UDC: 664.641.1.016
Review article

PROPERTIES OF FLOUR OBTAINED FROM MALTED GRAINS – REVIEW

Gjore NAKOV[1], Mishela TEMKOV[2], Iliana LAZOVA-BORISOVA[1], Jasmina LUKINAC[3]

[1*] *Institute of Cryobiology and Food Technologies, Agricultural Academy—Sofia, BG*
[2] *Faculty of Technology and Metallurgy, St. Cyril and Methodius University in Skopje, MK*
[3] *Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, HR*
[*] *Corresponding author e-mail: gore_nakov@hotmail.com*

Abstract

Germination as part of the malting process produces malt flour, which can be obtained from various grains (e.g., barley, sorghum, wheat, and rye). Malting is a technological process that involves several operations: steeping, germination, kilning, and cleaning, resulting in malt as the final product, which is usually used for brewing. Further milling of the malted grain produces malt flour, which is often used as an additive to wheat flour to enrich it and obtain better technological properties in the production of bread and bakery products. Information on malt flour with high enzyme content can be found in the literature. However, the literature lacks data on the general changes during germination in the malting process, affecting both carbohydrates and protein complexes. This review aims to present the changes in grains during the germination process and to use malt flour for the production of new functional products.

Keywords: germination, grains, malt flours, functional products

1. Introduction

Cereal grains are foods consumed by humans and animals. On a global scale, the most important cereals for human consumption are wheat, rice, corn, barley, and sorghum. In contrast, the use of rye, millet, and oats is less significant. The grains are considered a good source of energy, protein, fiber, minerals, and other biologically active substances (tocopherols, phytosterols, lignin, phenolic acids, folic acid, etc.) (Huebner and Arendt, 2013). The cereal used for malt production is very often barley due to the balance of starch and proteins. However, in addition to barley, malt can also be produced from wheat, rye, sorghum, millet, triticale, oats, etc. Malting is a process that involves several operations, including steeping, germination (Sofi et al, 2020), and kilning (Fig. 1). Throughout the malting process, the physical appearance of the seed changes significantly, as does the synthesis and activation of various enzymes that characterize the final product (MacLeod and Evans, 2015). The first step in malting is water penetration (steeping), during which the seed swells significantly.

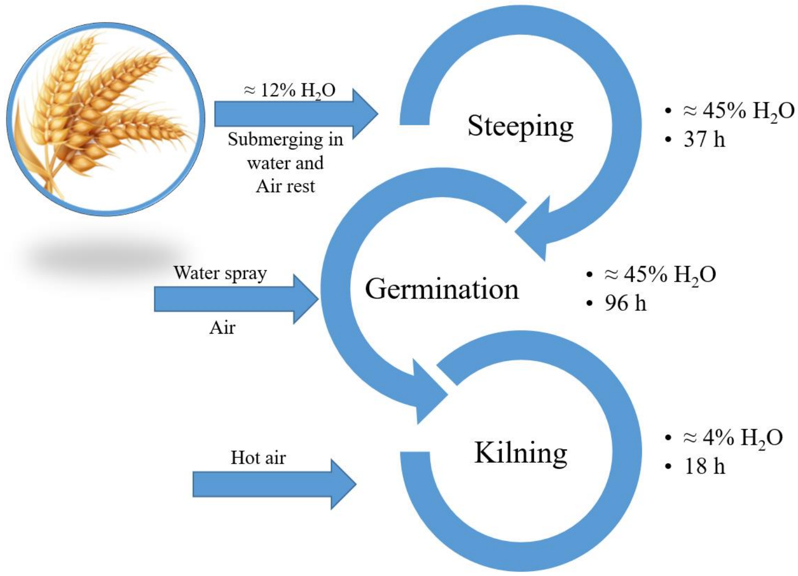

Fig1. Operations in the malting process (Fox, 2018)

Carbohydrates

Different grains contain different amounts of starch. Wheat, rice, and barley have percentages of 60-75%, 75-80%, and 62-77%, respectively, which greatly affects their technological properties (Oliveira et al, 2022). Starch contains amylose (linear molecule, 1-4 linkages) and amylopectin (branched molecule, 1-6 linkages with amylose). Starch is the main component in mature grains. When the seeds are soaked in water, the enzymes present in the dried seeds become active. The carbohydrates change during the malting process (Langenaeken et al, 2020). During germination, amylolytic enzymes (mainly α-amylase acting on α-(1-4) bonds) hydrolyze starch into glucose, maltose, dextrins, and oligosaccharides (Baranzelli et al, 2018). If you increase the germination time, the activity of amylases (especially α-amylase) increases. According to Baranzelli et al, 2018, a period of 24 hours for germination is not sufficient to activate the amylolytic enzymes. In addition, β-glucans are degraded during germination as part of the cell wall of the endosperm, which means that they are only present in small quantities in malting products (Huebner et al, 2010).

Rheological properties of germinated flour

Cho and Lim (2016) have demonstrated that the germination time of wheat has a major impact on the rheological properties of the dough. From their data, controlled wheat germination (3 and 5 days) leads to better flour quality and consequently better bread. Baranzelli et al, 2018 found that a prolonged germination time could decrease the endurance but increase the extensibility of the dough. They reported decreasing values from 1.5 to 0.6 for the endurance/ extensibility, but not when the process duration was 24 hours. On the other hand, gluten strength decreased when the germination period was 24 hours and even at 72 hours. Helland et al, 2002 studied the effects of corn germination on the viscosity of a germinated corn suspension in water. It was found that the reduction in the viscosity of the suspension occurs after three days of corn germination.

Proteins

During grain germination, proteins are hydrolyzed by proteases into amino acids and low-molecular-weight peptides, which in turn increases the bioavailability of amino acids. (Cho and Lim, 2016; Liu et al, 2022). Philco-Quesada et al, 2020 found that the amount of crude protein in quinoa (Chenopodium quinoa) and kiwicha (Amaranthus caudatus) increases after germination, but this is associated with a decrease in dry matter, especially due to the loss of carbohydrates through the active process of respiration during seed germination. Therefore, the protein content in germinated grains depends on the ratio of degraded proteins and proteins synthesized during germination, which is quite different for different seeds. Germination has a positive effect on amino acid content in seeds, although the magnitude of changes in amino acids and grains is different. Ohm et al, 2016 found that prolonged germination of up to 5 days can increase the content of the following amino acids: Alanine, aspartine, aspartic acid, glutamic acid, glutamine, glycine, isoleucine, leucine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, and valine. Optimization of malting conditions of barley (Nie et al, 2010) showed increased content of lysine, histidine, alanine, proline, tyrosine, methionine, leucine, phenylalanine, and tryptophan, while the amount of aspartic acid, serine, asparagine, glutamine, γ-aminobutyric acid and lysine was reduced during barley kilning.

Vitamins and minerals

Vitamins are essential components because they have an important physiological function but cannot be synthesized by human metabolism (Hübner and Arendt, 2013). Changes in macro and micro-content of vitamins during germination have been reported in different cereals. According to Pinheiro et al, 2021, riboflavin content in sorghum increased significantly after germination compared to the control sample. On the other hand, this process led to a decrease in the vitamin content of sorghum (1180.6 μg/100 g DM) compared to the control (2216.4 μg/100 g DM). The influence of the germination process on vitamin content was also demonstrated by Anaemene and Fadupin (2022). They observed a negative effect of germination on vitamin A content in pigeon pea flour, which decreased by 12.24% compared to the control sample. Meanwhile, Jeong et al, 2019 observed a significant increase in niacin, folic acid, and thiamine in rice during germination. Liu et al, 2022 considered that water-soluble vitamins such as vitamin C, niacin, and folic acid increased after the germination process, while the content of fat-soluble vitamins decreased. According to Oliveira et al, 2022, germination is a simple and fast method to naturally enrich cereals with minerals such as Fe, Zn, Ca, Se, and I. Moreover, when investigating the influence of the germination process on the mineral content of oats, Hübner et al, 2010 found that the Ca content increased. Non-germinated oats had 20.8 mg Ca/100g, the oats germinated at 20°C for 48 hours had 31.1 mg Ca/100g, while the extended germination time of 144 hours at the same temperature did not change the Ca content. Mg content in oats increased during germination of the raw material (from 114 mg/100g DM in the control test to 122 mg/100g DM in the 48 hours germinated sample and to 130 mg/100g DM in the 114 hours germinated sample). Cu content increased from an initial 0.2 mg/100g DM to 1.1 mg/100g DM during 48 hours of germination at 20°C. In contrast, Cu content decreased to 0.5 mg/100g DM during 144-h germination of oats. During germination, a decrease in Fe content was observed from 4.0 mg/100g DM in opaque oats to 3.7 mg/100g DM in 48-h germinated oats and 3.9 mg/100g DM in 144-h germinated oats. During germination, Zn content in oats increased from 2.7 mg/100g DM in unterminated oats to 3.6 mg/100g DM and 3.5 mg/100g DM in 48 hours and 144 hours germinated oats, respectively.

Role of germination in the production of functional food

Due to the increasing consumption of food and people's awareness of a balanced diet, malt flour could be a great potential raw material for the production of functional foods. Substitution of malt flour for wheat flour leads to the production of nutritionally superior food products. Jukić et al, 2022 developed biscuits in which wheat flour was replaced by malted barley flour (MBF). The study shows that an optimized biscuits formulation with a 20% substitution of wheat flour with malted barley and a 66.6% reduction in sucrose was found to have very similar quality characteristics to the control sample. These novel biscuits are considered functional due to the increased content of β-glucans, polyphenols, and antioxidant activity. Agu et al, 2020 also developed biscuits formulations using malt flour (MF), which was found to be richer in protein, carbohydrate, fat, ash, and crude fiber. According to Liu et al, 2022, the use of germinated grains and legumes can be applied in the production of puffed snacks from germinated brown rice, wheat germ oil, germinated triticale biscuits, functional supplements made from germinated pigmented rice, germinated brown rice drink, germinated soybean bread, germinated brown rice yogurt, and nutritious baby food made from germinated brown soybean. Baranzelli et al, 2018 studied the influence of the wheat germination process at different time intervals (24, 48, and 72 hours) and its use in bread making. Compared to the control sample, the germination process resulted in changes in the content of damaged starch and gluten index in the flours. The use of germinated flour in the final product had positive effects on specific volume and hardness. Sofi et al, 2020 studied the effect of germination on the physicochemical and rheological properties of chickpea flour. It was found that germination time significantly affected the nutritional profile of the flour, resulting in a significant increase in protein and crude fiber content. Independently, germination improved the functional properties of the flour and decreased its non-nutritive, thermal, and sticky properties. In addition, Yang et al, 2021 found that germination time plays an important role in improving the nutritional and antioxidant properties of cereals. They developed a technology to produce biscuits from wheat malt flour. This product had higher fiber and phenolic content, as well as a better appearance and texture. The authors considered 3 to 4 days to be the optimal germination time of raw cereals in terms of malting efficiency, phenolic fraction content, and antioxidant properties.

2. Conclusions

Germination is a traditional, non-thermal process that improves the nutritional quality of grains by increasing the digestibility of nutrients and reducing the content and activity of non-nutrient compounds. This process increases the content of free amino acids as well as carbohydrates. After germination is completed, malt flour is obtained, which has improved functional properties. Malt flour has great potential for use in the production of cakes and other confectionery products, creating new healthy and functional foods with excellent sensory properties.

Acknowledgments

This work was financially supported by the Bulgarian Ministry of Education and Science, National Research Fund under contract number КП-О6-М56/3-2021.

References

[1]. Agu H.O., Onuoha G.O., Elijah O.E. and Jideani, V.A. 2020. Consumer acceptability of acha and malted Bambara groundnut (BGN) biscuits sweetened with date palm. Heliyon 6, e05522.

[2]. Anaemene D. and Fadupin G. 2022. Anti-nutrient reduction and nutrient retention capacity of fermentation, germination, and combined germination-fermentation in legume processing. Appl. Food Res. 2, 100059.

[3]. Baranzelli J., Hüttner D., Colussi R., Fernandes F., Camargo B., Zavariz M., Miranda D. and Zavareze R. 2018. Changes in enzymatic activity, technological quality, and gamma-aminobutyric acid (GABA) content of wheat flour as affected by germination. LWT - Food Sci. Technol. 90, 483–490.

[4]. Cho D.H. and Lim S.T. 2016. Germinated brown rice and its bio-functional compounds. Food Chem. 196, 259–271.

[5]. Finney P.L. 1983. Mobilization of Reserves in Germination. Mobilization Reserv. Germination.312.

[6]. Fox G. 2018. Starch in Brewing Applications, Starch in Food: Structure, Function, and Applications: Second Edition. Elsevier Ltd. 633-659.

[7]. Helland M.H., Wicklund T. and Narvhus J.A. 2002. Effect of germination time on alpha-amylase production and viscosity of maize porridge. Food Res. Int. 35, 315–321.

[8]. Hübner F. and Arendt E.K. 2013. Germination of Cereal Grains as a Way to Improve the Nutritional Value: A Review. Crit. Rev. Food Sci. Nutr. 53, 853–861.

[9]. Hübner F., O'Neil T., Cashman K.D. and Arendt E.K. 2010. The influence of germination conditions on beta-glucan, dietary fiber, and phytate during the germination of oats and barley. Eur. Food Res. Technol. 231, 27–35.

[10]. Jeong B.G., Moon H.G. and Chun J. 2019. The water-soluble vitamin and GABA contents of brown rice are affected by germination. J. Korean Soc. Food Sci. Nutr. 48, 1359–1365.

[11]. Jukić M., Nakov G., Komlenić D.K., Vasileva N., Šumanovac F. and Lukinac J. 2022. Quality Assessment of Cookies Made from Composite Flours Containing Malted Barley Flour and Wheat Flour. Plants 11.

[12]. Langenaeken N.A., De Schepper C.F., De Schutter D.P. and Courtin C.M. 2020. Carbohydrate content and structure during malting and brewing: a mass balance study. J. Inst. Brew. 126, 253–262.

[13]. Liu S., Wang W., Lu H., Shu Q., Zhang Y. and Chen Q. 2022. New perspectives on physiological, biochemical and bioactive components during germination of edible seeds: A review. Trends Food Sci. Technol. 123, 187–197.

[14]. MacLeod L., and Evans E. 2015. Barley: Malting. Encycl. Food Grains Second Ed. 3–4, 423–433.

[15]. Nie C., Wang C., Zhou G., Dou F. and Huang M. 2010. Effects of malting conditions on the amino acid compositions of final malt. African J. Biotechnol. 9, 9018–9025.

[16]. Ohm J.B., Lee C.W. and Cho K. 2016. Germinated wheat: Phytochemical composition and mixing characteristics. Cereal Chem. 93, 612–617.

[17]. Oliveira M.E.A.S., Coimbra P.P.S., Galdeano M.C., Carvalho C.W.P. and Takeiti C.Y. 2022. How does germinated rice impact starch structure, products, and nutritional evidence? – A review. Trends Food Sci. Technol. 122, 13–23.

[18]. Pilco-Quesada S., Tian Y., Yang B., Repo-Carrasco-Valencia R. and Suomela J.P. 2020. Effects of germination and kilning on the phenolic compounds and nutritional properties of quinoa (Chenopodium quinoa) and kiwicha (Amaranthus caudatus). J. Cereal Sci. 94, 102996.

[19]. Pinheiro S.S., Anunciação P.C., Cardoso L. de M Della Lucia C.M., de Carvalho C.W.P., Queiroz V.A.V. and Pinheiro Sant'Ana H.M. 2021. Stability of B vitamins, vitamin E, xanthophylls, and flavonoids during germination and maceration of sorghum (Sorghum bicolor L.). Food Chem. 345, 1–8.

[20]. Sofi S.A., Singh J., Muzaffar K., Mir S.A. and Dar B.N. 2020. Effect of germination time on physicochemical, functional, pasting, rheology, and electrophoretic characteristics of chickpea flour. J. Food Meas. Charact. 14, 2380–2392.

[21]. Yang B., Yin Y., Liu C., Zhao Z. and Guo M. 2021. Effect of germination time on the compositional, functional, and antioxidant properties of whole wheat malt and its end-use evaluation in cookie-making. Food Chem. 349, 129125.