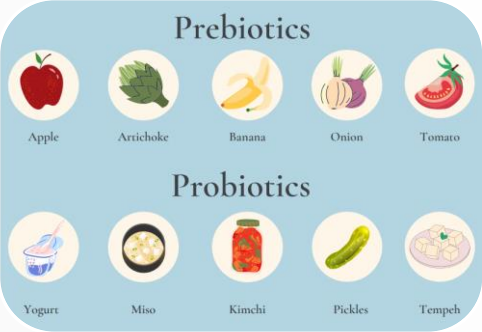
B1) Vitamin enriched products

B2) Mineral enriched products

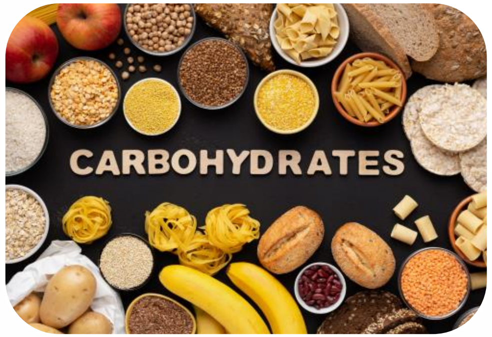
B3) Functional bakery products with added folic acid



B4) Functional bakery products enriched with phytosterols



B5) Advantages on consuming probiotic / prebiotic / symbiotic enriched bakery products



B6) Carbohydrate enriched products

B7) Fiber enriched products

B8) Protein enriched products

B) Enriched bakery products

Enriched products are functional products that have proven to have beneficial effects on health along with basic nutritional effects. It is important that the process does not affect the basic organoleptic properties of the product (Markovics E., 2007).

B1) Vitamin-enriched products

Vitamins are vital biological compounds essential for the body [6]. By enriching with vitamins, the amount of vitamins, essential for the human body, is increased. For bakery products, B vitamins, such as vitamins B1, B2, B3, B6 and B9 are added. B-complexes are most commonly used for this purpose (Markovics E., 2007).

B2) Mineral enriched products

The minerals in our body promote the proper functioning of enzymes and stimulus transmission processes. Bakery products are often enriched with minerals such as Fe, Ca and P. The essential amount of iron in humans is small, but obvious for the enzymes hemoglobin, cytochrome, peroxidase and catalase (https://www.news-medical.net/health/What-is-Phenylketonuria-(PKU).aspx)

The daily dose of Ca and P is 800 mg, which is the highest of the minerals (Markovics E., 2007).

B3) Functional bakery products with added folic acid

Except β - glucan, and other ingredients, characterized by beneficial properties for health can be added to bread and bakery products. These ingredients are either substances that are not contained in conventional products, or substances that already exist but in small quantities - often too small to influence people's health and well-being.

B) Enriched bakery products

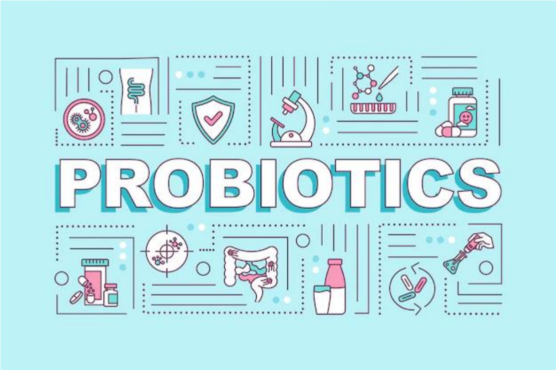
B4) Functional bakery products enriched with phytosterols

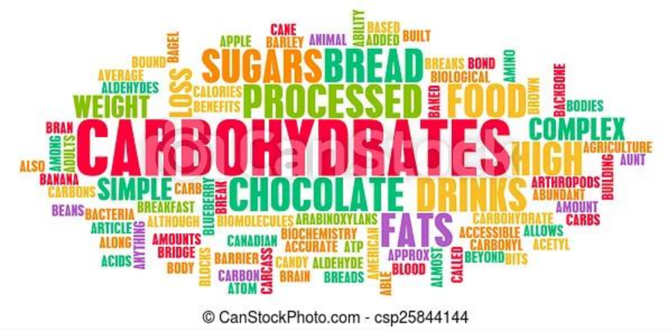
Phytosterols (plant sterols) are some of the compounds that make up plant cell membranes. Their chemical structure is similar to the structure of cholesterol, so they can be treated by the human body as cholesterol, and as a result, their consumption can cause a drop in blood cholesterol levels.

B5) Advantages of consuming probiotic / prebiotic / symbiotic enriched bakery products

The term "probiotic" is derived from the Greek word "pro bios" which means "for life" and is associated with bacteria that have beneficial effects on human and animal health.

The first mention of probiotics was made by Elie Meltchnikoff, who introduced the concept of "probiotic" for the long and healthy life of Bulgarian peasants who consumed fermented dairy products daily.





B6) Carbohydrate-enriched products

Carbohydrates, including mono and disaccharides, are an important source of energy for our body due to their easy and fast digestibility (https://www.news-medical.net/health/What-is-Phenylketonuria-(PKU).aspx)

During exercise, carbohydrates are a quick source of energy. Phenylketonuria (PKU) is a genetically inherited disease in which phenylalanine, an essential enzyme that dissociates phenylalanine - hydroxylase, is absent, resulting in the amino acid that builds up in the blood and then in the brain, causing severe and often irreversible brain damage. (https://www.news-medical.net/health/What-is-Phenylketonuria-(PKU).aspx)

B) Enriched bakery products

B7) Fiber-enriched products
Dietary fiber (eg. cellulose, hemicellulose, pectin and other stored polysaccharides) are complex, indigestible carbohydrates. Digestion of cellulose in foods high in fiber helps to intensify bowel movement, thus reducing the time required to pass through the intestinal tract.

B8) Protein-enriched products
Proteins are our basic building materials, help capture water, transfer nutrients, participate in metabolic processes and are an important source of energy (Markovics E., 2007). The emergence of protein-rich products among bakery products is now extremely fashionable and necessary.

B) Enriched products (vitamins, minerals, fibers, proteins, carbohydrates)

Romania

Ireland

Italy

Hungary

C) Products with reduced content (carbohydrates, fat, salt)

Carbohydrates

Products with reduced content of carbohydrates, salt and fats

Fat

Salt

C) Products with reduced content (carbohydrates, fat, salt)

Low-fat foods are functional foods in which the quantitative reduction of substances with excessive intake has a detrimental effect on health. In the bakery industry, low-carbohydrate, low-salt or low-fat products have emerged for this purpose.

C1) Low carbohydrate content bakery products

Low-carbohydrate products are preferred primarily by consumers with metabolic problems, but also by dieters.

The most severe form of carbohydrate metabolism disorder is diabetes, where type 1 and type 2 can be distinguished (https://cukorbetegseg-inzulin.hu/cukorbetegseg-fajtai).

C2) Low salt bakery products

In the current context, the concentration of salt in food has become a real problem. Due to the high salt content in the diet, there are problems such as high blood pressure that can lead to stroke and heart disease.

C3) Low fat bakery products

Fats provide our body with energy and chemical compounds essential for maintaining the structure of membranes, building materials for hormones and vitamins (Fenyvessy J., Forgács J., 2000).

Excessive intake will accumulate in our body which can lead to obesity and complications.

To prevent this, today's low-fat products have become fashionable. In the bakery industry, the manufacture of these types of products is still in the experimental stage.

C) Products with reduced content (carbohydrates, fat, salt)

Hungary

Romania

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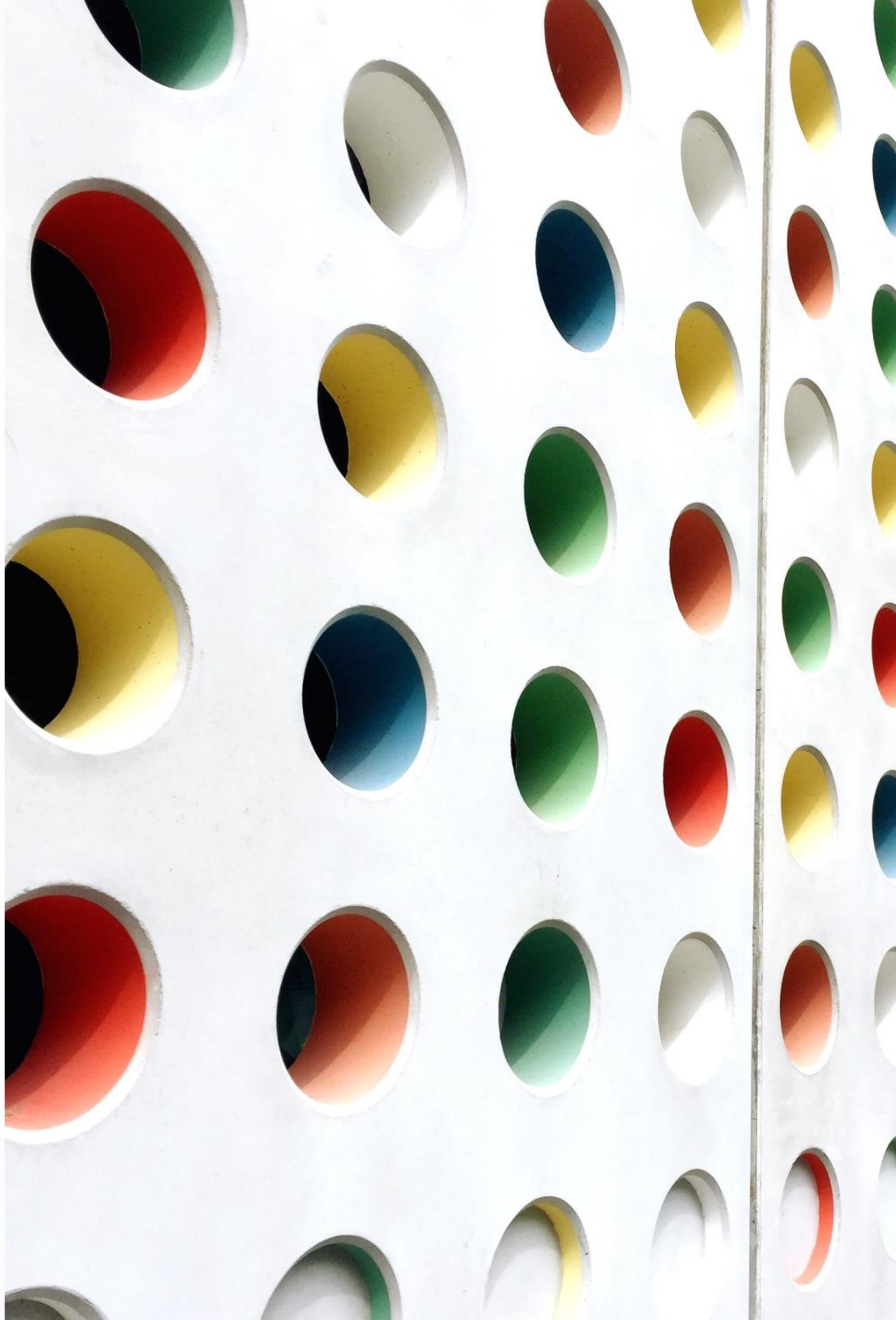
CHAPTER 3.

Newly developed functional bakery products depending on the digestive disorders



3.1 Functional bakery products for digestive disorders

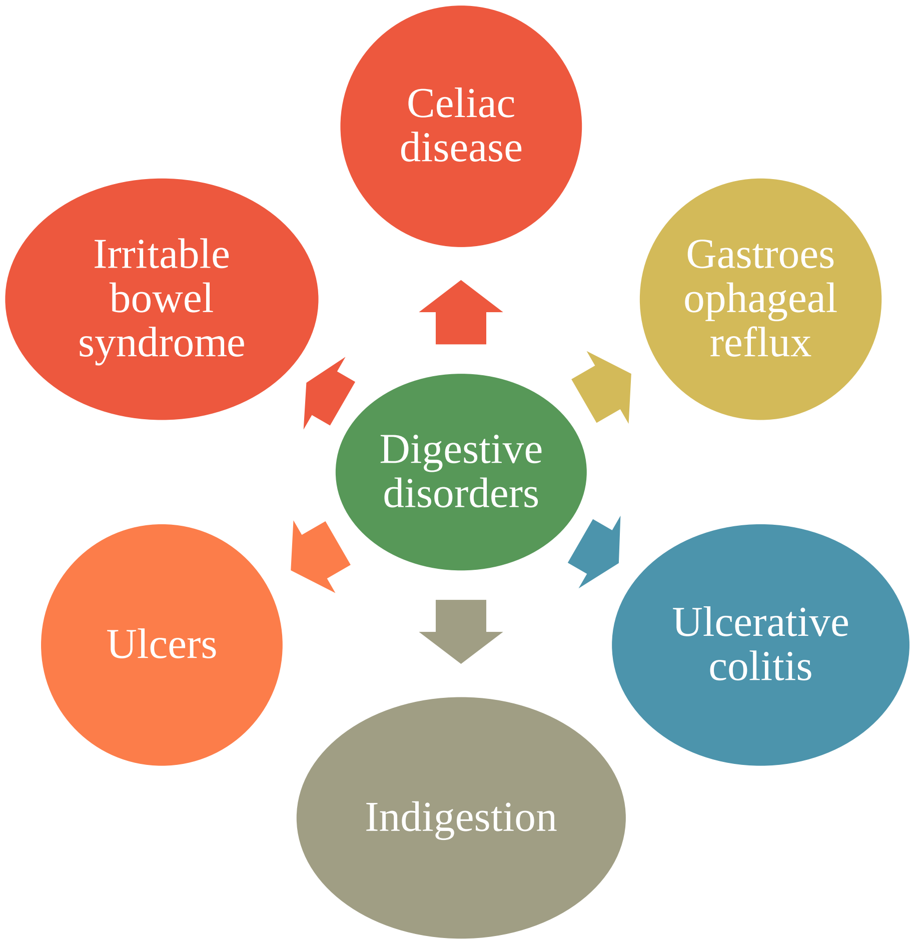


Figure 3.1. Digestive disorders

FUNCTIONAL BAKERY PRODUCTS FOR GASTROESOPHAGEAL REFLUX DISEASE

Table 3.1. The recommended diet and the types of products for **gastroesophageal reflux** disease

Products	Recipe	Observations
Whole-wheat products	60% wholemeal flour (wheat, rye or spelled) and up to 40% other wheat, rye or spelled meal.	The technology involve the use of sourdough or sourdough substitute
Bran bread	10 kg of bran made from cereals or the corresponding legumes per 100 kg of total flour	The starch content of the bran must not exceed 15% of the dry matter.
Graham bread	90% wheat Graham flour and up to 10% other wheat or rye meal (typically flour).	
Bread with high fiber content	10-20% apples, peas and oats as substitute of wheat flour	During the technology we should take into account that dietary fibers affect the water absorption capacity of the dough.
Bread with high vitamin content	small amount of vitamin	vitamins are unstable substances
low-fat pastries	pastries made of water-based and milk-based dough	

Functional bakery products for ulcer disease

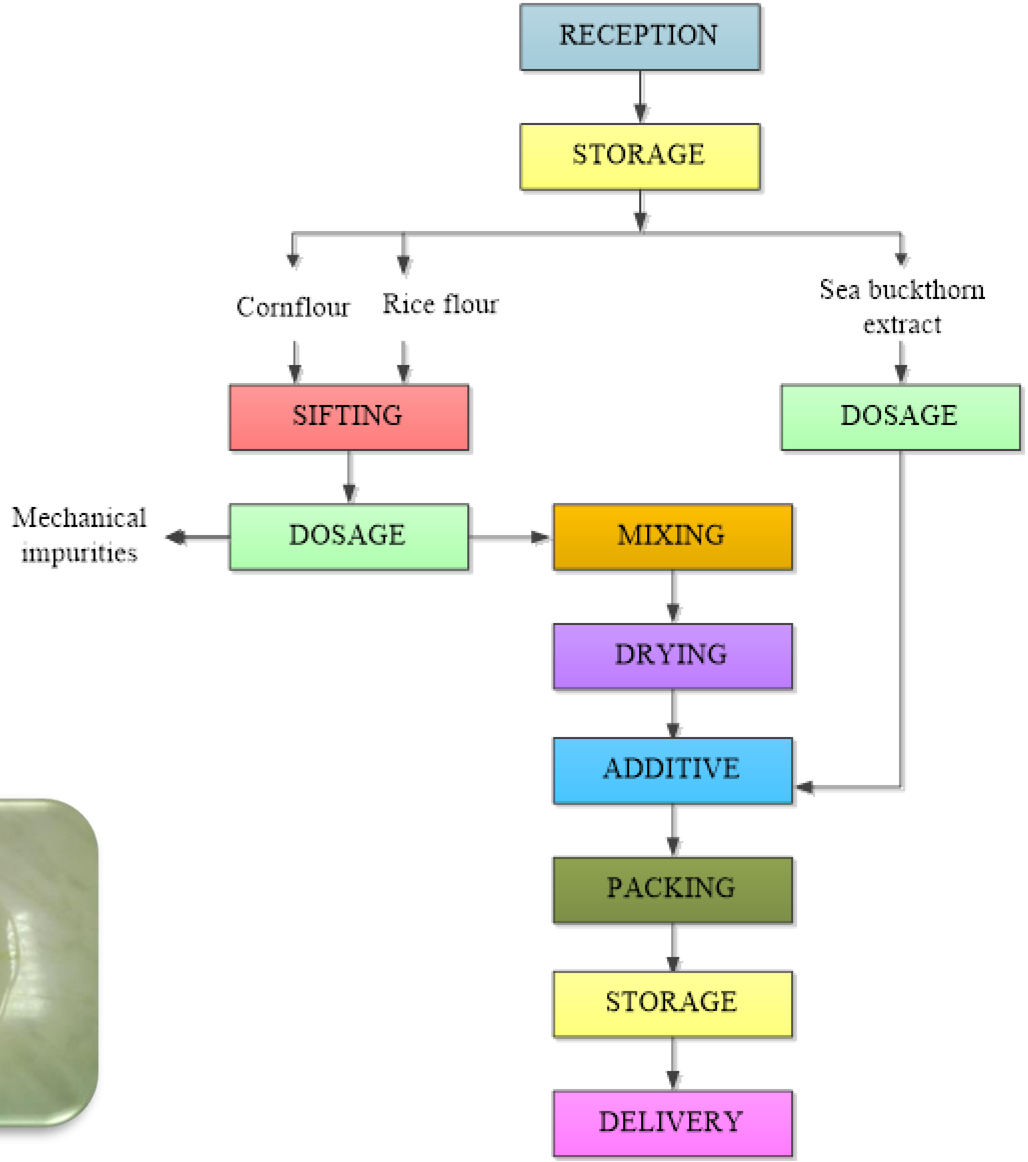
Table 3.2. The recommended diet and the types of products **for different digestive disorders**

Digestive disorders	Flouring products	Observations
➢ **Ulcerative colitis**	Matzo thin, perforated bread dough made using only water and wheat flour	The technology is a short-term process, during which the goal is to avoid the occurrence of various fermentation and other processes in the dough. The whole technology takes 16-18 minutes. Baked at 220 °C for 2-3 minutes.
➢ **Indigestion**	Pastries made from cereal grains of water-based and milk-based dough (at least 3% skimmed milk powder) Characteristic products: Milky crescent, Kaiser Roll and challah	a loose structure
	Flouring products with artificial sweeteners sorbitol use for for reducing carbohydrate content	sugar substitutes, not participate in Maillard reactions and affect the caramelization (skin coloring) and flavor formation
	Flouring products with natural sweeteners:beet sugar (sucrose), fruit sugar (glucose), grape sugar (fructose), malt sugar (maltose), invert sugar (a mixture of glucose and fructose), milk sugar (lactose), and starch syrup and honey	
Ulcers	white bread	Baking technology using a sourdough
	semi-brown bread made from 85% half-white wheat bread flour and 15% light rye flour.	the maximum salt 2.35%, bread with a shiny, crunchy crust and a soft and elastic structure.
	high-fiber foods (fresh fruits and vegetables, bread, tortillas or wholemeal rolls / oatmeal rolls, barley, popcorn with butter or other additives)	
	low-fat biscuits	weaker structure due to its low gluten content
➢ **Irritable bowel syndrome**	diet rich in fiber	

3.2. Newly developed functional bakery products produced in present depending on the digestive disorders

1. *GLUTEN-FREE PREMIX BASED ON CORN AND RICE FLOUR WITH ADDED OF RAISINS AND FIGS*

Raw materials: rice flour, maize flour, raisins and dehydrated figs (Alexa E., 2010b)



Technical specification – Gluten-free premix

Trade name: Gluten-free premix
Description: gluten-free premix with sea buckthorn extract
Weight: 500 g ± 5%.
Composition: cornmeal, rice flour, sea buckthorn extract.

Table 3.3. Organoleptic properties (according to the manufacturer's technical specification)

Properties	Admissibility conditions
Appearance	Uniform "gray"
Color	Yellow to orange-yellow
Taste	Normal, slightly sweet, neither bitter nor sour, no crackling due to mineral impurities (sand, ground, etc.)
Smell	Pleasant, specific to healthy flour, without the smell of mold, heat or other foreign matter.

Table 3.4. Physico-chemical properties (according to the manufacturer's technical specifications)

Properties		Value
Humidity (%)		16,5
Fineness	Residue on metal screen no. 22% maximum	-
	Residue on metal screen no. 24% maximum	2
	Passing through the metal sieve no. 34% maximum	10
	Passing through the metal sieve no. 55% maximum	-

Table 3.5. Microbiological properties (according to the manufacturer's technical specifications)

Properties	Value
Yeasts and molds, max./g	absent
E. coli, max./g	1
Salmonella, /25 g	absent
Coagulase-positive staphylococcus, /25 g	absent
Bacillu cereus, max/g	1

Storage conditions: the storage of the finished products must be done in optimal conditions, which will ensure their quality until the introduction in the manufacturing process. The following factors are important for this purpose: air temperature and relative humidity and light. The optimal parameters are the temperature of 18-20ºC, the relative humidity of 65–70% and the lack of light.

Transport method: transport belts.

Shelf life is 3 months. The shelf life refers to the product stored and transported under the conditions provided by the manufacturer and is recorded from the date of packaging.

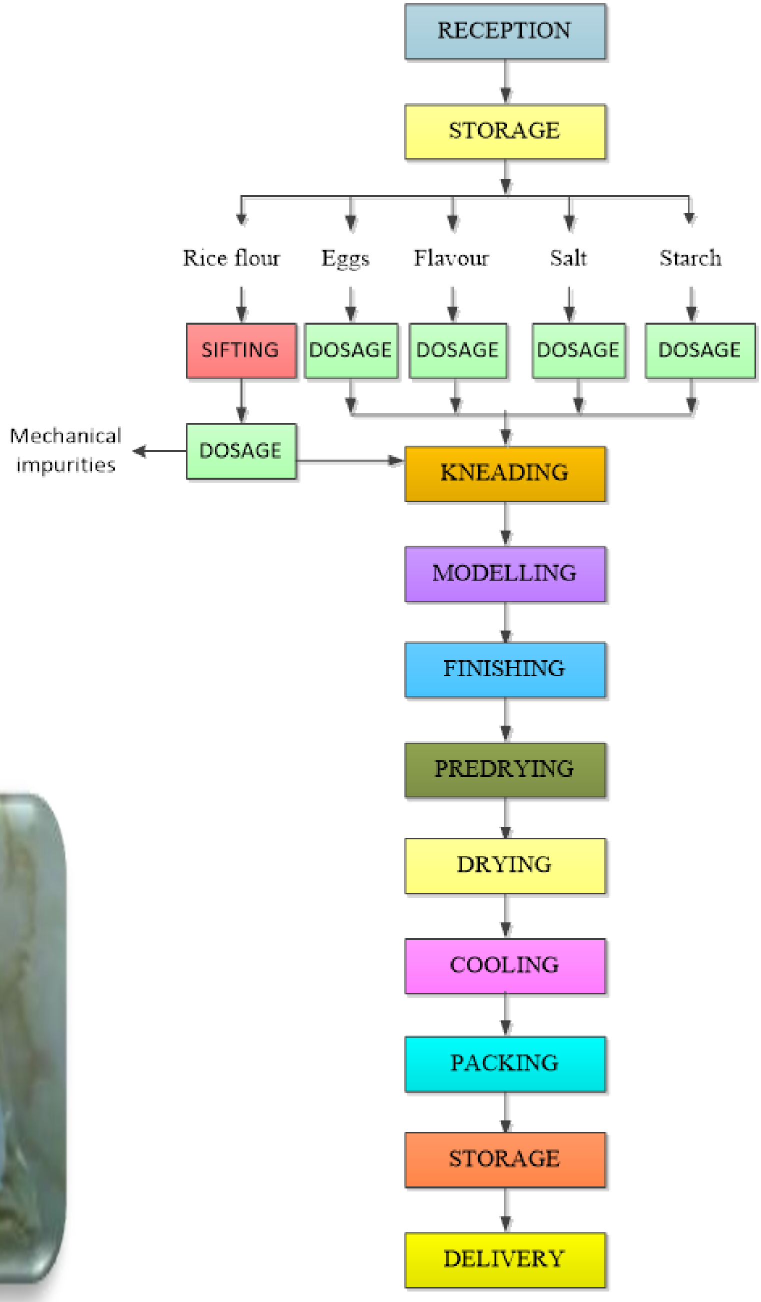
Consumer category: people with gluten intolerance (celiac disease).

Presentation: packed in paper bags weighing 500 or 1000 g. After filling, the bag is glued to the mouth and labeled.

Stability when using the product: the product kept under the prescribed conditions, has stability within the shelf life and above that, approx. 3 months. Failure to comply with the recommended storage conditions will shorten the shelf life, as the product may become unstable (Alexa E., 2010a).

2. *GLUTEN-FREE PASTA OBTAINED FROM RICE FLOUR*

Raw materials: rice flour, corn starch, eggs, water**.**



Technical specification – gluten-free pasta

Trade name: gluten-free pasta
Description: gluten-free pasta obtained from rice flour mixed with maize starch
Weight: 500 g ± 5%.
Composition: rice flour, corn starch, eggs, water

Table 3.6. Organoleptic properties (according to the manufacturer's technical specification)

Properties	Admissibility conditions
Appearance	Smooth surface, without traces of flour, matte / translucent, with a glassy appearance in section
Color	Uniform, yellowish white to yellow-orange
Taste	Normal, characteristic, neither bitter nor sour
Smell	Pleasant, specific, without the smell of mold, heat or other foreign smell.

Table 3.7. Physico-chemical properties (according to the manufacturer's technical specifications)

Properties	Value
Humidity (%)	7
Acidity, maximum degrees	4
Boiling volume increase, maximum %	250
Minimum bending load N (gf)	3,5 (350)

Table 3.8. Microbiological properties (according to the manufacturer's technical specifications)

Properties	Value
Yeasts and molds, max./g	absent
E. coli, max./g	1
Salmonella, /25 g	absent
Coagulase-positive staphylococcus, /25 g	absent
Bacillu cereus, max/g	1

Storage conditions: the storage of finished products must be done in environments with relative air humidity of maximum 60–65% at a temperature of 10-20ºC, avoiding sudden temperature variations, which lead to condensation of water on the surface of the products.

Transport method: transport belts.

Shelf life is 12 months. The shelf life refers to the product stored and transported under the conditions provided by the manufacturer and is recorded from the date of packaging.

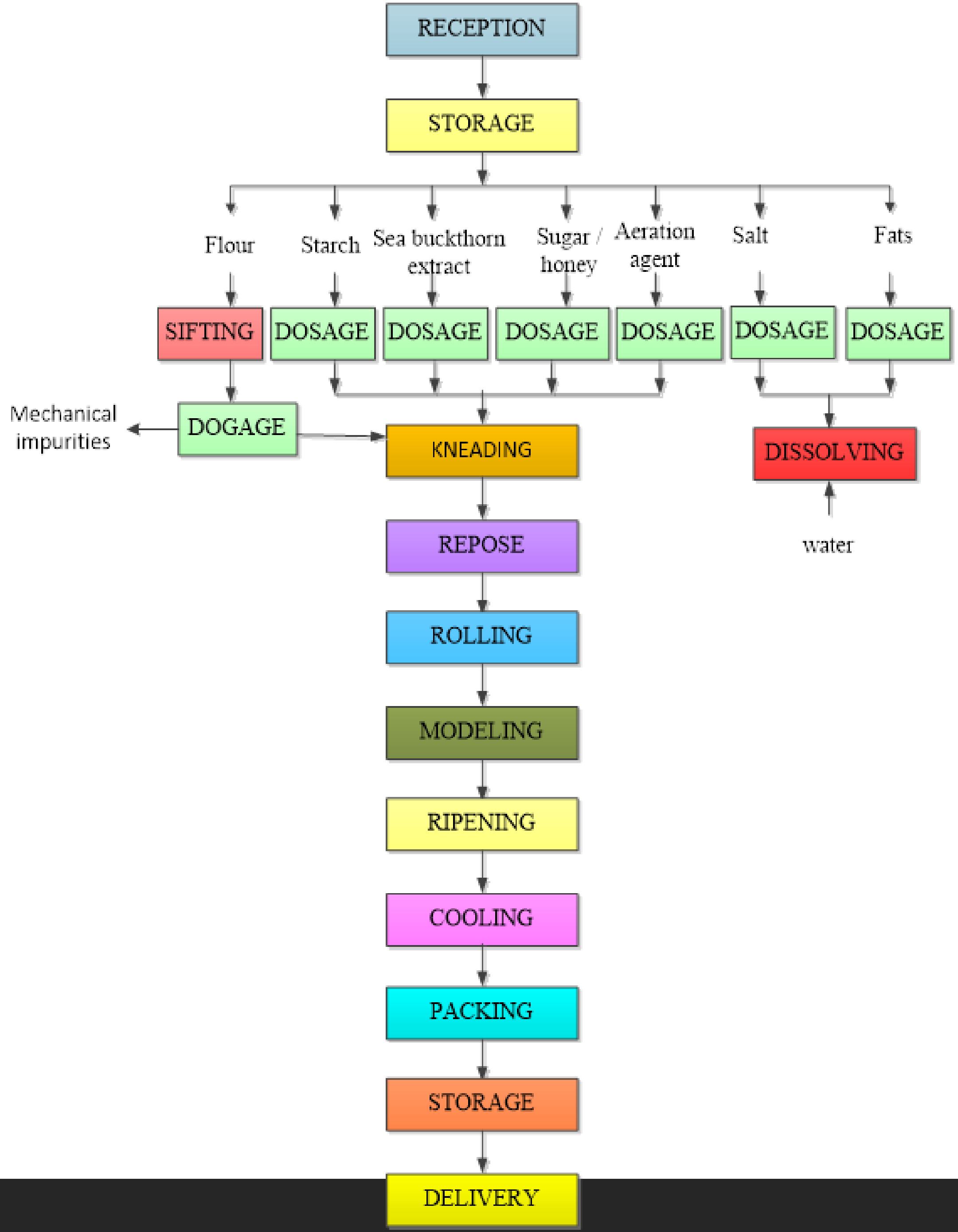
Consumer category: people with gluten intolerance (celiac disease).

Presentation: for pasta, a presentation packaging and a protective packaging against mechanical shocks are made, which can intervene during transport. The presentation packaging consists of: cardboard boxes; parchment paper, cellophane or plastic bags; bulk. Packaging for mechanical protection is done by inserting boxes, envelopes, bags in wooden boxes and corrugated cardboard.

Stability when using the product: the product kept under the prescribed conditions, has stability within the shelf life and above that, approx. 12 months. Failure to comply with the recommended storage conditions will shorten the shelf life, as the product may become unstable (Alexa E., 2010b).

3. GLUTEN-FREE BISCUITS OBTAINED FROM RICE FLOUR AND SEA BUCKTHORN EXTRACT

Raw materials: rice flour, walnut kernels, sea buckthorn extract, eggs, vegetable fat, aeration agents, sweeteners / sugar



Product description – gluten-free biscuits

Trade name: gluten-free biscuits

Description: gluten-free biscuits obtained from rice flour with added fruit

Weight: 5 g ± 5%.

Composition: rice flour, corn starch, aeration agents, sea buckthorn extract, ground walnut, eggs, sugar

Table 3.10.. Organoleptic properties (according to the manufacturer's technical specification)

Properties	Admissibility conditions
Appearance	Round, flattened
Color	Diameter 5 cm
Taste	Pleasant, nuts
Smell	Pleasant, characteristic, suitable for sweet, without sour or bitter taste, without crackling due to mineral impurities (sand, ground, etc.)
	Pleasant, fruity, characteristic, without foreign odor (mold, rancid, stale, etc.)

Table 3.11. Physico-chemical properties (according to the manufacturer's technical specifications)

Properties	Value
Core moisture (%)	2,5
Proteins (%)	8,5
Fats (%)	15
Carbohydrates (%)	16
Gluten (%)	absent
Energetic value, kJ/kg	1857
Acidity (degrees)	max. 6
Porosity (%)	min. 62 – 63
Salt content (%)	max. 1,4
Sugar content (%)	-
Fat content (%)	-

Table 3.12. Microbiological properties (according to the manufacturer's technical specifications)

Properties	Value
Yeasts and molds, max./g	100
E. coli, max./g	1
Salmonella, /25 g	absent
Coagulase-positive staphylococcus, /25 g	absent
Bacillu cereus, max/g	1

Storage conditions: the biscuits must be kept in storage in such a way as to ensure that their taste, consistency, tenderness, color and shape are maintained. The following factors are important for this purpose: air temperature and relative humidity and light. The optimal parameters are the temperature of 18-20ºC, the relative humidity of 65 - 70% and the lack of light. Storage is done in packaging that protects them from light.

Method of transport: ripe products are collected using conveyor belts.

Shelf life is 6 months. The shelf life refers to the product stored and transported under the conditions provided by the manufacturer and is recorded from the date of packaging.

Consumer category: people with gluten intolerance (celiac disease).

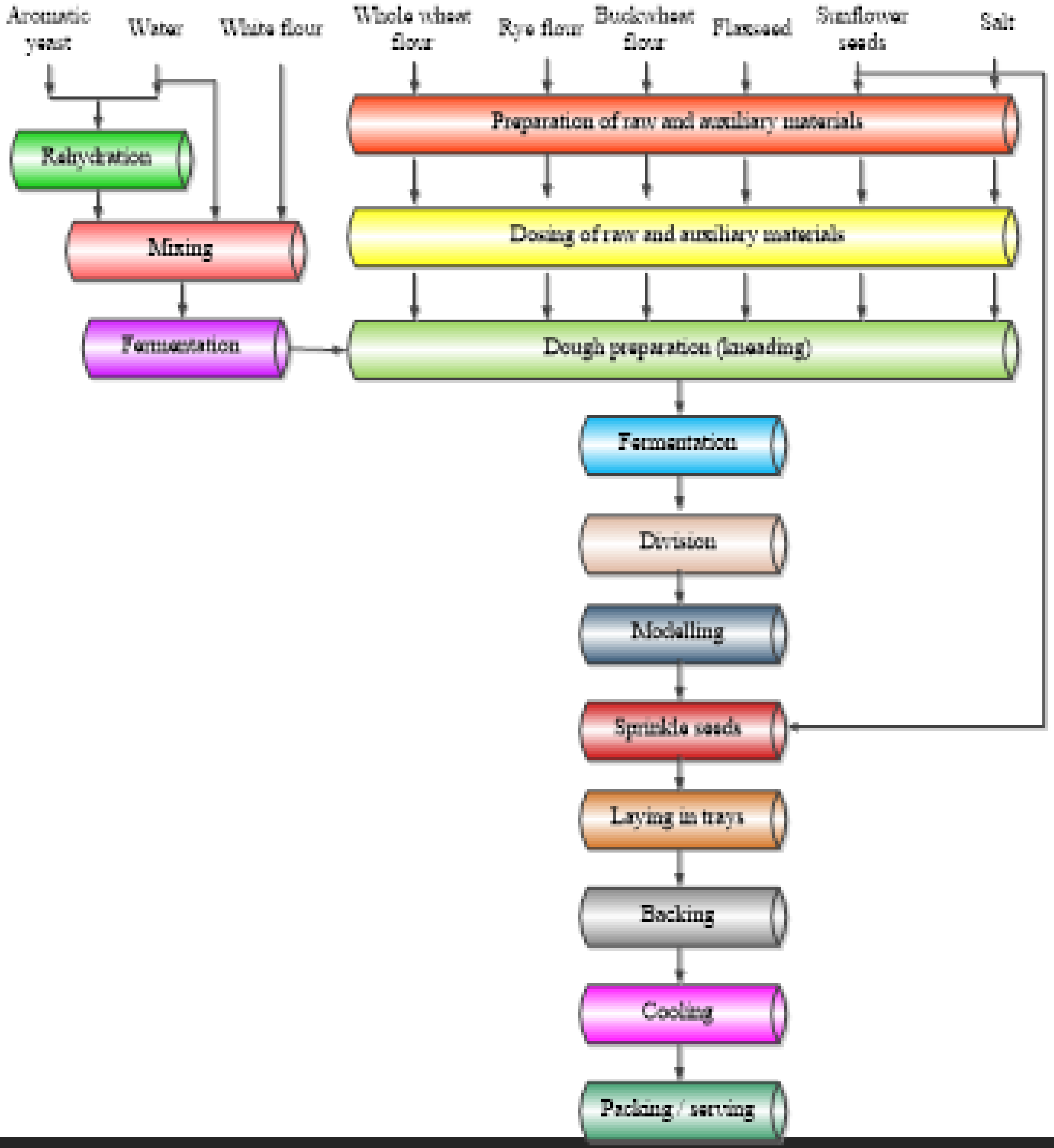
Presentation: it is packed in bags, in cardboard boxes, or in a wrapper that is placed in cardboard boxes or wooden crates.

Stability when using the product: the product kept under the prescribed conditions, has stability within the shelf life and above that, approx. 6 months. Failure to comply with the recommended storage conditions will shorten the shelf life, as the product may become unstable (Alexa E., 2010a)

4. GLUTEN FREE BREAD BASED ON RICE, MILLET, FLOUR AND MIX OF SEEDS

Product description: Gluten free bread based on rice flour, millet, flax and seed mix is an assortment of bread that is part of the range of gluten-free products, intended for people suffering from celiac disease, but also for those who want to adopt a healthy lifestyle.

Raw and auxiliary materials: Millet flour, rice flour, flax flour, xanthan gum, dry yeast, sea salt, cane sugar, olive oil, flax seeds, chia seeds, sunflower seeds. https://www.usab--tm.ro/utilizatori/tpa/file/student%20fest/2019/catalog%20student%20fest%202018%20final.pdf

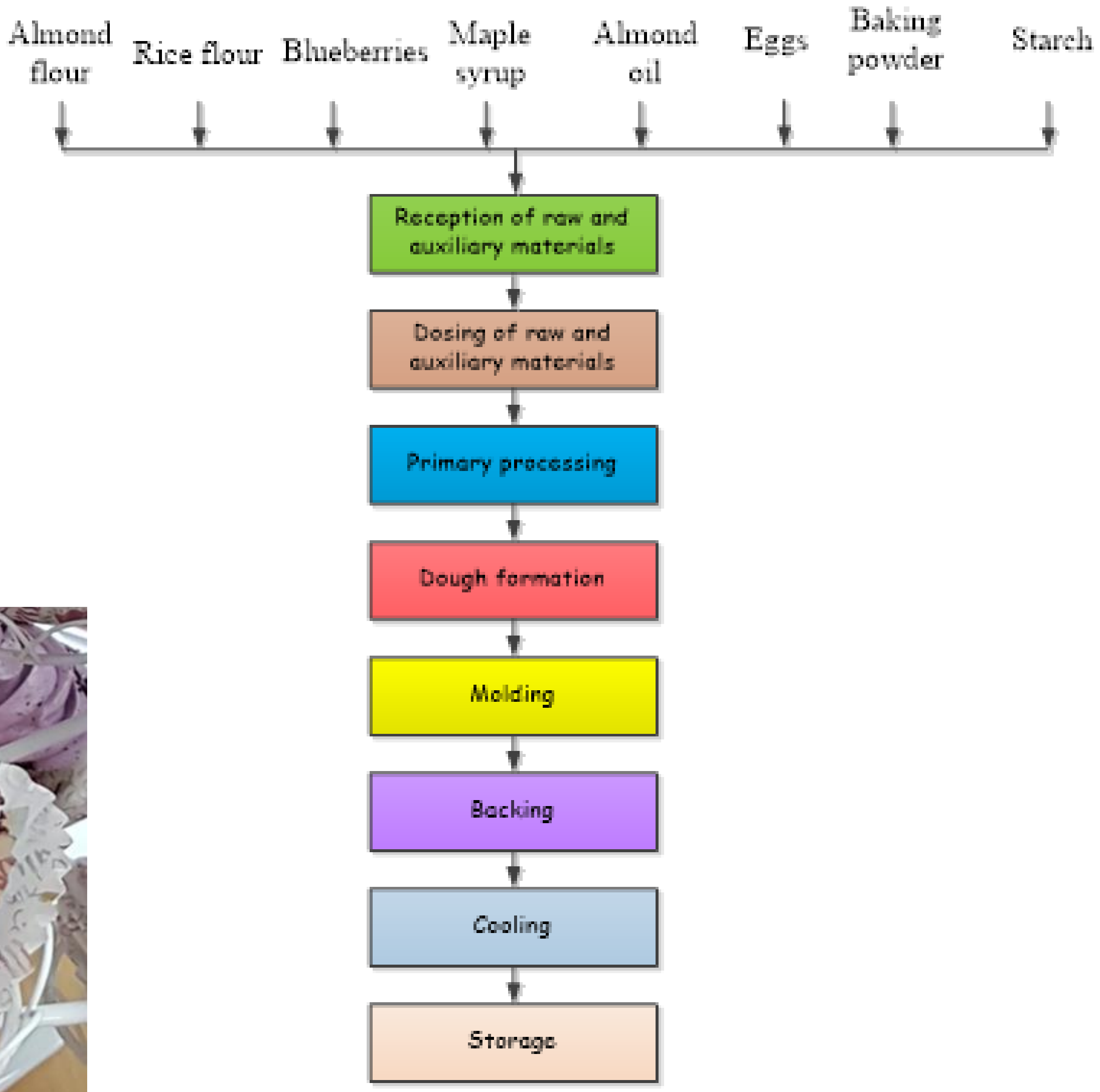


5. GLUTEN FREE MUFFINS WITH RICE FLOUR, ALMONDS AND BLUEBERRIES

Product description:

Gluten free muffins with almond and blueberry flour are included in the wide range of products specially designed for people with gluten intolerance, for diabetics, but can be eaten just as well by all those who want to adopt a healthy and balanced diet from a nutritional point of view.

Raw and auxiliary materials: Almond flour, rice flour, blueberries, maple syrup, almond oil, eggs, baking powder, starch (https://www.usab--tm.ro/utilizatori/tpa/file/student%20fest/2019/catalog%20student%20fest%202018%20final.pdf).

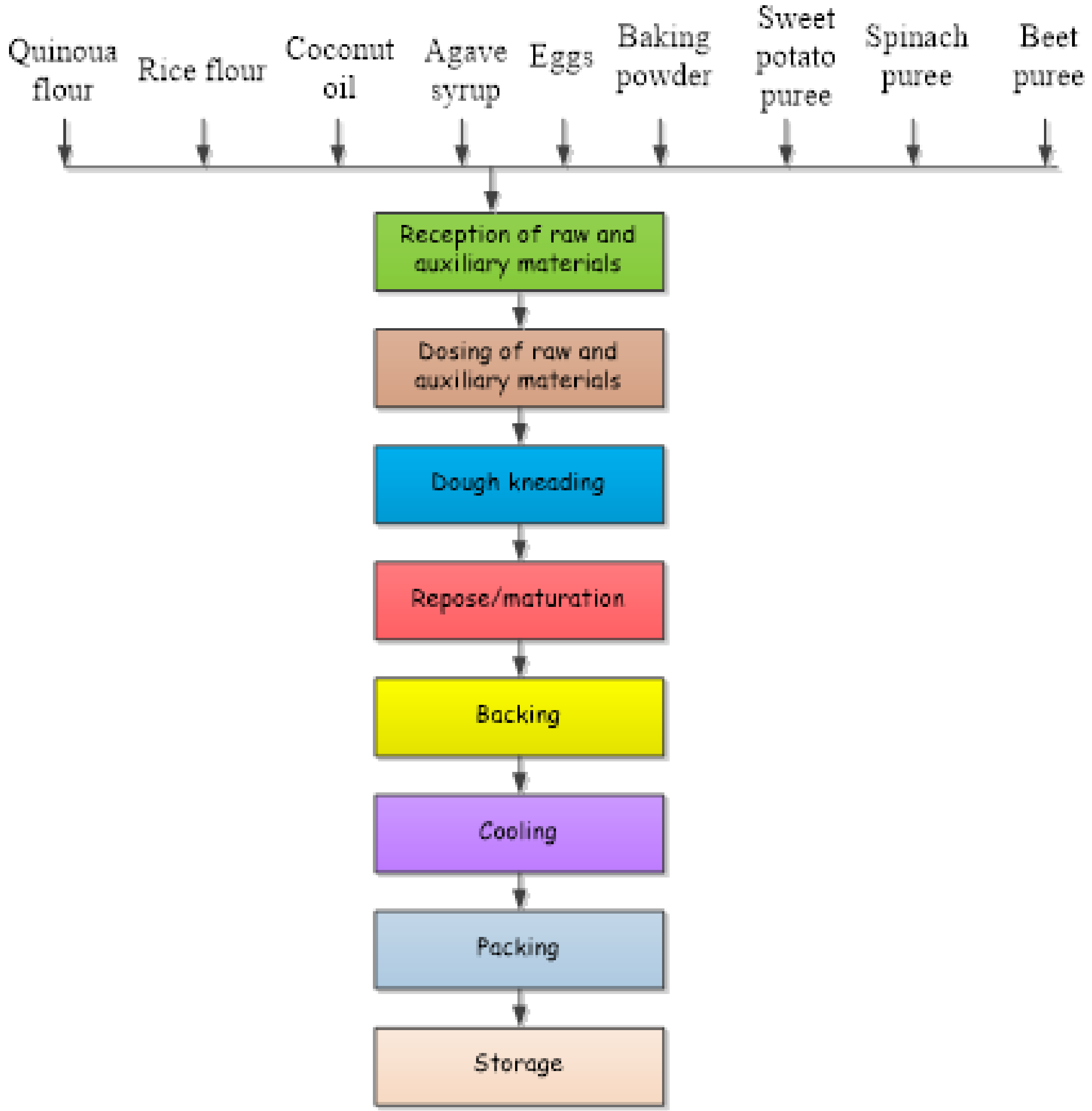


6. GLUTEN FREE MUFFINS WITH RICE AND QUINOA FLOUR, WITH ADDATION OF SWEET POTATO, SPINACH AND BEET

Product description:

Gluten free muffins made from rice and quinoa flour with the addition of sweet potato puree, spinach and beets are gluten-free pastries obtained from the desire to be consumed by as many people as possible: from people who are forced to excludes gluten from the diet and young children (who are more sensitive to food allergens), up to people who want to adopt a nutritionally balanced lifestyle.

Raw and auxiliary materials: rice flour, quinoa flour, coconut oil, agave syrup, eggs, baking powder, sweet potato puree, spinach puree, beet puree (https://www.usab-tm.ro/utilizatori/tpa/file/student%20fest/2017/catalog%20student%20fest%202017.pdf)



7. GLUTEN FREE MUFFINS WITH CHESTNUT FLOUR, CONFIDED CURTAINS AND CHESTNUT PURE

Raw and auxiliary materials: chestnut flour, whole meal rice flour, coconut milk, egg, stevia extract, coconut flakes, candied currants, coconut oil, vanilla essence, baking powder, mascarpone, whipped cream, puree of chestnuts.

Nutrition facts (g/100 g product): Fats: 20.98 g Proteins: 15.72 g Ash: 2.86 g Total carbohydrates: 50.81 g Dietary fiber: 9.63 g Caloric value: 780 Kcal (https://www.usab-tm.ro/utilizatori/tpa/file/student%20fest/2017/catalog%20student%20fest%202017.pdf).

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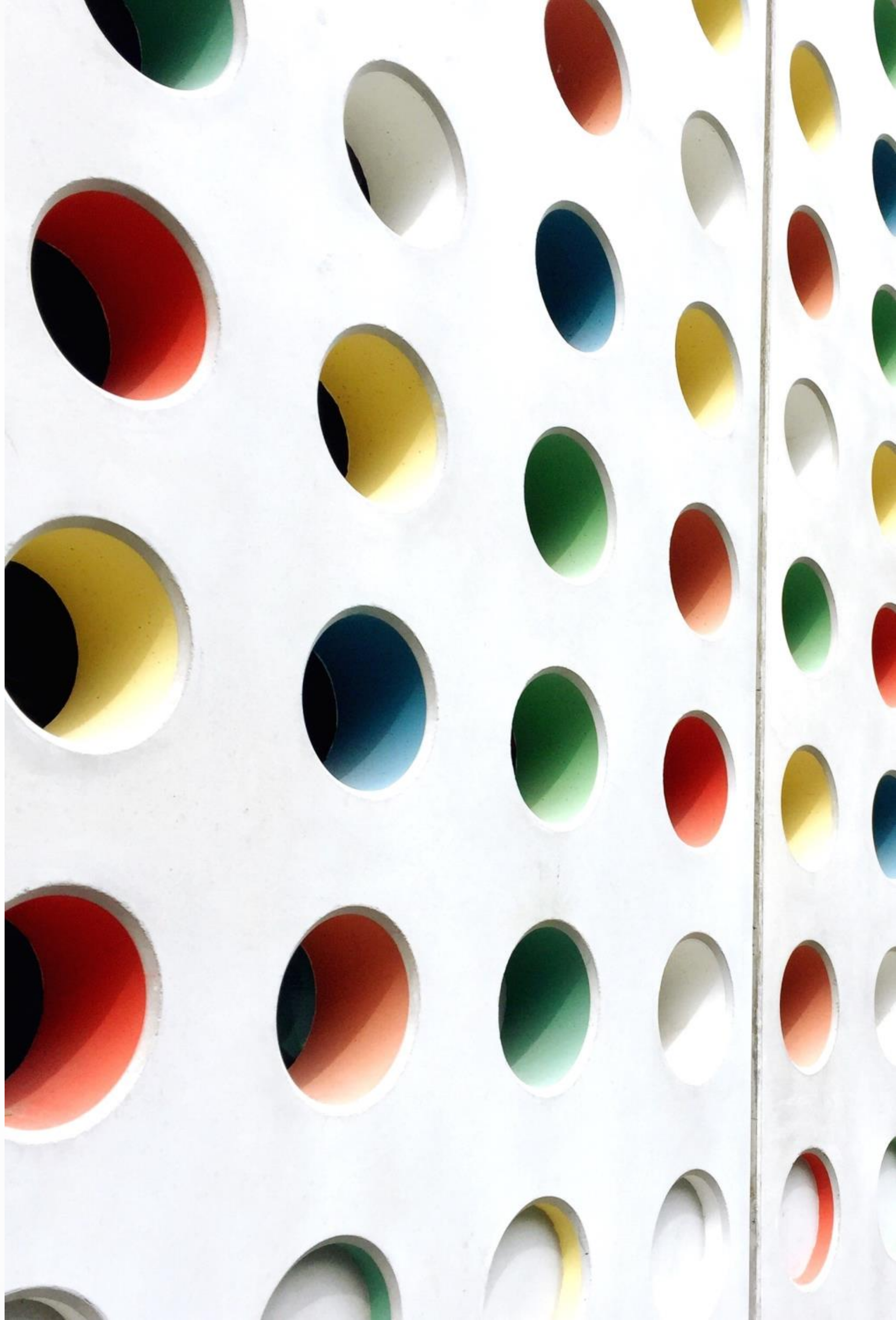
***https://www.usab-tm.ro/utilizatori/tpa/file/student%20fest/2017/catalog%20student%20fest%202017.pdf

***https://www.usab--tm.ro/utilizatori/tpa/file/student%20fest/2019/catalog%20student%20fest%202018%20final.pdf

CHAPTER 4.

Manufacturing technology for bakery products with added soluble fiber



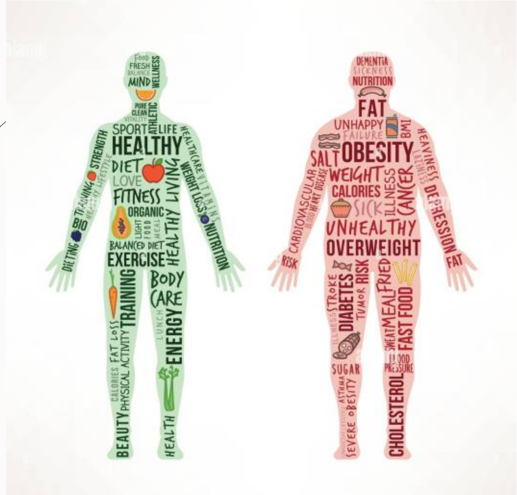
GENERAL

Dietary fibre are considered by the consumers to be important and related to several health benefits due to their consumption. Although the consumers are aware of their benefits very few are consuming the recommended daily intake.
For example, Western Europeans consume only 60-70% of the recommended daily intake and 80% of Britons are unaware of what quantity of dietary fibre they should consume daily.

Figure 4.1. *Global Number of New Product Launches Containing Fibre 2012-2014(projected)*

4.1. Dietary fibers: description, health benefits, functionalities, and application in bakery

Plant-based carbohydratyes are called dietary fiber and, unlike other carbohydrates (starch or sugars, etc.) are digested in the large intestine and not in the small intestine.
Non-digestible soluble and insoluble carbohydrates (with 3 or more monomeric units) and lignin that are intrinsec and intact in plants; isolated or synthetic non-digestible carbohydrates determined by FDA to have physiological effects beneficial to human health (Dietary Fibre, 2020).



For keeping the health of the human body and reduce the risk of chronic health diseases such as cardiovascular diseases, Type 2 diabetes and colon cancer (Slavin, 2013; Soliman, 2019).
In present, the fibre intake is lower than the given recommendations. (Boseley, 2019).
The fiber intake per day recommended by The World Health Organization is of at least 25-29 grams of fibre (Boseley, 2019). The average fibre intake ijs around 20 grams per day.

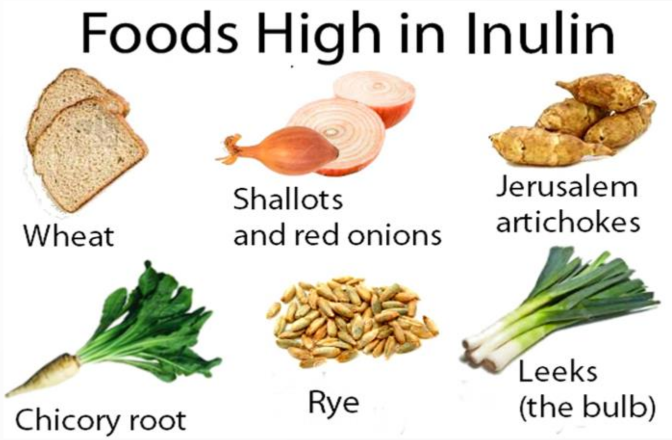
A convenient medium for delivering dietary fibre are the bakery products that are consumed daily. But, there are some challenges regarding adding fibre in bread and their negative effects on the procesability, dough reology and final products quality (Foschia, Peressini, Sensidoni, & Brennan, 2013).

4.1. Dietary fibers: description, health benefits, functionalities, and application in bakery

Addition of fiber can affect the quality of bread, because it's affects the volume and firmness of the bread. The presence of a high level of fiber in bread can significantly affect the sensory properties of bread.Thus, it may compromise the texture, crust color, core color, taste, aroma and general acceptability. (Kohajdová, Karovičová, & Jurasová, 2012; Bhise, Kaur, & Aggarwal, 2013; Jingwen, Yonghui, Yong, Donghai, & Weiqun, 2021).

The fibers used in the bakery products can be divided into three categories. The first category is represented by cereals and cereals by-products such as wheat, oat, barley and rice.
The second category is composed of non-cereals, such as nuts, peas, oranges, sugar beet, potatoes and apples.
Hydrocolloids like gums (guar gum, Arabic gum), cellulose, oligosaccharides represent the last category.

Inulin
In processed foods inulin is widely used. It's main use is like a substitute for fat or sugar in order to offer the desired characteristics. 25-30% of the energy is provided by inulin in comparison with the digestible carbohydrates (Shoaib, et al., 2016). Depending on its structure the fiber can offer various functionalities and can be linear or highly branched. The highly branched inulin is able to develop a gel network that can change the product's texture and provide a fat-like mouthfeel. Thus, it acts like a hydrocolloid and is suitable for fat replacement in different food matrices (Paciulli, et al., 2020; Samakradhamrongthai, et al., 2021).



4.1. Dietary fibers: description, health benefits, functionalities, and application in bakery

Citrus fibers

They can be obtained from different industrial sources and from fruits like lemons, lime, oranges, and grapefruit. In the pulp and the peel of the fruits we can find the fibers. Citrus fibers are more used and are more popular because they are more available.

Citrus fibers have more advantages because they have a large amount of dietary fiber in comparison to alternative sources (eg. cereals). Pectin and cellulose are the soluble fibers mainly find. Citrus fibers have another advantage because pectin is present that is the ability to gel, thicken and emulsify.

Wheat fiber

In the wheat plant insoluble fibers can be found. It is used because it has a neutral colour and taste. The texture and stability of fiber-enriched products will be improved by adding wheat fiber. The ingredients will not interact with the fibers. There is still a special property, capillarity, that can allow water retention and independent connection of water temperature. (VITACEL Wheat Fiber Awarded with the ECARF Seal of Quality, 2007).

Soluble corn fibers

Fiber that comes from corn can be labelled as maltodextrin or as soluble fiber from corn. It can be easely mixed with insoluble fiber and has prebiotic health benefits (Allgeyer, Miller, & Lee, 2010). Some products with insoluble fibers do not contain fiber that can help reach the recommended dose and combine the nutritional benefits, taste and texture due to their organoleptic properties.

Due to it’s sweet taste and low calorie content soluble corn fiber can be used as a sugar substitute.

4.1. Dietary fibers: description, health benefits, functionalities, and application in bakery

Acacia fibers

Acacia gum or Arabic gum are the names on which acacia fibers are known. In the confectionery industry Acacia gum has been used as a stabilizer, emulsifier, binder and thickener (Phillips, Ogasawara, & Ushida, 2008). It is composed by a complex of polysaccharides and is a natural gum made from the hardened sap of two species of Acacia: Acacia Senegal and Acacia Seyal. Both of the species are used in various applications; mostly is used as an emulsifier.

Emulgold ™ fiber is one of the ingredients used. It is a selected Acacia gum (Phillips, Ogasawara, & Ushida, 2008) from the Acacia trees that offers several benefits like ability to reduce glycemic index in the product, satiety effect, prebiotic effect, low caloric value and the occurrence of non-cariogenic consequences. (Calame, Thomassen, Hull, Viebke, & Siemensma, 2011). Thus, it is the right ingredient to meet the consumer's requirements regarding fortified products. The Acacia fibers behaved very well in white bread in a study, and only a few adjustments to the recipe were applied. In the tests conducted there were water reduction in the formulation and extension of the kneading time that led to obtaining a product similar to the control sample (without the addition of fiber) regarding the volume, texture, dough machinability and taste. A softer bread was obtained in comparison with the control that maintained a moist texture during the shelf life.

The addition of Acacia fibers in baking, applied on white bread and burger buns had the best results due to the minimal impact on the specific volume, firmness and structure of the core during shelf life. For obtaining the best results and a high quality product it is important the water quantity of water in recipe, extended kneading time and Acacia fiber as a solution.

In biscuits, Acacia fiber did not affect the dough of the finished product. In some cases, harder and crispier biscuits were obtained and at some point there were considered unacceptable.

When using inulin better results were obtained regarding the sensorial properties. Thus, inulin may be preferred to other types of fibers.

4.2. Application of Acacia (Emulgold) fibers in white bread

Acacia fiber (Emulgold ™) was used in white bread in order to obtain a product “high in fiber” (6g / 100 in the final product). With this occasion the impact on processing, rheology of the dough and product quality were assessed.

The dry mixture of “wheat flour and acacia fiber” was compared to the moisturizing capacity of wheat flour during the farinogram performed at 30 ° C for 30 min. The equipment used was Mixolab from Chopin technologies.

Figura 4.2. Mixolab 2, Chopin technologies

White bread formulation

In order to observe the application of Acacia a control sample and a high fiber (T1) sample were used. In the T1 sample the amount of water was reduced by 9,3% in comparison with the control sample. Following the farinographic analysis with the Mixolab this adjustment was made. Also, the farinogram showed a decrease of the hydration capacity from 54% to 49% at a moisture content of 14%.

In the tests a wheat flour with the following characteristics was used: 10.7% protein, 2% fiber and 15.5% moisture. And the Emulgold ™ used in the tests has the following content: 1% protein, 85% fibers and 9% moisture.

4.2. Application of Acacia (Emulgold) fibers in white bread

Table 4.1: *Recipe control sample and high fiber sample (T1)*

		Reference		T1	
Ingredients	ppm	%	g	%	g
Wheat flour		100	3100	100	3000
Water		57.00	1767	51.70	1551
Fresh Yeast		3.50	108.5	3.50	105
Salt		1.40	43.4	1.40	42
White Shortening		1.00	31	1.00	30
Ascorbic Acid	60		0.186		0.18
Enzymes	55		0.1705		0.1705
Calcium Propionate		0.4	12.4	0.4	12
Acacia fibre				8.15	244.5
TOTAL			5063		4985

In order to achieve the high in fiber claim: 8.15% acacia fiber (Emulgold™, Kerry ingredients, Ireland) has been added.

White tin bread production

All the ingredients were mixed in a spiral mixer (Kemper, Germany).

The Reference dough has been mixed for 9 min (mixing settings 500/1500), while T1 for 10 min and 45 s (mixing settings 500/2000).

4.2. Application of Acacia (Emulgold) fibers in white bread

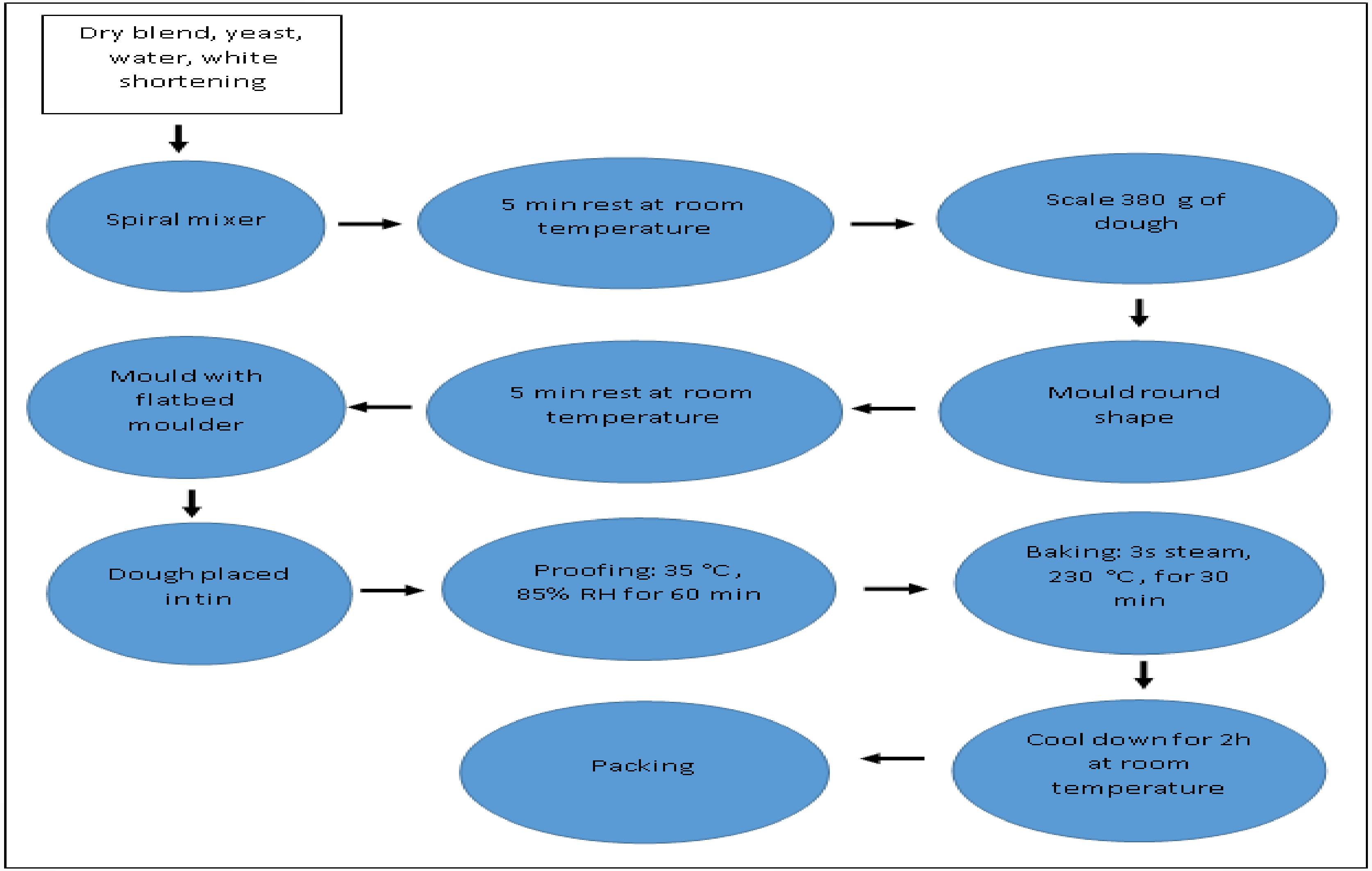


Figure 4.3. White tin bread production

4.2. Application of Acacia (Emulgold) fibers in white bread

Bread quality measurements

Several measurements have been carried out in order to evaluate the quality of the baked products, including moisture content (AACC Standard 44-154A) and water activity (mod. Aqualab CX-2, Decagon Devices Inc.™, Washington, USA) during shelf life

Texture Analyzer was used in order to evaluate the crumb firmness and resilience (the capacity of bread crumb to recover after been applied a compression force) (TA.XT Plus, Stable Micro System, UK;
Figure 4.4.a) equipped with a 5 kg load cell.

In the tests, a 35 mm probe was used and two slices of bread (12.5-mm-thick each slice) were applied a double compression at 1 mm/s until 50% of their original height. Between the two compressions there was a gap of 30 seconds.

The analysis was achieved during the entire products shelf life (day+1, day+4, day+11).

Figure 4.4. a) Texture Analyzer (TA.XT Plus, Stable Micro System, UK); b) 35 mm probe

Table 4.2. *Production parameters*

	Reference	T1
Baking time (min)	30	30
Proving time (min)	60	60
pH	6	5.8
Dough temperature (°C)	25	27

4.2. Application of Acacia (Emulgold) fibers in white bread

Bread quality

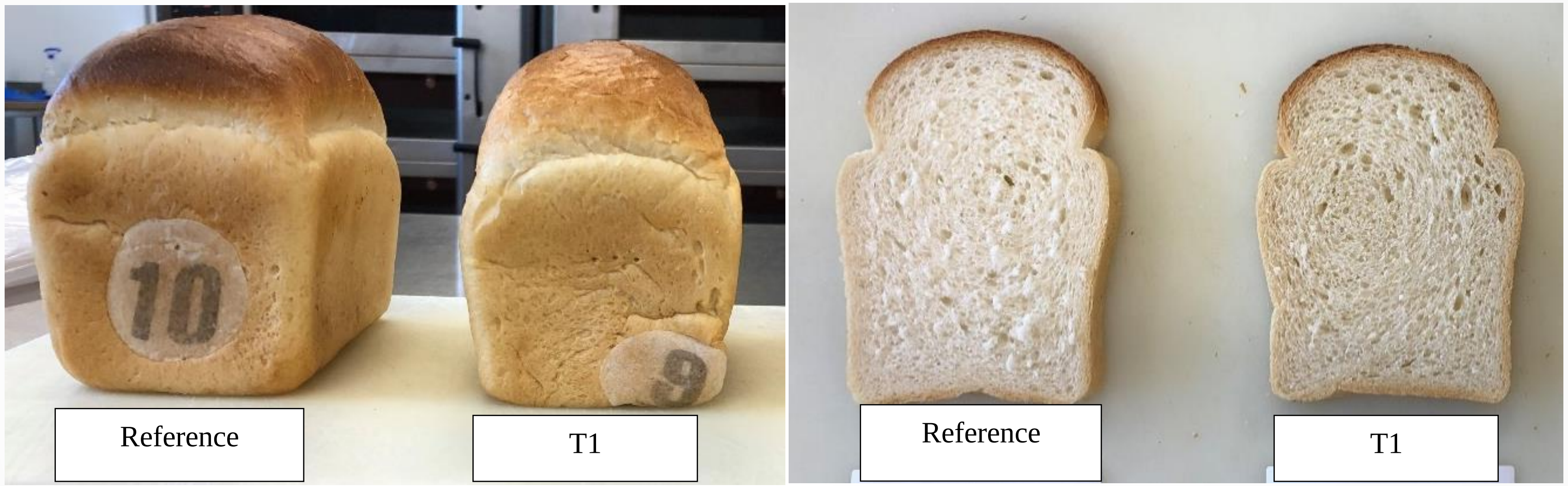


Figure 4.5: *Pictures of bread loaves and slices for Reference and T1(high in fibre)*

4.2. Application of Acacia (Emulgold) fibers in white bread

Conclusion

There was concluded that there is no negative effect on the dough rheology, processability, texture, appearance and taste of the product in the tests conducted with added Acacia fibre.

However, there were some adjustments made to the recipe used and process. The water content was modified and the mixing time was prolonged in order to have a final product with the same quality characteristics.

In the bread samples the total dietary fibre content was evaluated based on the enzymatic gravimetric method based AOAC 991.43 (Lee, Prosky, & DeVries, 1992).

There were obtained results that confirmed that the claim “high in fiber” is valid (Table 4.3).

Table 4.3. *Nutritional profile for Reference and T1 (high in fiber) breads.*

Nutritional (100g)	Energy (Kcal)	Fat (g)	Protein (g)	Carbohydrates (g)	Fibre (g)
Reference	258	1.6	8.0	50.6	1.6
High in fibre (Emulgold™)	247	1.5	7.8	52.9	6

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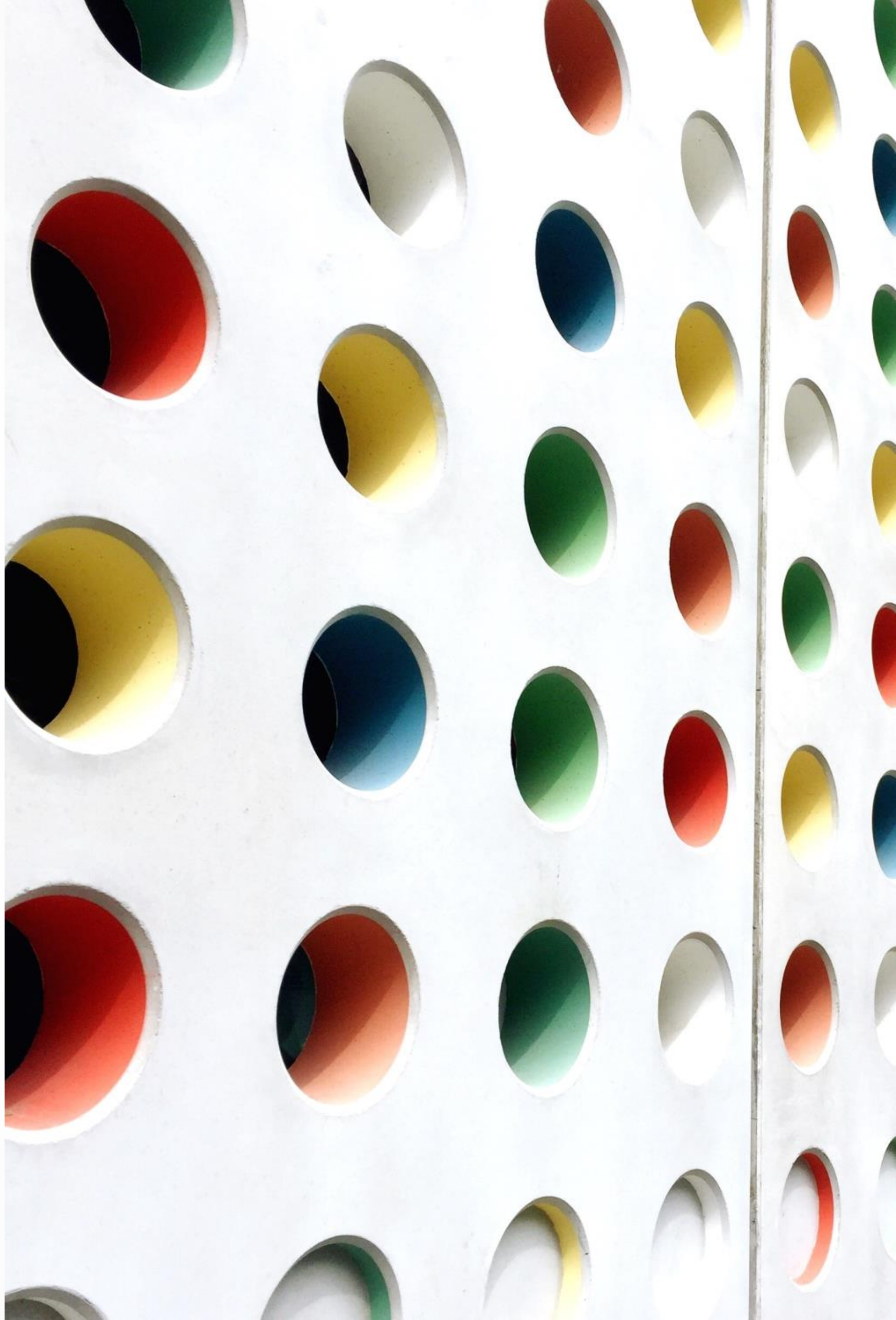
CHAPTER 5.

Technology for the manufacture of bakery products with the addition of probiotics for the regulation of the digestive system

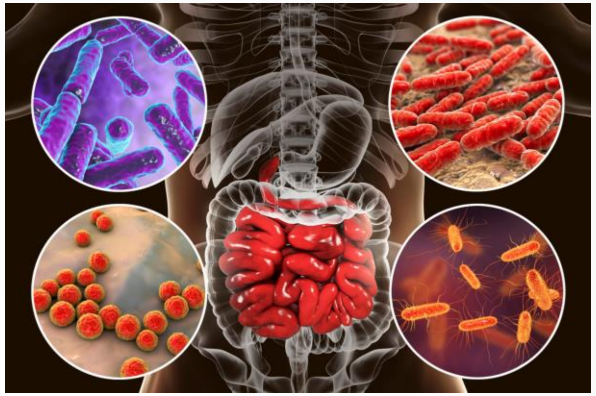


GENERAL

Initiation in the bakery industry with the addition of probiotics to regulate the digestive system

5.1. Intestinal microbiota and digestive disorders

In recent years, a large body of scientific literature highlighted the link between alterations in the gut microbiota and symptoms associated with the development and clinical course of several gastrointestinal diseases, including irritable bowel syndrome and coeliac disease (Cristofori, Indrio, Miniello, De Angelis, & Francavilla, 2018; De Angelis et al., 2021). Here, we provided a concise overview of the relationship between gut microbiota and gastrointestinal diseases, focusing on microbial-based approaches to ameliorate disease symptoms (Figure 1). (Pecora, Persico, Gismondi, Fornaroli, Iuliano, De Angelis, & Esposito, 2020). In addition to the oral administration of traditional lactobacilli and/or Bifidobacterium, researchers are evaluating the efficacy of novel probiotic candidates, in particular spore-forming species that can preserve their vitality under gastrointestinal conditions (Francavilla et al., 2019; De Angelis et al., 2021).



According to a recent study, the oral administration of a multi-species combination of lactobacilli and Bifidobacterium relieved irritable bowel syndrome (IBS)-type symptoms of coeliac patients (CD) on a strict gluten-free diet (Francavilla et al., 2019; De Angelis et al., 2021). Although no concrete evidence was provided for the microbial survival and effective degradation of gluten under gastrointestinal conditions, the treatment led to a beneficial change in the composition of the gut microbiota.

However, for the clinical translation of these microbial preparations, it is important to demonstrate their survival under gastrointestinal conditions, associated with activity against gluten epitopes, as well as to expand the range of candidate probiotic microorganisms (Francavilla, Cristofori, Vacca, Barone, De Angelis, 2020). A further option is the use of protein/peptide hydrolases (e.g. glutanase) purified from microbial sources (e.g. *Bacillus stearothermophilus*, *Bacillus thermoproteolyticus*, *Bacillus licheniformis*, *Streptomyces griseus*, and *Aspergillus niger*) or plant matrices (Serena, Kelly, & Fasano, 2019).

GENERAL

5.1. Intestinal microbiota and digestive disorders

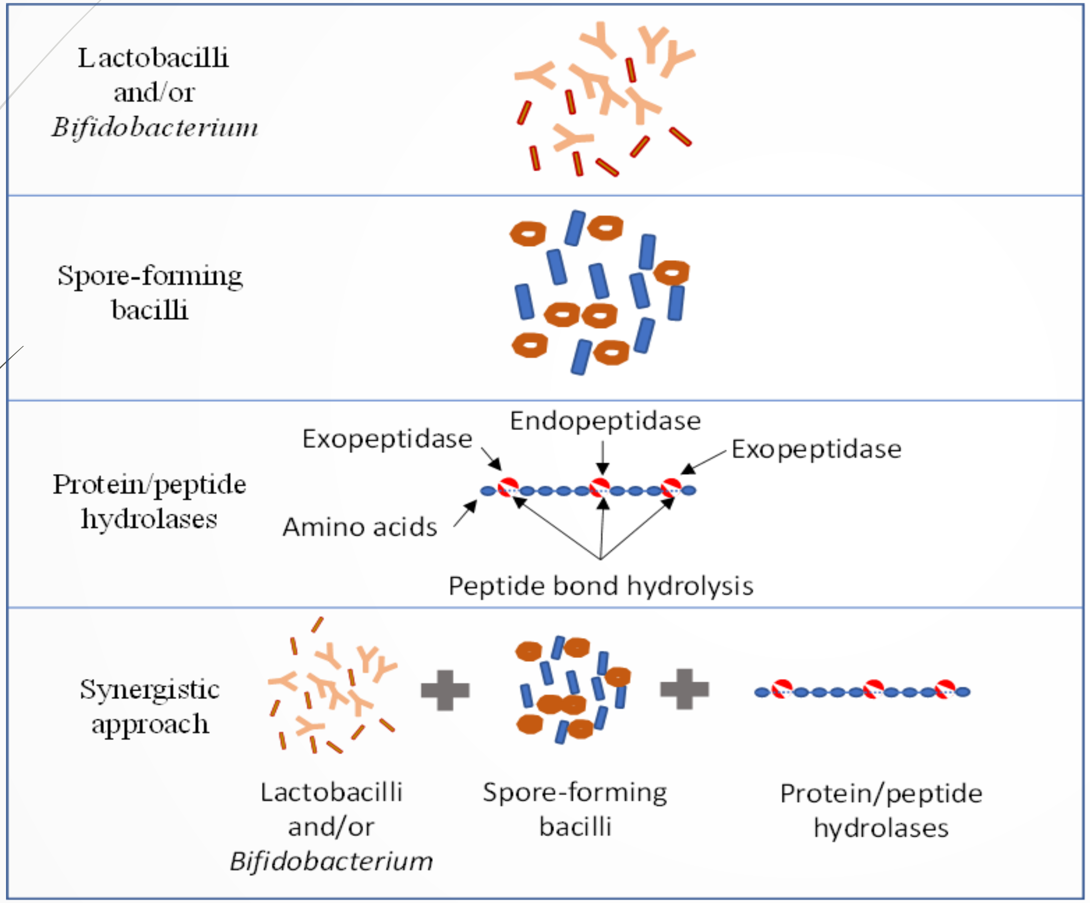


Figure 5.1. Main microbial-based approaches to ameliorate digestive disease symptoms.

The limitations of this approach can be traced back to the limited evidence on their efficacy in gastro-intestinal conditions and the risk of partial hydrolysis of gluten, which may lead to an increase in toxic epitopes instead of a decrease (Krishnareddy, Stier, Recanati, Lebwohl, & Green, 2017). A synergistic approach combining oral administration of selected bacteria (from a large pool of Bacillus spp., lactobacilli, Pediococcus spp., and Weissella spp.) and commercial proteolytic enzymes was recently proposed (De Angelis et al., 2021). Two microbial consortia (Consortium 4: Lactiplantibacillus plantarum DSM33363 and DSM33364, Lacticaseibacillus paracasei DSM33373, Bacillus subtilis DSM33298, and Bacillus pumilus DSM33301; and Consortium 16: Lactiplantibacillus plantarum DSM33363 and DSM33364, Lacticaseibacillus paracasei DSM33373, Limosilactobacillus reuteri DSM33374, Bacillus megaterium DSM33300, Bacillus pumilus DSM33297 and DSM33355), containing commercial enzymes (Aspergillus oryzae E1, Aspergillus niger E2, Bacillus subtilis Veron HPP, and Veron PS proteases) allowed to convert gluten to non-toxic and non-immunogenic peptides under gastrointestinal conditions (De Angelis et al., 2021).

5.2. Role and application of probiotic cultures in baking

Up to this point we described the potential of probiotic cultures in improving the symptoms of digestive diseases. From a preliminary analysis, bakery products can be a good vehicle for the intake of probiotic microorganisms, as they are staple foods consumed by people of different age groups and on various occasions. In addition, bakery products contain prebiotics that can promote the growth of probiotic microorganisms.

Table 5.1. Cooking technology for various types of bakery products (adapted from Arepally, Reddy, Goswami, & Coorey, 2022).

Bakery product	Cooking technology
Bread	Convection
	Microwave
	Infra-red + microwave
	Steam baking
Pan bread	Drying + convection
Biscuits/cookies	Convection
	Microwave
	Convection + microwave
	Steam assisted + convection baking
	Vacuum baking
	Convection + vacuum
Cake	Convection
	Vacuum + convection

Actually, fortifying bakery products with probiotic cultures poses several challenges. Indeed, the effectiveness of probiotic formulations depends on the viability of microorganisms, which must remain high during processing, storage, until consumption and during transit through the upper gastrointestinal tract. The main obstacle is the high cooking temperatures (usually between 160 and 250°C), which can significantly reduce the viability of probiotic microorganisms. In addition to the temperature/time combinations, other factors that may affect the viability of probiotics are the type of ingredients (e.g. wheat, barley, millets, oats, rice, sorghum, quinoa, corn, fruits, etc.) and cooking technology (e.g. conventional oven, microwave, infrared-assisted microwave, steam and vacuum), as well as any other processing condition (Table 5.1) (Arepally, Reddy, Goswami, & Coorey, 2022; Cappelli, Lupori, & Cini, 2021). Thus, each baked product has its own uniqueness that requires a unique design to develop a probiotic formulation (Figure 5.2).

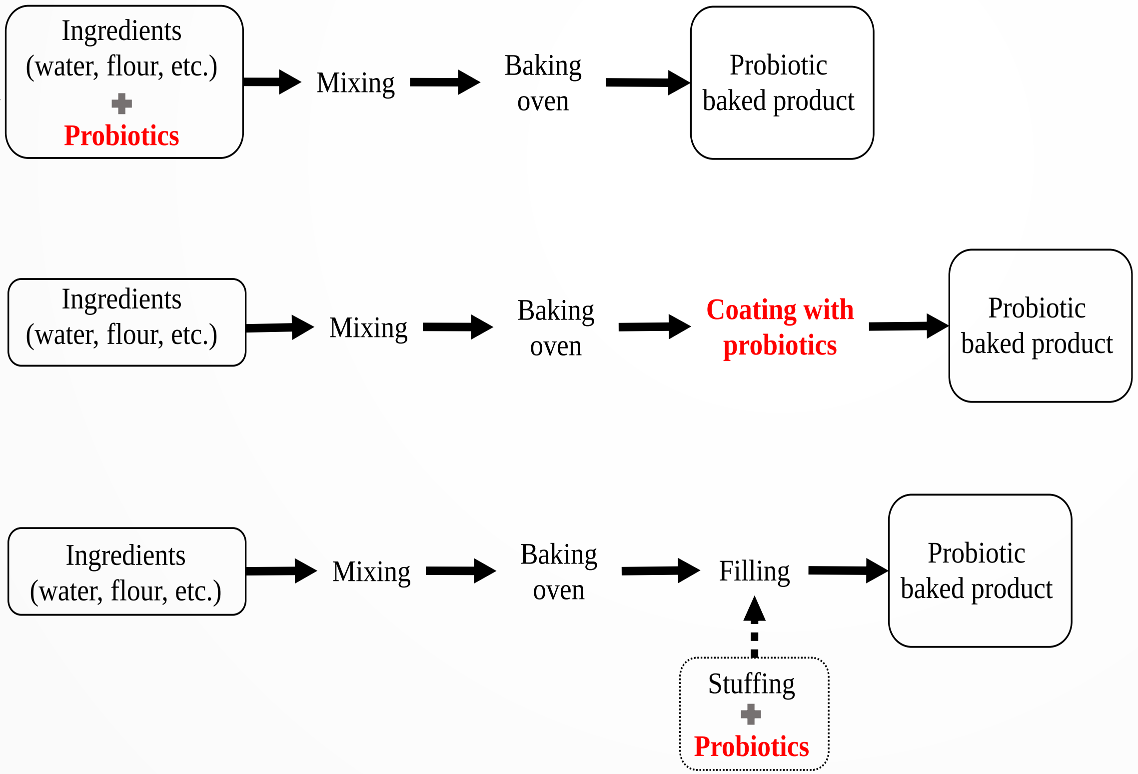


Figure 5.2. Schematic illustration of methods for applying probiotics to bakery products: (i) probiotics added to the dough; (ii) probiotics coated on the surface of baked product; probiotics added to the filling of baked product (adapted from Arepally, Reddy, Goswami, & Coorey, 2022).

In order to protect the probiotic cultures from the multiple stresses they encounter during baking and to ensure high viability until consumer intake, microencapsulation was proposed as a valuable technological solution. Microencapsulation is the trapping of microbial cells within a dispersed material in order to protect the cells and control their release (Frakolaki, Giannou, Kekos, & Tzia, 2021;

Camelo-Silva, Verruck, Ambrosi, & Di Luccio, 2022). This is generally achieved through physico-chemical or mechanical processes. The protective layer must consist of a food-grade carrier or material. In addition, the use of matrices containing prebiotic substances (e.g. fibre, phenolic acids, flavonoids and betacyanins, etc.) can help to improve the viability of probiotics during and after encapsulation.

The effectiveness of microencapsulation treatment depends on the characteristics of the outer layer and the encapsulation technology Most commonly used encapsulation technologies include spray drying, spray chilling, extrusion, freeze-drying, and emulsion (Table 5.2) (Frakolaki, Giannou, Kekos, & Tzia, 2021). The choice of technology depends on the ability to protect microbial cells and the ease of application in the production environment.

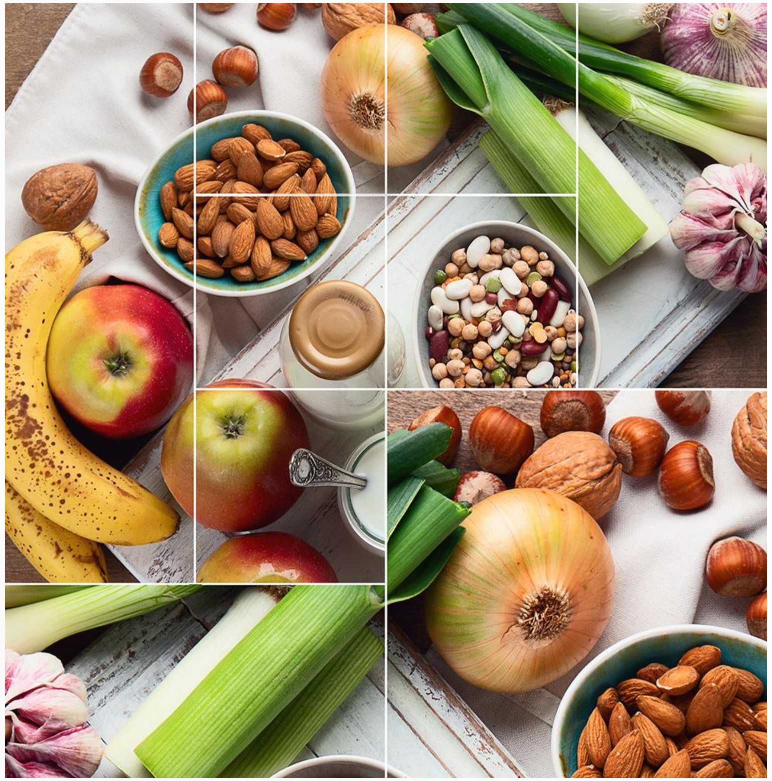


Table 5.2.a Microencapsulation of probiotics and incorporation in bakery products (adapted from Frakolaki, Giannou, Kekos, & Tzia, 2021; Camelo-Silva, Verruck, Ambrosi, & Di Luccio, 2022).

Probiotic species	Encapsulation technology	Encapsulation Matrix	Bakery Product	Reference
Lactiplantibacillus plantarum	Emulsification	Alginate, maltodextrin, pectin, canola oil, tween 80	Cupcake	Dong, Luan, & Thuy 2020
Lactiplantibacillus plantarum	Emulsification	Skimmed milk or κ-carragenan coating with skimmed milk, vegetable oil, tween 80	Cupcake	Dong, Luan, Thuy, 2020
Lacticaseibacillus casei	Emulsification	Calcium alginate, resistant starch	Stuffed cake	Khosravi Zanjani, Babak, Sharifan, Mohammadi, Bakhoda, & Madanipour. 2012.
Lactobacillus acidophilus	Emulsification	Alginate, fish gelatin	Bread	Hadidi, Majidiyan, Jelyani, Moreno, Hadian, & Mousavi Khanegah, 2021
Lactobacillus acidophilus, Lacticaseibacillus casei	Emulsification	Calcium alginate, Hi-maize resistant starch, chitosan	Hamburger bun	Seyedain-Ardabili, Sharifan, & Tarzi 2016
Lactobacillus acidophilus	Spray drying	Whey protein isolates, CMC, pectin, inulin, agave sirup	Bread	Altamirano-Fortoul et al. 2012

Table 5.2.b Microencapsulation of probiotics and incorporation in bakery products (adapted from Frakolaki, Giannou, Kekos, & Tzia, 2021; Camelo-Silva, Verruck, Ambrosi, & Di Luccio, 2022).

Probiotic species	Encapsulation technology	Encapsulation Matrix	Bakery Product	Reference
Lactobacillus acidophilus, Lacticaseibacillus casei	Emulsification	Calcium alginate, Hi-maize resistant starch, chitosan	Hamburger bun	Seyedain-Ardabili, Sharifan, & Tarzi 2016
Lactobacillus acidophilus	Spray drying	Whey protein isolates, CMC, pectin, inulin, agave sirup	Bread	Altamirano-Fortoul et al. 2012
Limosilactobacillus reuteri	Spray drying	Sodium alginate, chitosan	Chocolate soufflé	Malmo, La Storia, & Mauriello 2013
Saccharomyces boulardii, Lactobacillus acidophilus, Bifidobacterium bifidum	Spray chilling + spray drying or spray drying + spray chilling	Gum Arabic, β-cyclodextrin, hydrogenated palm oil	Cakes	Arslan-Tontul, Erbas, & Gorgulu, 2019
Lactobacillus acidophilus	Fluidized bed granulation and coating	First layer: xanthan, alginate; second layer: chitosan, gellan	Bread	Mirzamani, Bassiri, Tavakolipour, Azizi, & Kargozari, 2021
Lacticaseibacillus rhamnosus	Extrusion	WPI	Biscuits	Reid et al. 2007

5.2.2. Spore-forming probiotics

Aerobic non-pathogenic sporigenic gram-positive *Bacillus* cultures has shown greater resistance to harsh food processing as well as gastrointestinal conditions compared to probiotic lactobacilli and *Bifidobacterium* strains, primarily because their spore-forming ability. Thus, *Bacillus* spp. can provide a valuable biotechnological solution for the fortification of baked goods with probiotic cultures, assuming they are generally recognised as safe and their probiotic properties are supported by scientific evidences. *Bacillus* spp. spores are highly resistant to high cooking temperatures, low pH values, nutrient deficiencies and high sugar concentrations. They also exhibit strong gastric stability and can be stored in non-refrigerated conditions. Furthermore, these spores do not compromise the nutritional and sensory properties of the baked product. Within this framework, researchers and manufacturers of food supplements/additives selected and marketed probiotic spore-forming *Bacillus* strains suitable for bakery products fortification (Table 5.3).

Table 5.3. Spore-forming *Bacillus* strains with claimed probiotic properties exploited in bakery products.

Probiotic strain	Products	References
Bacillus subtilis R0179	Bread, cookie, cakes, scones, muffins, pizza, doughnuts, croissants, soft pretzels, tortillas, brownies, grain-based bars, crackers, waffles, breakfast cereals, etc.	GRAS Notice (GRN) No. 1007 Part 2
Bacillus coagulans GBI-30	Muffins, bread, cereal bars, etc.	GRAS Notice (GRN) No. 660
Bacillus subtilis ActiBio®-BS	Bread, cakes, muffins, etc.	Registration no: 3590758 | FDA no: 16806073982
Bacillus coagulans 15BN ActiBio®-BC	Bread, cakes, muffins, etc.	Registration no: 3590758 | FDA no: 16806073982

5.2.3. GanedenBC30 (Bacillus coagulans GBI-30, 6086)

GanedenBC30 (Bacillus coagulans GBI-30, 6086) is a probiotic ingredient suitable for the fortification of baked goods due to its robustnes and convenience.

It is already used in the formulation of over 1,000 food, beverage and animal feed products marketed by different brands. It is based on spores that remain viable through harsh manufacturing processes and gastrointestinal conditions, so it is particularly suitable for the fortification of bakery products. Its application and probiotic efficacy is supported by an extensive literature. In particular, it can support digestive health, immune system and protein absorption (Figure 5.3) (Kalman et al., 2009; Hun, 2009; Dolin, 2009; Jensen et al., 2010; Kimmel et al., 2010; Maathuis et al., 2010; Nyangale et al., 2015; Jäger et al., 2016; Gepner et al., 2017; Keller et al., 2017; Anaya-Loyola et al., 2019; Stecker et al., 2020).

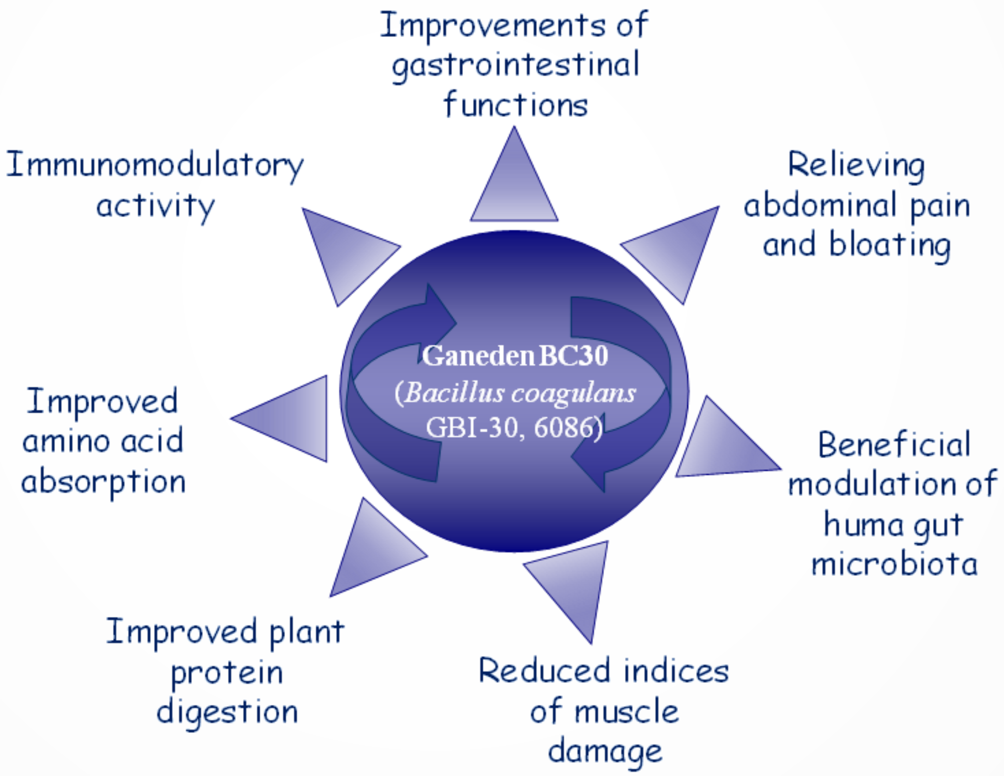


Figure. 5.3. Functional properties of GanedenBC30 (*Bacillus coagulans* GBI-30, 6086).

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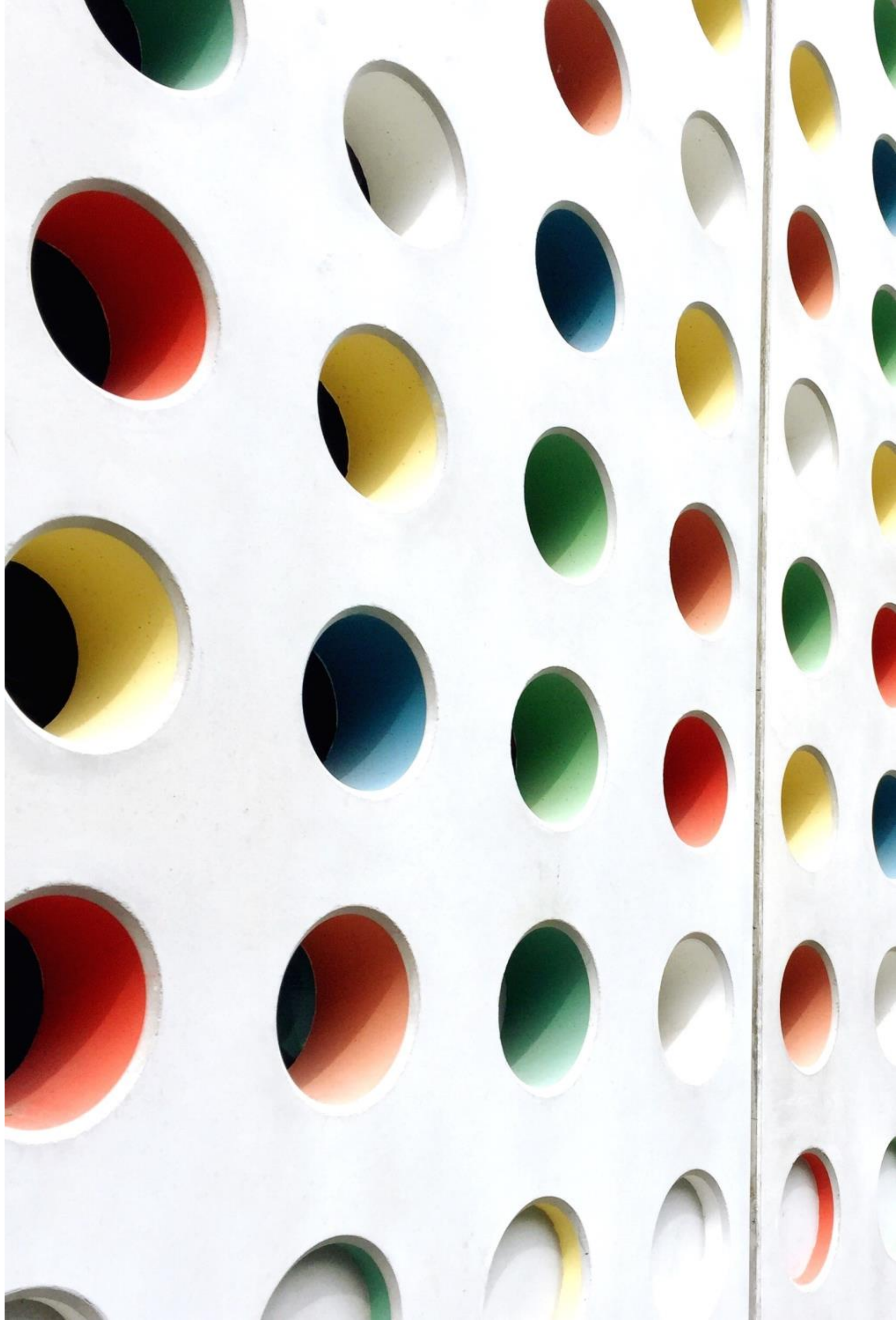
CHAPTER 6.

Technology for the manufacture of bakery products with low sugar and fat content



6.1. Main ingredients of dough

The main ingredient in the dough are flour, sugar and fat. All of these ingredients are nutraceuticals with high energy content. Flour contains digestible carbohydrates (i.e. glucose), while the most common sugar is saccharose (disaccharide of fructose and glucose). Fats are esters of glycerol and saturated and unsaturated fatty acids. In fats beside triglyceride, many other compounds can be found, for example, fat soluble vitamins and cholesterols.

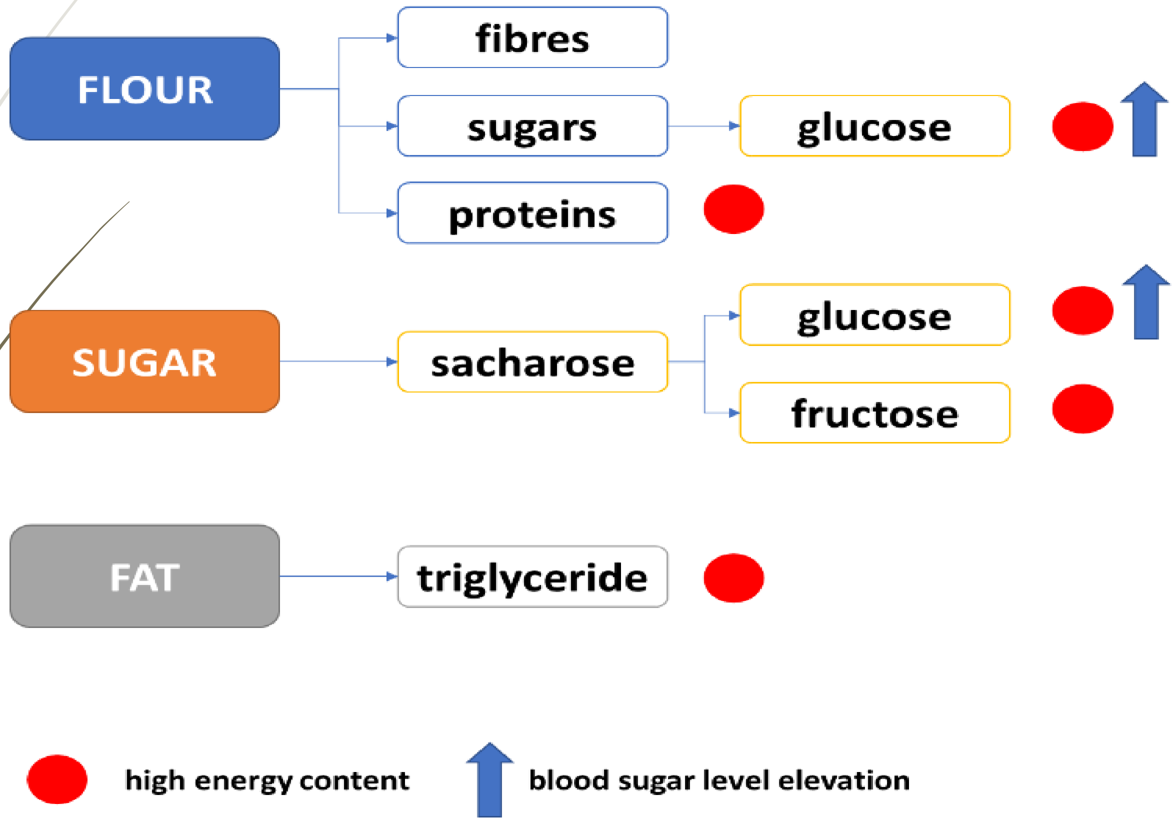


Figure 6.1. Main ingredients of dough

Sugars and fats are good source of energy. The proper amount and quality of these ingredients are playing crucial role as fuel for consumers without any health condition. However, these compounds might be limited or restricted in case of consumers with specific health issues (i.e., obesity, diabetes, cardiovascular diseases).

Sugars resulting in glucose during digestion are contributing to blood sugar elevation, thus person with diabetes or insulin resistance should consider intake in reduced amount these compounds. All type of sugars and fats are high source of energy; thus, limitation must be considered in case of consumers with obesity. Fats, especially those whit high *trans* fatty acid content, are risk factor for people predisposed to cardiovascular health issues or for consumers already having these health conditions.

Replacement or reduced amount of these ingredients might achieve reduced risk for developing health issues and even these products might have beneficial health effects.

6.2. Role of sugar and fat in technology

Replacement or reduced amount of sugar and fat in order to achieve beneficial health effects might sound logical step; however, the role of these ingredients is not limited only to energy source and deliver the sweetness, but they are important in baking technology. Starch, on higher temperatures goes under gelatinization, which is decreased by addition of sugars, due to the high affinity of sugar to water (Struck, Jaros, Brennan & Rohm, 2014). Furthermore, the sugar influences the color of the products, aroma and shelf-life (Sahin, Zannini, Coffey & Arendt, 2019).

Fat or oil disrupts the protein and starch structure, avoiding the gluten and starch particles to adhere to each other; consequently, the bakery products show tender and well aerated texture. Further contribution to bakery product quality of fats are: texture, mouth feel, flavor, lubrication, incorporation of air and extended shelf-life (Ghotra, Dyal & Narine, 2022).

6.2.1. Strategy to replace sugar in bakery products

Sugar is not only bulking agent and deliver sweetness to products, however it has crucial role in technology, just like adjusting starch gelatinization at proper temperature, contribution to products flavor, influences the color of the product and shelf-life. At the same time the traditionally applied sugars (e.g. saccharose) are also source of fast absorbing glucose and they have high energy content, which is a strong disadvantage in several health conditions, including obesity, diabetes, and insulin resistance.

Sugar replacement agents should be limited in energy and glucose content; however, they must harbor all those properties which are necessary in baking technology. The most common agents which are applied as sugar replacers and bulking agents are polydextrose, oligofructose, and maltodextrin (Sahin, Zannini, Coffey & Arendt, 2019).

Although these components have useful properties in food technology, they are not able to deliver the sweetness perception of the sugar. Since the use of artificial sweeteners is strictly limited only for nutritional uses (EU Regulation, No 1129/2011, 2011), further sugar mimetics are needed to deliver the expected sweetness. Polyols are reduced sugars produced via fermentation. Polyols are delivering sweet taste, they have no interference in insulin levels and lack of carcinogenic effect, yet these compounds might exert laxative effect. Honey might be an option for partial sugar replacement, since the sugar content is glucose-fructose 1:1, thus it is rich in energy and has interference with insulin.

6.2.2. Strategy to replace fat in bakery products

Fat has crucial role during baking technology. In formulation the fat forms a hydrophobic coating on the flour granules and prevents adherence of gluten to starch. Fat results in tender and well aerated texture of the bakery product, furthermore it provides mouth feel, flavor, and lubrication, finally it extends shelf-life of the product.

Since fat contributes calories to the organism and excessive use of fat might result in accumulation of body weight, people with obesity try to avoid fat and there is a need to reduce the amount of fat.

Since fat plays crucial technological role, the replacement is not easy at all. Further problems might arise the fat replacement with olive or other vegetable oils. There are margarines with reduced fat content, however there is more demanding need from side of the costumers to keep fat content as low as it is possible.

Fat reduction might be achieved with several products which are able to mimic some characteristics of fat. Long chain polysaccharides (e.g., starches, maltodextrin, hydrocolloids) and dietary fibers can be applied for replacing part (but not all) of the fat in the formulation. Polydextrose might be applied in biscuits. It provides good dough rheology and texture quality when combined with glycerol monostearate and guar gum or with resistant starch (Aggrarwal, Sabikhi & Kumar, 2016; Sudha, Srivastava, Vetrimani & Leelavathi, 2007; Moriano, Cappa & Alamprese, 2018). Inulin is usually applied in cakes, but there are some disadvantages on products, since it batters with low apparent viscosity, volume loss, higher crumb porosity (Rodríguez-García, Slavador & Hernando; Punia, Siroha, Sandhu & Kaur, 2019).

Low-fat content bakery products, especially shortbreads and puff pastries, are lacking good fat replacing agent.

6.2.3. Sugar replacers' effect on product quality

Table 6.1. Bulking agents for sugar replacement

Bulking agents	Product application	Effect on product	Reference
polydextrose	high ratio cake chiffon cake pound cake muffin cookies	contributes to browning, lowers specific volume, increases mean air bubble size in cake batter, decreases viscosity and viscoelasticity of batter, decreases structure setting temperature, increases cookie brittleness	(Hicsasmaz, Yazgan, Bozoglu & Katnas, 2003; Martínez-Cervera, Sanz, Salvador & Fiszman, 2012; Zoulias, Oreopoulou & Kounalaki, 2022)
oligofructose	sponge cake short dough biscuits	contributes to browning, maintains specific volume, increases cake crumb firmness, decreases biscuit snap force, decreases biscuit dough hardness	(Ronda, Gomez, Blanco & Caballero, 2005; Gallagher, O'Brien, Scannell & Arendt, 2003)
maltodextrin	biscuits	contributes to biscuit spreading and browning	(Pourmohammadi, Habibi Najafi, Majzoobi, Koocheki & Farahnak, 2017)

6.2.4. Fat replacers' effect on product quality

Table 6.2. Fat mimetics

Fat mimetic	Product application	Effect on product	Reference
polydextrose	biscuits	in combination with glycerol monostearate and guar gum or with resistant starch good dough rheology and texture quality obtained	(Aggarwal, Sabikhi & Kumar, 2016; Sudha, Srivastava, Vetrimani & Leelavathi, 2007; Moriano, Cappa & Alamprese, 2018)
inulin **modified mung bean starch**	cake	batters with low apparent viscosity, volume loss, higher crumb porosity volume and hardness of the cakes increased with an increase in the level of modified starch	(Rodríguez-García, Salvador & Hernando; Punia, Siroha, Sandhu & Kaur, 2019)

6.3. Technology guideline for manufacture of products

6.3.1. Technology for the manufacture of low-sugar products

Energy content: 1,385 kJ/100 g

Honey% Ingredients (kg)	0% (100% sugar)	25%	50%	75%	100%
Flour	1	1	1	1	1
Sugar	1.0	0.75	0.5	0.25	0.0
Honey	0.0	0.25	0.5	0.75	1.0
Lossening agent	0.0015	0.0015	0.0015	0.0015	0.0015
Flavouring	0.0015	0.0015	0.0015	0.0015	0.0015

Partial replacement of sugar by honey

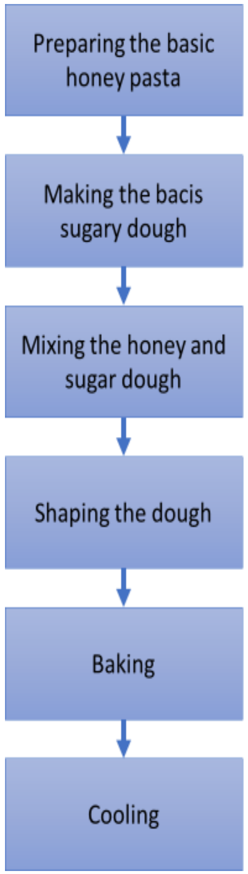


Figure 6.2. Manufacture flow chart for sponge cake with partial sugar replacement (honey).

Sugar substitution

Ingredients	Erythriol sponge cake	Xylitol sponge cake	Stevia sponge cake
Flour (g)	80 g	80 g	80 g
Egg (piece)	6	6	6
Sweetener (g)	120 g	80 g	0.27 g

Figure 6.3. Sponge cake with erytritol (A), xylitol (B), and Stevia (C)

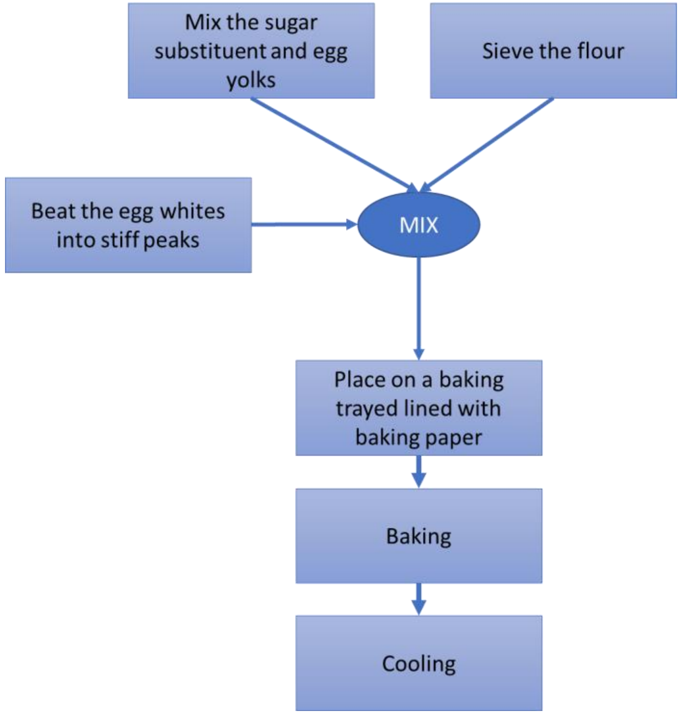
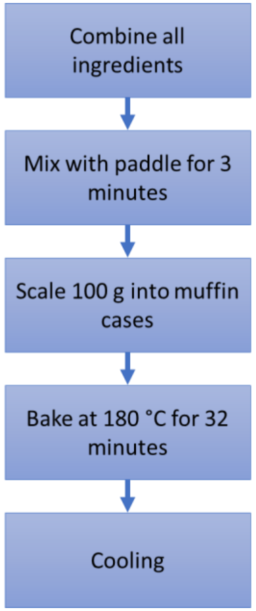


Figure 6.4. Manufacture flow chart for sponge cake with reduced sugar content

Muffin with Tastesense^{TM} (30% sugar reduced)



Ingredients:	**total**	**100**
• soft wheat flour		22.5
• sugar		16.5
• whey powder		1.32
• baking powder		0.88
• salt		0.36
• wheat gluten		0.36
• dextrose		0.18
• distilled monoglycerides (E471)		0.36
• liquid egg		18.9
• vegetable oil		18.4
• water		12.1
• wheat starch		7.9
• Tastesense^{TM}		0.1

Figure 5. Manufacture flow chart for muffin with reduced sugar content

6.3.2. Technology for the manufacture of low-fat products

Fine plaited cakes (fat reduced to 8%)
Ingredients calculated on total flour%

	Fat reduced	Control
BL55 flour	100	100
yeast	5	5
salt	1	1
sugar	10	10
margarine	8	11
milk powder	3	3
eggs	1.5	1.5
additive	0.5	0.5

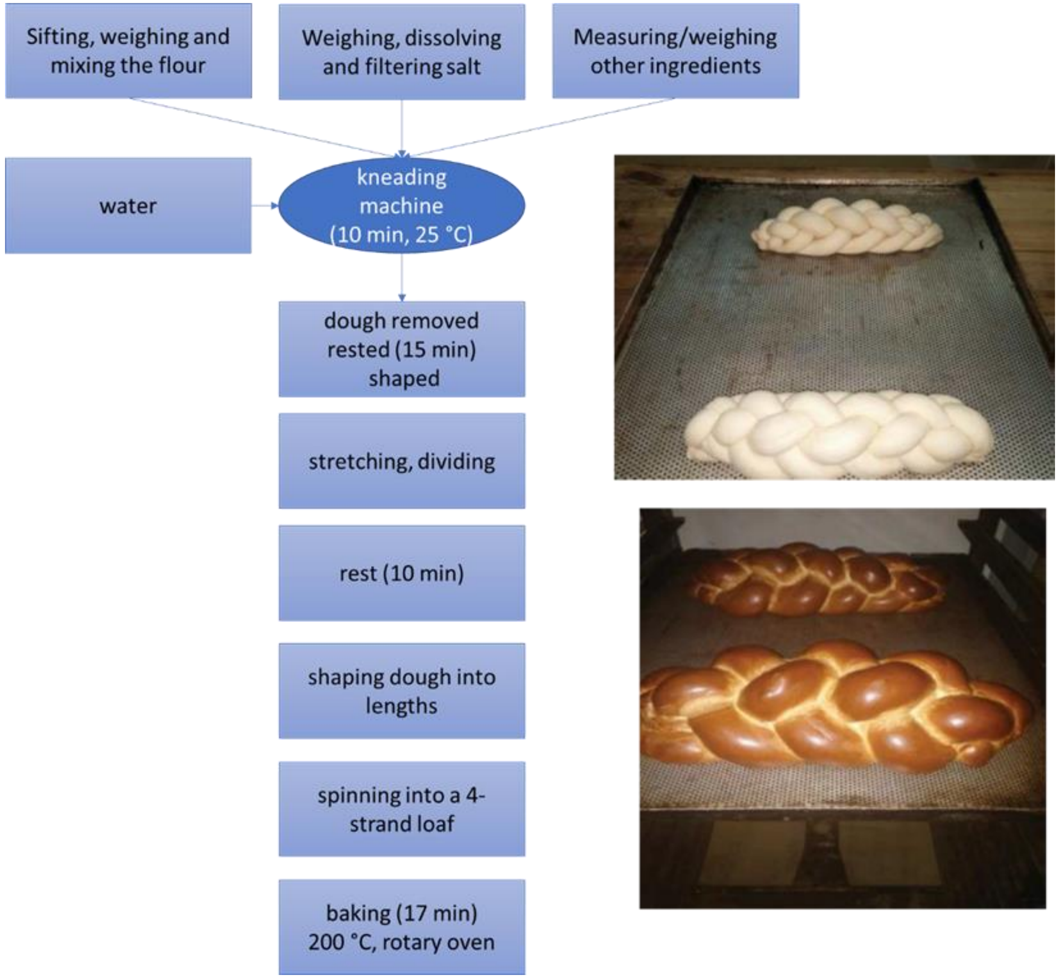


Figure 6.6. Manufacture flow chart for fine plated cake

Wafer products

	Fat reduced	Control
BL55 flour	1 kg	1 kg
icing sugar	0.5 kg	0.5 kg
olive oil / margarine	0.45 kg	0.45 kg
milk	1 L	1 L

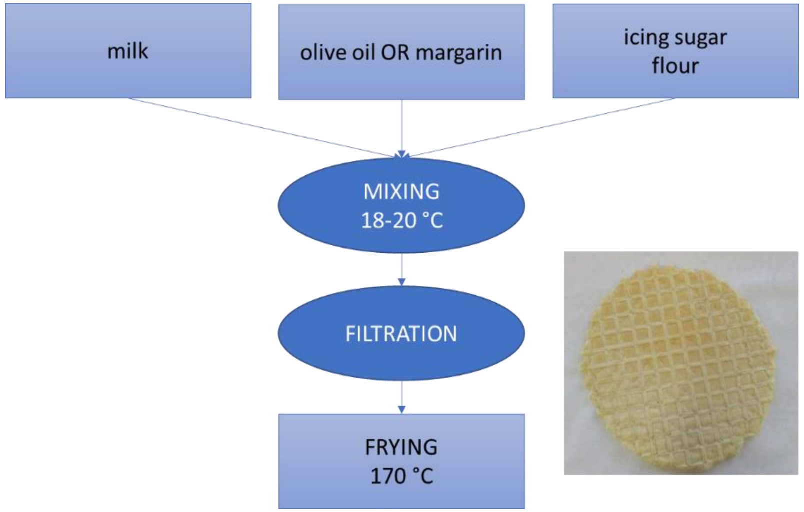
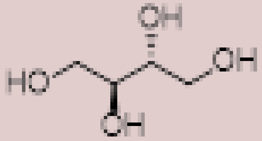
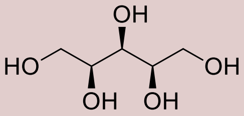


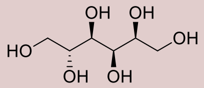
Figure 6.7. Manufacture flow chart for wafer products with olive oil

6.4. Main additives for sugar and fat replacement (fact sheets)

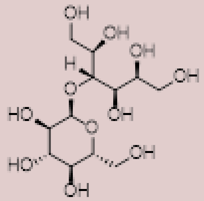
Erythtritol		
E number	E968	
CAS number	149-32-6	
Formula	$C_4H_{10}O_4$	
Molecular weight (g/mol)	122.12	
Solubility (in 100 g water)	37–43 g	
Sweetness to sucrose (%)	60–70	
Calories (kcal/g)	0.2	
Glycemic index	1	

Xylitol		
E number	E967	
CAS number	87-99-0	
Formula	$C_5H_{12}O_5$	
Molecular weight (g/mol)	152.15	
Solubility (in 1 L water)	~100 g	
Sweetness to sucrose (%)	~98%	
Calories (kcal/g)	2.4	
Glycemic index	12	

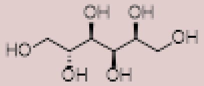
Sorbitol	
E number	E420
CAS number	50-70-4
Formula	$C_6H_{14}O_6$
Molecular weight (g/mol)	182.17
Solubility (in 1 L water)	2,350 g
Sweetness to sucrose (%)	55
Calories (kcal/g)	1.68
Glycemic index	4



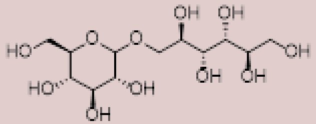
Maltitol	
E number	E965
CAS number	585-88-6
Formula	$C_{12}H_{24}O_{11}$
Molecular weight (g/mol)	344.31
Solubility (in 1 L water)	1,750 g
Sweetness to sucrose (%)	75–90
Calories (kcal/g)	2.4
Glycemic index	35



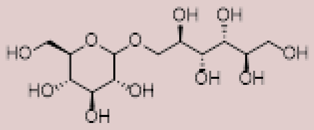
Mannitol	
E number	E421
CAS number	69-65-8
Formula	$C_6H_{14}O_6$
Molecular weight (g/mol)	182.17
Solubility (in 1 L water)	216 g
Sweetness to sucrose (%)	60–70
Calories (kcal/g)	1.6
Glycemic index	2



Isomalt	
E number	E953
CAS number	64519-82-0
Formula	$C_{12}H_{24}O_{11}$
Molecular weight (g/mol)	344.31
Solubility (in 1 L water)	240 g
Sweetness to sucrose (%)	55
Calories (kcal/g)	2.0
Glycemic index	2



Lactitol	
E number	E966
CAS number	585-86-4
Formula	$C_{12}H_{24}O_{11}$
Molecular weight (g/mol)	344.31
Solubility (in 1 L water)	377 g
Sweetness to sucrose (%)	30–40
Calories (kcal/g)	2.4
Glycemic index	3



Polydextrose	
synthetic polymer of glucose	
E number	E1200
CAS number	68424-04-4
Solubility (in 100 g water)	400 g
Sweetness to sucrose (%)	10
Calories (kcal/g)	1.0
Glycemic index	4–7

Oligofructose (fructooligosaccharides - FOS)	
CAS number	308066-66-2
Sweetness to sucrose (%)	30–60
Calories (kcal/g)	1.0
Glycemic index	0

Maltodextrine	
CAS number	9050-36-6
Sweetness to sucrose (%)	0–5
Calories (kcal/g)	39
Glycemic index	85–110

Inulin	
CAS number	9005-80-5
Solubility (in 1 L water)	104 g
Sweetness to sucrose (%)	10
Calories (kcal/g)	3.9
Glycemic index	14

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