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Pharmacological And Biomedical Effects of Malting on Cereal Grains

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***Abstract*: Health is an asset to be treasured. Diet is a medium through which health is maintained. diet including Cereals like Rice, Wheat, Barley, Oats, Millets, etc., are global staple foods for millions of people. Cereals are known as the largest source of energy, now-a-days, cereals are known for their various functional properties. Various methods are followed to improve these properties. Malting is one of a process by which the cereal grains are enriched with functional properties that gained its use in pharmacological and biomedical fields. Malting is a traditional and simple method that has potential of increasing iron content, amino acid content, sugar content of cereals and provides enhanced digestibility of cereals. Malting of cereals finds its applications in food, beverage and cosmetics industry due to its bio-active properties. In this review, the importance of healthy lifestyle through diets including cereals, the process of malting and its effects, pharmacological and biomedical properties and its applications were presented.**

***Keywords*: Malting, Biomedical effects, Beverages, Diet, Cereals**

Introduction

By definition and realisation, health is a natural aspect of life. Staying healthy is dependent on one's way of life. We have placed overall health in our bodies, and we come diligently and constantly to keep our physical condition. When it comes to our food, we realise the critical components of overall health. Eating natural, complete foods and making a commitment to avoiding foods heavy in fat and oil (Kumar, 2017).

Health extends people's lives and minimises newborn and maternal mortality. A healthy diet, personal hygiene, and regular exercise are essential for optimal health (Shridhar *et al.*, 2015). A healthy lifestyle that includes a good food, physical activity, no smoking, a healthy weight, and no to low alcohol use will help prevent heart failure. These findings highlight the need of emphasising overall healthy lifestyle in public health programmes aimed at preventing heart failure and increasing healthy life years at all ages. (Limpens, 2022).

Advocating for a healthy lifestyle from a young age will lessen both the disease's occurrence and its long-term repercussions (Kaundal *et al*., 2022 and Lie Fong *et al*., 2021). Starting a healthy lifestyle requires a change in food as well as regular physical activity and exercise (diabetes). Diet and physical activity are two of the most important aspects of diabetes self-management (Spandana, 2022).

Building a healthy lifestyle, regardless of age, has been shown to minimise the risk of cardiovascular disease, the incidence of obesity and diabetes, the risk of malignancy, psychiatric problems, and cognitive dysfunction(Lee *et al*., 2010 and Willoughby *et al*., 2008; Cojocaru *et al*., 2014).

Cereal grains account for almost half of global calorie intake, with higher proportions in low and middle-income nations, particularly in Africa and South Asia. Cereal grains account for over 70% of daily caloric consumption in these regions(Kearny, 2010). According to FAO STAT 2021, global cereal food consumption is 176 kg per capita per year, or around 480 g per capita per day. Wheat and maize are the most abundant crops (766 and 1148 million metric tonnes, respectively), followed by rice (755 million metric tons). Other globally important cereal crops include barley, sorghum, and oats (FAO STAT, 2021).

Grains are an important source of energy (30 percent of intake), proteins (25 percent –30 percent), carbohydrates (40 –45 percent), fibre (40 –60 percent), and vitamins and minerals such as thiamine (25 –35 percent), folate (30–35 percent), iron (40 –45 percent), calcium (10 –30 percent), and selenium, depending on the amount and quality of grains consumed by adult populations (20 percent) (Mckevith, 2004 and Valsta *et al*., 2021).

In addition to being major sources of nutritional energy, most cereals contain variable amounts of proteins, lipids, minerals, and vitamins. Wheat accounts for around 20% of total dietary calories and proteins worldwide (Shiferaw *et al*., 2013), while rice accounts for 20% of total calories and contains key minerals, vitamins, and bioactive phytochemicals, along with other essential food components found in rice bran (Fukagawa and Ziska, 2019). Whole maize grain is high in anthocyanins and has several nutritional benefits that can be increased by the traditional 'nixtamalization' method. (Rosales *et al*. 2016; Ba˜nuelos-Pineda *et al*. 2018).

Some cereals, particularly coloured rice, wheat, maize, and millets, include useful bioactive components such as polyphenols, tocopherol, oryzanol (antioxidants), and vitamins. These grains have functional features that help fight diseases and prevent or regulate some diseases in the body, such as cardiovascular risk, cancer risk, type 2 diabetes, hypertension, high blood pressure, and so on(Baniwal *et al*., 2021, Bartlomiej *et al*., 2012)(Klopcic *et al*., 2020).

Cereals have unique traits that go beyond their nutritional value, such as biomedical properties. Wheat bioactive components such as phenolic acids (hydroxycinnamic acids and hydroxybenzoic acids), flavonoids, benzoxazinoids (BXs), carotenoids, alkyl resorcinols, and others have numerous therapeutic applications in the treatment and prevention of obesity, cardiovascular disease

(CVD), type-2 diabetes, anti-colorectal cancer, and others (Liu *et al*., 2020). Rice is a popular diet for new-borns due to the presence of lysine (Baniwal *et al*., 2021). Brown rice is a whole grain product that is low in calories but high in fibre, vitamins, particularly vitamin B, iron, and manganese. Brown rice has been shown to help reduce heart problems by lowering cholesterol levels, as well as to be important for cleaning the digestive tract and preventing the formation of blood clots. When crushed rice powder is applied to the skin, it has a medicinal effect on skin disorders(Lavanya *et al*., 2017).

Rice is well-known for its anti-oxidant and chemoreceptive characteristics, and its red colour is due to the presence of the pigment "proanthocyanin" (Mehra *et al*., 2020). Barley is a non-gluten grain. The hull-less barley has been discovered to have a high glucan content that aids in the prevention of induced colon cancer (Idehen *et al*., 2017 and Baniwal *et al*., 2021). Quinoa is a pseudo-grain that can be used to induce hunger in persons who do not have an appetite. Quinoa's reduced Glycemic Index is responsible for this feature(Lopes *et al*., 2019).

According to a study (Lattimer & Haub, 2010), fibres in oats have the ability to lower LDL cholesterol levels, which is especially relevant for patients with diabetes. Oats include beta-glucan, which helps to keep blood sugar levels stable (Chen & Raymond, 2008).

Malting process:

Malting and fermentation are significant unit procedures used to improve food quality during processing. Malting is the process of modifying the biochemical alterations that increase the nutritional and bioactive qualities of cereal grains during controlled germination (Dahiya *et al*., 2018).

Steps involved in malting process

The malting process consists of three major phases. The first step is to soak the barley, commonly known as steeping, in order to awaken the dormant grain. The grain is then allowed to germinate and sprout. Finally, the barley is heated or kilned to obtain its final colour and flavour.

Step 1: Steeping

Steeping is the first and most important process in producing high-quality malt. This is accomplished by submerging or "steeping" the grain in water, followed by an air rest period that allows the grain's water content to grow. Under optimal growth conditions, the absorbed water activates naturally occurring enzymes and promotes the grain to generate new enzymes. The steeping procedure varies depending on grain type and size, but it usually takes 24-48 hours. When the barley has attained a moisture level that allows for a consistent breakdown of starches and proteins, the steeping process is complete.

Step 2: Germination

The second stage is to carry on the germination process that began with steeping. Grain growth and alteration take place here. Rootlets develop from the kernel from the outside of the grain. This process usually takes 4-6 days and produces what is known as "Green Malt." The grains are separated with occasional rotation to avoid grain clumping, non-uniform heating, and different rates of germination.

Step 3: Kilning

Kilning is the third and last step in the malting process. The green malt is dried by convection heat treatment to prevent further germination. Most malts begin by removing moisture from the germinated grain, a process known as withering. Additional drying decreases the moisture level of the malt and prepares it for flavour and colour development.

Malting increases total sugar and free fatty acids due to protease and amylase enzymes, which break down the complex structure of protein and carbs in cereals into simple and soluble components (Sandberg & Andlit, 2002). (Olamiti *et al*., 2020). Fermentation is a process in which microbe enzymes operate on a substrate, most commonly a carbohydrate, to produce energy, acids, gas, and alcohol (Kohajodova and Karovicova, 2007). (Olamiti *et al*., 2020). Fermentation is crucial for increasing the nutritional contents of food and preserving it. This approach aids in the preservation of food products while also improving the flavour, colour, and nutritional content of raw materials (Chinenye *et al*., 2017; Saleh *et al*., 2013). (Olamiti *et al*., 2020).

Endopeptidases degrade proteins into polypeptides with reduced molecular weight during the malting process, while exopeptidases degrade breakdown products into amino acids such as lysine, - aminobutyric acid, and asparagine (Ding *et al*., 2018; Grassi *et al*., 2018; Xie *et al*., 2014; Belcar *et al*., 2021). The protein level of the composite flour improved after fermentation (Gawande *et al*., 2018). Fermentation can also boost mineral availability and vitamin B levels, especially thiamine (Gawande *et al*., 2018; Mungula *et al*., 2003). Grain malt flour is utilised in the manufacturing of newborn and geriatric diets, as well as as a popular diabetic food supplement (Kumar *et al*., 2016; Udeh *et al*., 2018). The process of malting is done in almost all the cereals like wheat, barley, oats, quinoa, maize, rice for the preparation of malted beverages which are alcoholic and non-alcoholic in nature. Beers are the fermented beverages prepared from malted rice and malted barley. Malting of grain sprouts enhances the anti-oxidant activity of the cereals. The effect of malting on cereal grains is depicted in Table 1.

S.no	Cereal Grains	Malting Process	Time of Malting	Benefits	References
1.	Wheat	Germination	5 days	Reduction of undesired Cinnamic Acid	Langos *et al*., (2015)
2.	Fox Tail Millet	Germination	3 days	Concentration of minerals.	Coulibaly and Chen(2011)
3.	Pearl millet	Soaking	24 hrs	Enhanced Protein	Iyabo *et al*. (2018)
4.	Barely	Mashing	10 mins at 4^0 C	Degradation of protein into Amino Acids	Torres *et al*. (2022)
5.	Black Rice	Germination	8 days	High intensity of colour of rice wort could be achieved.	Usansa *et al*. (2011)

Table 1: Effect of malting on various cereals

Phytochemistry of various cereals:
Malting of cereals have considerable effect on the phytochemical parameters of the grains. The phytochemical parameters include moisture content, crude protein, crude fat, total carbohydrates (Hingade *et al*., 2019). The crude protein in wheat and barley grains after malting were increased substantially whereas moisture content, crude fat and crude fibre content were reduced after malting (Hingade *et al*., 2019).
There are many phytochemicals present in the cereals. The levels of phytochemicals increase during malting of the grains. These phytochemicals help in preventing many diseases like Type-2-Diabetes, cardiovascular problems, obesity problems (Belobrajdic *et al*., 2013)

Wheat: Wheat's antioxidant qualities are mostly related to its high phenolic content, including alkyl resorcinols and hydroxycinnamic acids (ferulic, sinapic, and coumaric acids) concentrated in the bran portion (Adom *et al*., 2005; Belobrajdic *et al*., 2013). Following the malting process, the concentration of flavonoids such as catechin and tocopherols in the bound fraction of wheat cultivars increased.

Barley: The most important phytochemicals found in barley are phenolics, tocopherols, and folate. Tocopherol levels in barley have grown about fivefold over normal levels. (Ward *et al*., 2008; Belobrajdic *et al*., 2013).

Rice: Although the quantities of these phytochemicals vary greatly amongst rice kinds, brown rice is a good source of lipid-soluble antioxidants such as ferulated phytosterols (γ-oryzanol), tocopherols, and tocotrienols. (Bruce *et al*., 2010; Belobrajdic *et al*., 2013). The total phenolic contents of the grains and anti-oxidant capacity increased after malting of the grains.

Rye: Rye has a higher concentration of alkyl resorcinols (568 to 3220 g/g) than the other major cereal kinds (0 to 750 g/g). The high amount of folate in the grain (0.55 to 0.80 mg/100 g) [64] is associated to the quantity of alkyl resorcinol in rye (Ross *et al*., 2004; Belobrajdic *et al*., 2013). Some rye varieties possess relatively high amounts of total phenolics (up to 1080 g/g), however the free phenolic content is quite modest (between 10 and 35 g/g). (Nystorm *et al*., 2008) Other phytochemicals, such as tocopherols and polyphenols, are found in modest concentrations in rye (Nystorm *et al*., 2008).

Oats: Tocopherols and tocotrienols, phenolic acids, sterols, selenium, and avenanthramides (a type of N-cinnamoyl anthranilate alkaloids found only in oats) are the most important phytochemicals found in oats (Peterson *et al*., 2001). The total phenolic levels in oats are similar to those in wheat and rye, but oats contain up to ten times freer and more conjugated phenolics. Other phytochemicals found in oats include folate, polyphenols, ferulic acid, and flavonoids at low quantities. (Belobrajdic *et al*., 2013). Different anti-oxidant activity along of the malted cereals along with extraction method is shown in the Table 2.

Cereal grains	Extraction process	Total phenols (mg/100gm)	DPPH (Trolox equ mg/g)	Flavonoids (mg/100g)	References
Wheat	Folin-Ciocalteu method	109.06 ± 9.41	103.10 ± 11.37 mg/ml	-	Niroula *et al.*, 2019
Barley	Folin-Ciocalteu method	127.40 ± 10.67	289.26 ± 25.21 mg/ml	-	Niroula *et al.*, 2019
Buck wheat	Methanol/Acid	912 ± 81.9 μg/g	80.0 ± 7.0 mg/ml	76.8 ± 8.2 mg/100g	Gorinstein *et al.*, 2006
Bajra	Folin-Ciocalteu method	133.63 ± 2.33	1.26 ± 0.18 mg/g	-	Sreeramulu *et al.*, 2009
Quinoa	Methanol/Acid	600 ± 53.8 μg/g	30.0 ± 2.8 mg/ml	38.6 ± 4.4 mg/100g	Gorinstein *et al.*, 2006
Finger Millet	Folin-Ciocalteu method	373.15 ± 70.07	1.73 ± 0.03 mg/g	-	Sreeramulu *et al.*, 2009
Rice	Methanol/Acid	330 ± 32.7 μg/g	20.0 ± 1.8 mg/ml	12.5 ± 1.7 mg/100g	Gorinstein *et al.*, 2006
Rice	Folin-Ciocalteu method	47.64 ± 0.82	1.23 ± 0.03 mg/g	-	Sreeramulu *et al.*, 2009
Maize	Folin-Ciocalteu method	112.68 ± 0.43	1.26 ± 0.18 mg/g	-	Sreeramulu *et al.*, 2009
Wheat	Folin-Ciocalteu method	170.78 ± 8.29 mg/100g	32.58 ± 1.86 mg/g	-	Leoncini *et al.*, 2012

Table 2: Anti-oxidant activity of different cereal grains

Pharmacology of malted cereal grains:
Malting finger millet increases its digestibility, sensory and nutritional quality, and has a significant influence on antinutrient reduction. Finger millet malting properties are superior to other millets and rank second only to barley malt (Pawar *et al.*, 2007). When three different types of malted barley were utilised to make cookies, the antioxidant research and total phenolic content were found to be higher than in regular wheat cookies(Jukic *et al.*, 2022).

S.No.	Cereals	Component	Effect	Mechanism	Health benefits	Reference
1.	Pearl Millet	Iron	Increased in malts	Breakdown of complex compounds to simple nutrients by Germination	Prevent Anaemic conditions	Vijay *et al.*, 2021.
2.	Finger Millet	Methionine	Increased in malts	Bio-availability due to sprouting	Removal of unwanted fat from liver	Jagati *et al.*, 2021.
3.	Pearl Millet	Protein	Increased in malts	Soaking and Germination provided mobility of Nitrogen	Prevent protein-energy malnutrition in body.	Gowda *et al.*, 2002.
4.	Wheat	Starch	Decreases in malts	Action of amylolytic enzymes on starch reserves.	Sugars obtained are the basic source of energy metabolism.	Byeon *et al.*, 2022.
		Total Phenol Content	Increased during malting	Decomposition of cell wall components and Bio-Synthesis of phenols	Antioxidant property	
6.	Barely	Anti-inflammatory agents like Vanillic Acid	Increased during malting	Formation of Short Chain Fatty Acids	Anti-inflammatory properties	Zeng *et al.*, 2020

Applications of Malting

Food Applications

When wheat flour is partially substituted with malted barley flour, the texture of the cookies improves and the amount of sugar used in cookie baking is reduced. These cookies have a lot of sensory appeal (Alka *et al*., 2017). Malted Millet flour was created as a healthier alternative to gluten-containing flour while baking cookies. Malted millet flour had favourable sensory, aroma, and flavour characteristics, as well as an increased amino acid profile (Adebiyi *et al*., 2017).

The addition of malted raw ingredients to goods has also been found to improve their sensory characteristics. Extrudates made from malted millet and soybean performed better in terms of flavour and texture than unmalted equivalents, and the malted flavour masks the disagreeable beany flavour derived from soybean (Obatolu, 2002).

The use of native or malted amaranth looks to be a promising method for producing high-quality breads with much higher dietary fibre content than the reference wheat bread (Onyango *et al*., 2022).

Traditionally, either malting or fermentation is used to process finger millet (Ragi) (Rao *et al*., 2001). A preparation known as 'ragi malt' that can be used as a health drink or energy drink and is popular in Indian states (Verma *et al*., 2013).

Industrial Applications

Wisconsin Mellin Company created the first malt-based feeding product given to infants with sterilised milk in 1850. (Hunziker, 1949). James and William Horlicks created Horlicks in 1887 using malted barley and wheat (Dhillon, 2005). Many items based on malted grains have been introduced in the business since then.

A malt beverage is a fermented drink manufactured from malted cereal grain such as barley, which includes germinating the grain in water and drying it (Chettri *et al*., 2002). Malt extract is a concentrated syrup made from barley that contains 70%–80% sugar (Aghel *et al*., 2016). Malt drinks are classified as alcoholic (containing more than 1.2 percent alcohol), low alcoholic (containing 0.5 percent to 1.2 percent alcohol), or nonalcoholic (containing less than 0.5 percent alcohol) (Briggs *et al*., 2004). Barely Malt, in conjunction with rice malt, is an essential component of the brewing industry for beverage production. Rice malt beer can also be manufactured in a typical manner, resulting in well-fermented beers with no off-flavor equivalent to barley malt bottom fermented beer (Marconi *et al*., 2017).

Because of the product's high nutrient density, beverage drinks made from tiger nutmilk and malted yellow maize in an 80:20 ratio can be utilised as a beverage food for both young and old people (Ogori *et al*., 2022).Several patents have been obtained for barely rootlets, a product obtained in the brewing industry following malting (Neylon *et al*., 2020). A patent has been obtained in the United States, where the rootlets can be utilised to extract functional chemicals for use in the beauty sector (Kihara *et al*., 2007).

The nutritional quality of wheat-malted sorghum-soybean composite flour is improved by malting. Composite flour with up to 20% malted sorghum could find use in the candyindustry (Aluge *et al*., 2016).

Medicinal Applications of Malting

In humans, a probiotic drink comprised of wheat, barely, or oats enhanced gut microbial equilibrium (Arya *et al*., 2018). Malted beverages immediately scavenge free radicals in the body, slowing the ageing process (Kim *et al*., 2014 and Yazhen *et al*., 2022). Malt-derived antioxidants suppress oxidative processes and can recover oxygen-free radicals (Vanderhaegen *et al*., 2006). Germination boosts calcium, copper, manganese, zinc, riboflavin, niacin, and ascorbic acid levels, according to Kaushik *et al.* (2010).Badau *et al*. (2005)discovered that malting decreases the phytic acid level of pearl millet varieties. Wheat polyphenols are well documented for their ability to efficiently regulate oxidative stress and have anti-inflammatory, anti-diabetic, and anti-cholesterolaemic properties (Martn-Diana *et al*., 2021).

Conclusion:

Malted beverages and malted items made from cereal grains are becoming more popular due to their numerous health benefits. The by-products of grain malting have numerous applications in food, industry, and medicine. Malting is the process of altering the biochemical properties of cereals in order to improve their nutritional and bioactive properties. Malted grains and malted beverages reduce the risk of cardiovascular disease and help avoid diabetes. Gluten-intolerant people can ingest malted flour since the malting process converts gluten to a soluble form. Malted plant-based milks and cheese can be utilised as an alternative source of dairy goods. Malted grain phytochemicals are utilised to make medications, and the by-products are employed in the cosmetic industry.

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