

Barley Grains and Barley Grass – Nutritional Value and Therapeutic Potential

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Abstract: Humans are continuously exposed to dangers that threaten their health due to the ready availability of unhealthy foods containing synthetic additives, as well as exposure to free radicals produced by cigarette smoking, alcohol, radiation, or environmental toxins. This fact has raised concerns among consumers, leading to an increased interest in healthy nutrition and a healthy lifestyle. Beneficial compounds such as β -glucan, tocopherols, and resistant starch are abundant in barley grains. Epidemiological studies consistently demonstrate that regular consumption of whole grain barley reduces the risk of developing chronic diseases. These health benefits are largely attributed to the presence of barley fibre, particularly β -glucan, in whole grain barley. Additionally, barley grass is considered the only plant on Earth that can provide complete nutritional support from birth to old age. Young barley grass has been found to have different nutritional content compared to mature barley grains, offering unique healing effects and slowing down the aging process of cells. This review aims to highlight the significant nutritional value and health benefits of both barley grains and barley grass.

Keywords: barley grains, barley grass, disease prevention, health benefits, nutritional composition.

Introduction

Humans are continuously exposed to health-threatening hazards due to the ready availability of unhealthy foods containing synthetic additives and the exposure to free radicals produced by activities such as cigarette smoking, alcohol consumption, radiation, or exposure to environmental toxins. Consumers are increasingly concerned about the use of synthetic additives in food, prompting

food processors to seek methods of producing food products without these additives. Therefore, there is a demand in the food industry for "clean label" products. In this context, the incorporation of medicinal plants into food products represents an excellent strategy for creating functional foods. This is because plant-based extracts are abundant in phytochemicals, which hold particular significance due to their health-promoting effects (Nieto, 2020).

Since ancient times, barley has been one of the most significant food grains. In terms of cultivated area and global production, barley ranks fourth, after wheat, rice, and maize. Approximately 75% of the global production is used as animal feed, 20% as a raw material for beverages, and 5% in human food (Sreenivasulu et al., 2008). Compared to wheat, barley exhibits good adaptability to unfavourable environmental conditions and demonstrates much higher tolerance to environmental factors (Nevo et al., 2012). Barley is classified into categories such as spring or winter, two-row or six-row, and hulless or hulled crops (Suman, 2019). Hulless barley has a higher nutritional value than hulled barley as it contains more proteins, lipids, and soluble dietary fibre (Zheng et al., 2023).

Barley grain has high nutritional value, primarily attributable to its chemical composition, which differs from that of barley grass.

A Japanese researcher discovered that young green barley provides an incredibly complete source of nutrition because it contains a wide spectrum of vitamins, minerals, and chlorophyll (Hagiwara, 1978; Hagiwara et al., 1979). Hagiwara et al. (2001) reported that BG is a superfood with remarkable health benefits. It is one of the most important green grasses, as it is the only vegetation on earth capable of providing sole nutritional support from birth to old age.

Barley is an excellent choice as a food source, both for people suffering from various types of diseases and for those seeking a healthy lifestyle. This cereal contains essential vitamins and minerals and is an outstanding source of soluble dietary fibre, particularly beta-glucans. Green barley is recommended for its significant antioxidant activity and as a source of vitamins and minerals. The abundance of these elements in barley contributes to the efficient functioning of the body. Barley water is also a beneficial option to harness all the advantages of barley (Boantă, 2019).

Plant Taxonomy

- Family: *Poaceae* or *Graminae*
- Subfamily: *Pooideae*
- Tribe: *Triticeae*
- Genus: *Hordeum*
- Species: *Hordeum vulgare*
- Scientific Name: *Hordeum vulgare* L. (USDA, 2009)

A short history of barley

Barley was one of the first crops to be domesticated and cultivated from the very beginnings of civilization. It played a significant role in ancient Greece and Roman culture as a staple cereal for bread production and an important food for athletes. Gladiators were even known as 'hordearii,' meaning 'barley eaters.' The use of barley in social and religious ceremonies by Hindus, Greeks, and Romans attests to its ancient heritage. Charred barley grains discovered in archaeological excavations at various sites in the Middle East and the Near East provide evidence that barley was cultivated between 7000 and 5000 BC (Harlan, 1968), and it was domesticated around 8000 BC (Zohary and Hopf, 1973)

After its cultivation, barley spread or was introduced to all geographical regions across the globe. Under the influence of diverse environmental conditions, barley underwent changes, evolution, and diversification. Cultivated barley may have originated from a single ancestor (monophyletic origin), namely the six-row wild barley, *Hordeum agriocrithon* (discovered in Tibet by Aberg, 1938). From this ancestral form, the species *H. vulgare* and *H. distichum* emerged, believed to have appeared either directly or through the species *H. spontaneum*. *H. irregulare* is considered to have arisen from the crossbreeding of *H. vulgare* and *H. distichum* (Mureşan and Crăciun, 1972).

Barley (*Hordeum vulgare*) has been a staple food for people in many countries throughout history, but due to changing dietary preferences, its use has been somewhat limited. Currently, barley has regained its place in human nutrition and is considered by nutritionists as one of the healthiest foods (Tiwari, 2010).

It was probably first used in human nutrition in its raw form or as toasted bread, porridge, or soups (Ullrich, 2011). Later on,

barley was primarily used as animal feed, in brewing beer, and in distillation processes. The decrease in the use of barley in human nutrition can be attributed largely to the expansion of wheat and rice cultivation and their growing importance. At present, it is estimated that the majority of barley production is used as animal feed (55-60%), followed by malt production (30-40%), with approximately 5% used as seed for crop reestablishment, and the smallest portion for human consumption (2-3%). In recent years, there has been a growing interest in incorporating barley into human nutrition due to its numerous health benefits, therapeutic potential in preventing and treating chronic diseases, and addressing obesity. Additionally, barley is reasonably priced, has good storage qualities, and is a nutrient-dense addition to the diet (Keenan et al., 2007). Furthermore, there has been a surge in the development of various barley grass products in recent years, including green barley supplements, extracts, juices, powders, barley water, tea, and coffee (Mărginean et al., 2021).

Barley grains

Barley grains possess the highest functional value, the lowest glycemic index (GI), the highest content of β -glucans, resistant starch, and antioxidant properties among all cereal crops. Figure 1 illustrates a schematic representation of the health benefits and applications of barley grains.

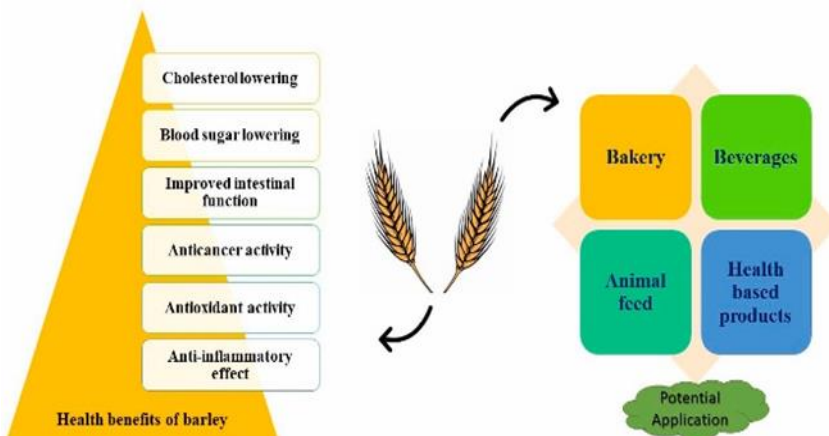


Figure 1. Health benefits of barley grains and application (Source: Raj et al., 2023)

Newman et al. (2008), Behall et al. (2004), and Qureshi et al. (1986) assert that barley constitutes an excellent source of dietary fibre. Soluble fibre, specifically glucans are polysaccharides that can enhance intestinal health and reduce blood sugar and cholesterol levels (Biswas and Ansari, 2023). They are found in seaweed, barley, oats, mushrooms, and yeasts. Barley holds an additional advantage over other cereals as beta-glucans are the major constituents of barley fibre and are present throughout the barley kernel, whereas in other cereals, fibre is primarily located in the outer husk (Source: www.barleyfoods.org). The primary advantage of consuming waxy hullless barley lies in its substantial β -glucan content. Qingke, the staple food of the Tibetan people, which is also a significant livestock feed, is cultivated on the Qinghai-Tibetan Plateau. This barley variety possesses numerous gene families related to stress responses, particularly differing antioxidant capacities attributed to specific polysaccharide and phytochemical compositions (Nadu and Nadu, 2016). The development of functional foods based on barley's β -glucans may expand the potential applications of barley-based products. Extruding barley into a high-fibre, ready-to-eat cereal is a promising approach (Jan et al., 2022).

Antioxidants present in barley have been demonstrated to enhance immunity and offer protection against free radical-induced damage. Some studies have associated barley's antioxidants with a reduced risk of certain cancers, including colon cancer (Raj et al., 2023).

Barley grains are also rich in **tocols**, which have been shown to lower serum cholesterol (Biswas and Ansari, 2023). Both oats and barley contain a high concentration of tocols compared to other cereals, although the tocol content in barley can vary significantly (Suriano et al., 2020). Extracted barley oil and brewery barley waste are good sources of tocols for food additives because they contain more tocols than whole grains.

Barley seeds serve as a primary source of **starch**, which is also beneficial for health. Starch constitutes 54–75% of the grain's weight and is concentrated in the endosperm layer (Gorton, 2018). Resistant starch has the potential to improve intestinal health and lower blood sugar levels (Biswas and Ansari, 2023).

Barley is rich in nutrients, boasting a variety of **minerals**, including calcium, iron, potassium, phosphorus, and zinc. Magnesium, present in barley, plays a crucial role in maintaining

healthy bones and regulating muscle and nerve function. Barley's abundance of phosphorus is essential for the growth and maintenance of tissues and cells in the body. Zinc, found in barley, supports the body's ability to heal wounds and fight infections. Iron, another important mineral, is required for haemoglobin, a protein in red blood cells that transports oxygen throughout the body, and barley serves as a good source of iron. Additionally, barley contains potassium, which aids in maintaining healthy neuron and muscle function, as well as regulating blood pressure. While barley provides low quantities of calcium, which is vital for strong bones and teeth, it is still a valuable source. The sodium, calcium, phosphorus, and potassium content in 100 g of hulled barley are 12 mg, 33 mg, 264 mg, and 452 mg, respectively. In the case of pearl barley, the amounts per 100 g are 9 mg, 29 mg, 221 mg, and 280 mg for sodium, calcium, phosphorus, and potassium, respectively. The energy content of hulled barley is 354 calories per 100 g (Geng et al., 2022). The chemical composition of barley is illustrated in Figure 2.

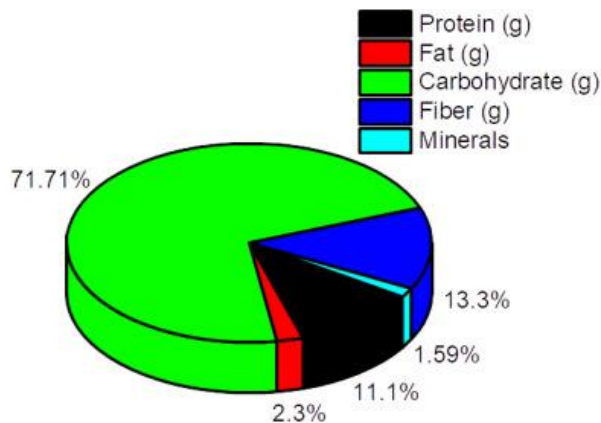


Figure 2. Nutritional composition of barley grains
(Source: Raj et al., 2023)

Barley is a cereal grain commonly used in the preparation of bread, baked goods, pasta, rice alternatives, breakfast cereals, beverages, stews, and various other dishes. Incorporating barley into one's diet can contribute to maintaining good health and improving overall nutrition. Table 1 outlines the health benefits of certain value-added barley products (Raj et al., 2023).

Table 1.

Health benefits of Value-Added Barley-Based Products

Barley products	Potential role	Action mechanism	Reference
Barley flour	Immunity booster	It contains hydroalcoholic extracts that can assist in reducing diabetes and other health disorders. Long-term consumption of hydroalcoholic extracts from barley seeds may offer some benefits in controlling and managing diabetes mellitus.	Mustafa et al., 2019 Minaiyan et al., 2014
Flat bread	Blood cleanser	Beta-glucan, a soluble fibre, binds to bile acids in the intestines, thereby reducing plasma cholesterol levels. A high intake of dietary fibre, particularly soluble fibre, can enhance glycemic control and lower plasma lipid concentrations.	Kim et al., 2010 Khalid et al., 2022
Pastas	Anti-inflammatory	It increased the activity of SOD and GSH-Px by inhibiting the cyclooxygenase and lipoxygenase pathways of arachidonic acid metabolism. Whole-grain barley reduced inflammation induced by a high-fat diet, potentially attributable to the formation of SCFA (Short-Chain Fatty Acids) and alterations in microbiota composition.	Yahfoufi et al., 2018 Zhong et al., 2015
Noodles	Prevention of bone disorder	Barley is rich in minerals like phosphorus, calcium, copper, magnesium, and zinc, which support the maintenance and integrity of bones.	Bose et al., 2013 Oso and Ashafa, 2021
Muffins	Tumour prevention	Elevate intracellular reactive oxygen species levels. The antitumor effects of β -glucans do not involve a direct assault on tumour cells but rather result from the stimulation of both specific and non-specific immune responses within the body.	Kim et al., 2010 Barsanti et al., 2011

(Source: Raj et al., 2023)

Barley grass

What is it, how is it consumed, and where can you find it?

Barley Grass (BG) is a type of green grass that is typically consumed in the form of juice because its texture can be unpleasant to eat directly. You have the option to cultivate your own barley grass and extract the juice, or you can purchase barley grass extract in various forms such as powder, tablets, capsules, or gummies. Barley grass juice is available at juice bars, health food stores, and even some larger supermarkets across the country.

How can you grow your own barley grass?

Barley grass consists of young green leaves (Fig. 3), typically used approximately 10-14 days after sprouting during the barley sprout stage up to the elongation stage before the plant stem enters the reproductive cycle. To initiate the growth, mature and dry barley seeds should be activated by soaking for at least 12 hours. Subsequently, regular rinsing and draining are required over the course of 12 to 14 days, after which the fresh microgreens can be harvested. The optimal nutritional resources for human cells are achieved when the green barley reaches a height of 20-30 cm (Hagiwara et al., 2001; Zeng et al., 2018, www.growyourpantry.com).

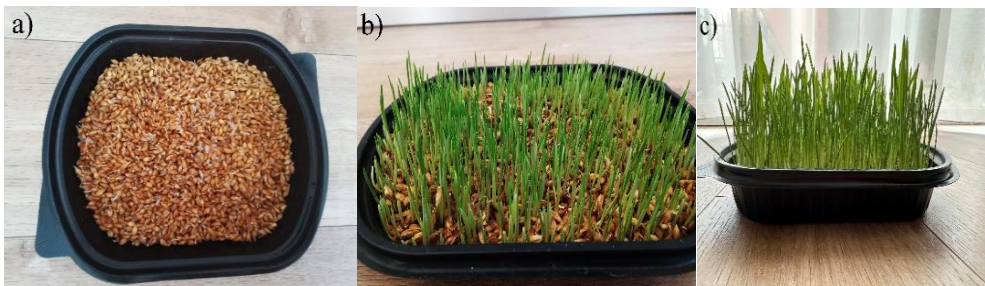


Figure 3. Barley
a) sprouts; b) seedlings at 5 days; c) grass at 10 days
(Source: original)

Nutritional profile and health benefits

Barley grass (BG) provides a wide range of health benefits due to its extensive array of minerals, vitamins, antioxidants, and the presence of eight essential amino acids that are crucial for our dietary needs (Lahouar et al., 2015). It is unique in being the only vegetation on Earth capable of providing complete nutritional support from infancy to old age. Young BG has been found to possess distinct nutritional content compared to mature barley grain, imparting the plant with a special healing effect that can slow down the aging process of cells (Hagiwara et al., 2001). Variations in the nutritional content of BG may be influenced by factors such as the plant's origin, soil quality, and harvesting techniques (Droushiotis, 2009).

BG is particularly rich in dietary minerals, including sodium, magnesium, iron, copper, and phosphorus, as well as vitamins like thiamine, riboflavin, tocopherols, tocotrienols, biotin, folic acid, and pantothenic acid (Table 2). These nutrient levels have been found to surpass those in certain popular vegetables (such as spinach, tomato, lettuce), fruits (like banana), and cow's milk (Hagiwara, 1998).

Table 2.

Nutritional profile of barley grass

Item	Per 100g
Fat	4.97g
Polysaccharides	52.58g
Dietary fibre	1.97g
Sugar	14.14g
Protein	34.11g
Beta carotene	24.962IU
Vitamin B1	0.23mg
Vitamin B2	1.01mg
Vitamin B6	0.302mg
Biotin	0.022mg
Folic acid	0.481mg
Niacin	4.00mg
Pantothenic acid	1.40mg
Vitamin K	0.57mg
Sodium	833mg

Magnesium	166mg
Potassium	2,762mg
Calcium	415mg
Iron	21.1mg
Chlorophyll	507mg/100mg

(Source: Edwin and Sheeja, 2006)

Barley grass is commercially available in dried and powdered forms, which are prepared from the whole leaves, or as juice extracted by milling the leaves (Lahouar et al., 2015).

Barley grass juice is a well-known health supplement with a long history of use in traditional medicine systems like Ayurveda, Chinese medicine, and Native American healing practices (www.ndtv.com). It has earned the status of a superfood due to its rich content of vitamins, minerals, and antioxidants. In contemporary times, it has become a prominent health and wellness trend, often recommended as an ideal way to start the day. Alongside other greens such as kale, spinach, spirulina, and wheatgrass, barley grass is gaining popularity at juice shops, health food stores, and supplement outlets. The juice is extracted from the plant using a cold-press process, preserving the plant's nutrients and enzymes. Cold-pressed juicing of fresh barley grass ensures maximum nutrient retention (www.purafons.ro).

While fresh barley grass can be challenging to source and juice on your own, the National Military-Medical Institute for Research and Development, Cantacuzino, in Romania, has developed a natural green barley juice available in ampoule form (Figure 4). This juice contains a rich blend of vitamins, minerals, trace elements, essential amino acids, and micromolecular compounds with antioxidant properties. It can serve as an antioxidant food supplement, fortifying the body during periods of stress, physical exertion, and intense mental effort. The recommended administration method for adults and children over 12 years of age is 2-4 ampoules per day, to be consumed 30 minutes before meals (www.cantacuzino.mapn.ro).



Figure 4. SOD NATURAL – 100% barley juice
(Source: www.cantacuzino.mapn.ro)

Other available forms of barley grass include barley grass juice powder and barley grass powder. While both are derived from the same plant and contain similar nutrients, there is a distinction in their processing methods.

In dehydrated barley grass powder, the cellulose content remains intact, which is indigestible for humans and often results in a lighter colour. On the other hand, barley grass juice powder undergoes a different process where the indigestible cellulose is removed, resulting in a much darker colour. During juicing, the cellulose, which makes up most of the thick cell walls of barley grass, is broken down and subsequently removed. Cellulose, when ingested as insoluble fibre, serves its purpose, but when broken down, it releases beneficial phytonutrients that can be absorbed by the body. The nutrients in barley grass powder are not as concentrated as those in juiced grass because the powder retains all of the cellulose. According to Anthony Williams of Medical Medium, barley grass juice powder contains ample amounts of Vitamins A, C, and B, as well as minerals like iron, calcium, potassium, magnesium, and phosphorus. Additionally, barley grass juice powder is known for its high water solubility as compared to dry barley grass powder, easily dissolving in beverages due to its extremely fine powder consistency (www.teaveli.com).

Barley grass supplements are widely recognized as a source of antioxidants, and numerous compounds with antioxidant properties have been extracted from young barley (Osawa T, 1992). Several human and animal studies have reported potential benefits, including cancer prevention and treatment, HIV infection

management, cholesterol reduction, detoxification of harmful metals and toxins, protection against solar and other types of radiation, enhanced energy and immunity, antiulcer, antioxidant, hypolipidemic, antidepressant, antidiabetic effects, and a laxative effect. However, it is essential to note that objective scientific evidence supporting many of these claims is currently insufficient (Yamaura, 2012; www.drugs.com; www.ndtv.com).

Hyperlipidemia

Cholesterol-lowering effects have been attributed to the hexacosyl alcohol and beta-sitosterol fractions of barley leaf extract. According to Yu (2004), beta-sitosterol is believed to function by inhibiting the intestinal absorption of cholesterol and expediting its conversion into bile acid. The mechanism of action of hexacosyl alcohol, however, remains unclear.

A dosage of 15 g/day of dried barley leaf extract has been employed for cholesterol reduction. At this dosage, it provided 40 to 45 mg of total phenols, 3,500 to 4,000 units of beta-carotene, and 15 to 20 mg of vitamins (Yu et al., 2004). Barley leaf extract demonstrated its greatest effectiveness in individuals with initially higher cholesterol levels. Similar findings were reported in men with type 2 diabetes mellitus (Yu et al., 2002).

Antioxidant activity

Blood levels of oxygen-free radicals were reduced through supplementation with 15 g/day of barley leaf extract in patients with type 2 diabetes mellitus (Lahouar et al., 2015; Yu et al., 2002). The addition of vitamins C and E to barley leaf supplements proved to be more effective in inhibiting the oxidation of small, dense LDL compared to barley leaf extract supplements alone. After supplementation with barley leaf extract, the lag phase of LDL oxidation increased. Similar outcomes were observed in non-diabetic, hyperlipidemic individuals (Yu et al., 2004). It's worth noting that the antioxidative effects were less pronounced in smokers compared to nonsmokers.

Cancer prevention

In terms of cancer prevention, barley grass extracts offer protection to human fibroblasts against carcinogens. The specific mechanism of action remains unknown but could be associated with the plant's antioxidant activity or its chlorophyll content. Chlorophyll and its metabolites have demonstrated antimutagenic effects in vitro and in vivo, with suggestions that complexes may form between the carcinogen and chlorophyll, potentially rendering the carcinogen inactive (Chernomorsky et al., 1999). Additionally, antioxidants, including superoxide dismutase found in high concentrations in green barley juice, provide protection against radiation and free radicals (Lahouar et al., 2015).

Barley grass extract induces apoptosis in breast and prostate cancer cells by elevating intracellular reactive oxygen species levels. This increase in intracellular reactive oxygen species generation is associated with the induction of apoptosis in cancer cells (Woo, 2017).

Is barley grass the same as wheat grass?

Many people ponder the pros and cons of barley vs. wheatgrass and often question whether barley grass is the same as wheatgrass. While there are several similarities between these two cereal grasses, there are also notable distinctions, as outlined on www.growthyourpantry.com:

1. Growth Duration - Wheatgrass begins sprouting on the second day and is ready for harvest between the sixth and tenth day. In contrast, barley grass takes 12 to 14 days to reach maturity, with initial sprouting occurring in less than a day.
2. Consumption Variances - Wheatgrass can be consumed in the form of wheatgrass juice, whereas barley grass juice is considered too bitter to be consumed directly and often requires additional fruit juice to balance the taste.
3. Growth Environment - Wheatgrass thrives indoors, while barley grass is best cultivated outdoors to enhance its chlorophyll content.
4. Flavour - Barley grass offers a milder taste compared to that of wheatgrass.

5. Nutritional Comparison - To assess these microgreens, one must compare their nutritional benefits and the quantities present in a single serving. Barley grass is undeniably more nutritious than wheatgrass, thanks to its higher nutrient, vitamin, and mineral content.

Adverse reactions

Similar to numerous other grains, barley can potentially serve as a source of allergens for certain individuals. These allergies are commonly linked to the storage proteins found in the plant's seeds rather than the green, above-ground portions of the plant. It may be advisable to limit the consumption of barley grass among hypersensitive individuals, including those with celiac disease (www.drugs.com).

Conclusion

Barley grains stand out for their exceptional nutritional value, boasting the lowest glycemic index (GI), the highest β -glucan content, abundant resistant starch, and remarkable antioxidant properties among all cereal crops. Conversely, barley grass juice emerges as a nutrient-rich superfood with a wide array of health benefits, thanks to its high levels of antioxidants, vitamins, and minerals, making it a potent supplement for overall health and well-being.

This study takes a differentiated approach to the consumable elements of the barley plant, emphasizing the nutritional value of barley grains and value-added products derived from them. Furthermore, it underscores the nutritional significance of green barley and its derivatives, such as green barley powder and green barley juice powder. Key distinctions between green barley juice and wheatgrass juice are highlighted, with freshly cold-pressed green barley juice being regarded as the most nutritionally comprehensive compared to other barley-derived products due to its maximum nutrient content.

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