A COMPRESSIVE REVIEW ON GERMINATED GRAINS AND THEIR UTILIZATION INTO VALUE-ADDED FOOD PRODUCTS

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Abstract
Owing to the multicomponent system of nutrients in grains, germinated grains such as cereals and legumes led to increased health assurance of population consuming them. The process of sprouting has many advantages on this nutrient composition of these grains such as sugars, vitamin B groups fat, protein, reduction in dry matter, starch, essential amino acids, and anti-nutrients get enhanced. Moreover, germinated grains improved the activities of hydrolytic enzymes like amylases, lipases, and proteases. This review focuses on the utilization of germinated grains, the impact on the biochemical activity on grains due to germination, and value-added products from the sprouted grains, like bakery products, multigrain beverages, and biodegradable packaging, fulfill the demand of the growing population.

Keywords: Germination, enzyme activity, germinated grains, germinated products.

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1. INTRODUCTION

Germination is a complex process that involves series of steps in the seed that enhances the intensity of metabolism and reach its completion. Further, subsequent seedling growth starts in the embryo to allow shoot out (Nonogaki et al., 2010).
Various metabolic reactions occur in seeds during germination which alter their chemical composition compared with raw seed. Soaking legumes seeds and holding them at ambient temperatures help in proper germination. The main components responsible for carrying out the metabolic processes and growth are amino acids (Sibian et al., 2017). The germination process results in significant alterations in the physicochemical and nutritional parameters (Yu & Bogue, 2013). Patane et al. (2009) have also reported germination to account for the composition variation in sweet sorghum grains (Patanè et al., 2009). The macromolecules, including starches, proteins, and lipids, are hydrolyzed by the activated endoenzymes during germination. That benefits further for plant growth and development (Khang et al., 2016). Processes like germination and fermentation have an essential role in improving the overall nutritional quality of the seeds. The hydrolytic enzymes are found inactive in raw seeds. The emergence of sprout is a process that occurs under controlled conditions, inexpensive as compared to fermentation, doesn't require any specific season, can be produced over time, and an excellent alternative to vegetables (Sibian et al., 2017).
During germination, proteins are metabolized, and the bioavailability of nutrients is also improved. This may be due to the activation of enzymes like protease. It helps enhance amino acid, thiamine, folic acid, riboflavin, and ascorbic acid content in cereals (Sibian et al., 2017).

Germinated grains

Compared with milled grain foods, the grain in its whole grain form acts as dietary staples and confer various health benefits (Nelson et al., 2013). The majorly used and most essential parts of the human diet are corn, wheat, rice, and minor grains like sorghum, barley, rye, oats, triticale, millet, and buckwheat. Grains are enriched with numerous bioactive constituents such as phenolic compounds and flavonoids along with anthocyanidins, quinones, chalcones amino phenolic compounds (Donkor et al., 2012). Therefore, the sprouts of cereals or pseudocereals have rich nutritive and physiological value compared to usual sprouts (Donkor et al., 2012). The legumes are sufficed with a high content of phenolic content and antioxidant activity (AA). Germination is also said to enrich the nutritional value of the legumes (Polat et al., 2020). Germination conditions and types of legumes influence the content of a phenolic and antioxidant activity. Kernels of cereals and legumes are first soaked in water and then germinated under suitable conditions. These lead to the acceleration of metabolic processes and developed embryo or metabolization of compounds, which can carry health benefits for the consumer (Spengler, 2019).

1.1. Germinated flaxseed *(Linum usitatissimum)*

Flaxseed is a good source of fibers, including soluble fibers and insoluble fibers such as lignin, cellulose, and hemicellulose. Insoluble fibers can prevent health-associated problems like bowel syndrome, constipation, diverticular diseases, and irritation due to their water-binding properties, which increase the bulk of food in the intestine. In addition, the soluble fibers reduce cholesterol levels (serum) and help mitigate the glycemic index by adjourning gastric emptying (Alshafe et al., 2015). Furthermore, the nutritional content of flaxseed is unique, which incorporates its use into functional foods (Kaur et al., 2020), which prevents the risk of prostate and breast cancer (Alshafe et al., 2015). The seeds are composed of fat (40%), dietary fibers (28%), proteins (21%), carbohydrates (6%), and ash (4%). These carbohydrates include lignans, sugars, and hemicellulose (Kyriakidis & Katsiloulis, 2000).

The germinated flaxseed possesses an improvised fatty acid profile for their stability and nutritional characteristics by soaking and germination at 30ºC. Further, it is dried for 36h at 40 ºC. The profile for fatty acid shows the presence of omega-6 fatty acids viz. linoleic, and omega-3 fatty acids viz. linolenic acids in the proportion of 13% and 40%, respectively. The remaining portion comprises monounsaturated and saturated fatty acids at 41% and 6%, respectively. The content of linoleic, oleic, and palmitic acid content is seen to increase compared to non-germinated seeds (Kaur et al., 2020). As reported by Li et al. (2019), flaxseeds (brown and golden) germinated under darker conditions in an incubator showed a higher fold increase in the whole length (0.48 to 11.06 cm) of sprouts in brown seeds and (0.4 to 8.26 cm) in golden seeds. The nutritional composition of geminated flaxseed is impacted, which shows that moisture content varies from 5.58% to 80.79% in brown seeds and 4.87% to 81.89% in golden seeds. But, reducing fat content increases the percentage of linolenic acid 15.61% to 16.94% and 15.42% to 16.86% in both the seeds (brown and golden). The germinated brown and golden seeds were observed for the enhancement of phenolic and antioxidant activities. The secoisolarlciresonol (SDG) content showed a decrease-increase-decrease pattern in both but was higher in brown seeds than golden. The germinated brown and golden seeds show an increased amount of SDG on day 2 of the germination that is 12.07 and 9.42 mg $g^{1,}$ but a significant decrease in 5 days by 32% and 22%. Li et al. (2019) have hypothesized that long-term germination negatively affects SDG content. Hong Wang et al. (2015) reported having the highest content of SDG on the 8^{th} day of 10 days germination of flaxseeds. The hike in SDG content could be the result of *de novo synthesis* of lignan during germination (Li et al., 2019). Germination increased the α-tocopherol content but resulted in a decrease of γ-tocopherol. The anti-nutritional components including lotaustralin, linustatin, cyanogenic glucosides and neolinustatin are reduced significantly in both germinated flax seeds (Li et al., 2019).

2.2. Germinated soybean *(Glycine max)*

Soybean contains about 48 to 50% of proteins (García et al., 2012), water 4 to 10% (García et al., 2012), lipids, 20% (García et al., 2012), total carbohydrate profile of 37% starch, 22% oligosaccharides and 41% sugars (Fehily, 2003). Other constituents in raw soybean are minerals such as copper, calcium, manganese, iron, zinc, cobalt, magnesium, potassium, vitamins such as thiamin(B) and riboflavin (B2) (García et al., 2012), niacin, vitamin B6, and folate (Fehily, 2003). It has many health benefits like preventing obesity, cholesterol, heart diseases, cancer, diabetes, and kidney diseases (García et al., 2012). Soybean contains various anti-nutritional factors like trypsin inhibitors and urease (Ma et al., 2020), which have harmful effects on digestion and metabolic processes (Fehily, 2003). Such anti-nutritional factors can be removed by conventional heat treatments like cooking and germination (García et al., 2012). The carbohydrates and proteins are degraded due to the endoenzymes (proteases and amylases), which are active during the germination process. Reduction in the total sugar content was found to be 162 to 156 mg/g, whereas the total amino acid content was seen to be 44.01 g/100g. The phenolic acid content in germinated soybean increased from 67.9% to 73.4% (Ma et al., 2020). But, the negative impact was seen on lysine content, which decreases in germinated seeds with enhancement in the niacin content (Bau et al., 1997). However, it was found that crude protein and lipid content in soybean sprouts was higher due to sugars' leaching during the germination process (Kylen and Mccready, 1975). Partial degradation of dietary fibers and phytic acid degradation was observed upon germination compared with the raw soybean seeds (Bau et al., 1997).

***2.3. Green gram** (Vigna radiata)*

Green gram is known for its content of highly digestible proteins. Green gram (mungbean) finds its use as an important ingredient in weaning and geriatric foods. It possessed higher digestibility, deficiency of sulfur-containing amino acids, and anti-nutritional factors like protease inhibitors, phytates, polyphenols, etc. The total sugar content may vary from 2.69 to 5.88%, 1.2 to 8.1% crude fiber, 20 to 40% protein on a dry basis, 2.14 to 3% lipid content,(3.5g /100g) mineral content, niacin varied from 1.1-2.5 mg /100g in raw green gram seeds(Adsule et al., 1986).

Upon germination, increased protein content (Kylen & Mccready, 1975) and riboflavin are observed than the raw seeds (Kylen & Mcready, 1975). Peroxidase activity was increased on the 3rd day of germination in germinated green gram at room temperature (Shaik Akbar Basha, 2017). The increase in lignin levels and an increase in peroxidase activity in sprouted green gram was found to be correlated with each other. The highest peroxidase activity was found when the grinding technique was used for extraction. The most increased specific activity, 85.38 U /mg of protein, was identified in the root of the sprouts. The isolated peroxidase from the root of green gram shows better thermal stability of 45°C and had a 50% residual activity at 70°C. The germinated green gram shows enhancement in flavonoid content from 4.71 to 7.45 mg. The phenolic content increases from (4.86 to 8.03) mg with more robust antibacterial and antioxidant activity, except anthocyanin degradation observed from 36.62 to 11.73 µg (Krishnappa et al., 2017).

2.4. Horsegram (*Macrotyloma uniflorum*)

Horsegram is an underutilized and unexplored crop (Prasad & Singh, 2015). It is termed to be an excellent source of protein, carbohydrates, energy sources. But sprouts of the horse gram seeds are more nutritious and widely consumed by the tribal population. The nutritional composition of horse gram finds proteins in abundance (17.9 – 25.3 %), whereas carbohydrates and lipids are present in the amount of 0.58-2.06% and 51.9 -60.9%, respectively, along with some minerals like iron, phosphorus, molybdenum, iron. These are also characterized by the presence of vitamins including thiamine, riboflavin, niacin, carotene, and vitamin C. Germination improved the digestibility of proteins of this legume (Satwadhar et al.,1981). Germination and dehydration of horse gram seeds influenced the physical properties of the flour (Sangeetha, 2016). Polyphenol content in horse gram was lower by 1.6% to 1.1% (24-hour germination) than non-germinated seed. The increase in reducing sugars observed in germinated as compared to non-germinated legumes. A pattern of decrease in vitamin content and an increase in the minerals contents was observed over sprouting. Thiamin content were reduced by 0.38 to 0.33 mg/100g; riboflavin content was increased over germination from 0.1 to 0.19 mg/100g, niacin content increased from 1.42 to 3.65 mg/100g (Shere and Surendar, 2018). The fat content of raw horse gram was 1.8 g/100g, which decreased to 1.6 g/100g. Germination had a significant effect on tannin content 780 mg/100g, which showed a reduction, the same pattern observed in total phenol content 2.8 mg/100g during germination (48 hours) (Verma, 2016).

2.5. Germinated wheat *(Triticum aestivum)*

Whole wheat is an excellent source of dietary fiber. It is also reported to lower the risk of diabetes mellitus, cardiovascular disease, and colon cancer. But anti-nutrient present in whole wheat hinders digestive enzymes with prevention in the absorption of nutrients (Dhillon et al., 2020). Whole wheat contains starch (60–70%) (Shewry, 2009), (8-15%) protein (Shewry, 2009), lipids (11%), and vitamins (Sawaya et al.,1985). Germination (30°C, three days germination) increased the hydrolytic activity of enzymes, enhancing vitamin C, folate, sugars, and proteins (Dhillon et al., 2020). Improvement in blood glucose levels is seen in healthy adults by consuming germinated wheat grains compared with non-germinated grains (Dhillon et al., 2020). Oil absorption capacity and solubility index of sprouted wheat flour enhanced with higher alpha-amylase activity. It also reported high antioxidant activity and total phenolic content (Dhillon et al., 2020). The enzyme activity had been seen to increase during germination (Baranzelli et al., 2019).

Germinated Rice

Almost 50% of the population of Asia consume rice as a significant part of their diet. Brown rice is a type of whole grain rice that retains the endosperm, bran layer, and embryo after dehulling from rough rice (Hongwei Wang et al., 2020). It is a storehouse of various nutrients that can benefit from functional foods such as gamma-aminobutyric acid (GABA), dietary fibers, vitamins, and gamma-oryzanol. Even then, it doesn't have a full consumption rate due to its hard texture and poor cooking properties. Rice is differentiated from other cereals because it tends to germinate either in the presence or absence of air (Wunthunyarat et al., 2020). Germination plays a crucial role in enhancing the nutritional and subjective qualities of brown rice (Ren et al., 2020). Compared to raw brown rice, germinated brown rice (GBR) is taking over the market because of its various functional properties like its improved eating quality by delivering sweetness, excellent taste, better texture, and easy cooking. Today, germinated brown rice consumption has increased due to its health improvising properties such as anti-viral, anti-inflammatory, anti-allergic, and antibacterial (Loan & Thuy, 2020). The significant component in brown rice is starch (70%) of final endosperm weight. But, till now, less research is carried out on changes in hierarchical structures of starch during germination and reported by Wang et al. (2020). The nutritional profile of germinated cam brown (GCBR) rice variety (15.5 hrs) over un-germinated one is as follows, increase in the protein of GCBR from 9.1% to 10.4%, along with a decrease in lipid content (3.1% to 2.7%). The anthocyanin content was found to be a maximum of 45.18 mg/100g.

GABA is known to be a neurotransmitter in the brain that is naturally present in some foods. It expresses many functions for healthy well-being, such as improved kidney and liver activity, reduction of blood pressure and cholesterol, and inhibition of tumors. GABA is found in the bran layer and the germ of rice. Reports are available saying that activation of certain enzymes, including amylases, glutamic acid, decarboxylases, and proteases, during germination leads to increased GABA content in GBR (Ren et al., 2020). With an increase in anthocyanin, nutrients amount also increases when compared with the un-GCBR for GABA(2.71 to 19.0) mg/100 g, polyphenol content 65.9 mg GAE/100 g increased by 17% and reducing sugar 2.1% increased by 22% (Loan & Thuy, 2020).

2.6. Other germinated cereals

The germination process enhances the nutritional profile of other grains like maize, finger millet, ragi, and foxtail millet. The free and conjugated phenolic, niacin, soluble fiber content, increased crude fiber, total protein content, and decreased fat were observed in germinated cereals (Nithyananthan et al., 2020). The impact of processing and enhancement in the nutritional quality of sprouted grains are shown in table no 1.

3. Pre and post-germination changes in grains

As reported by Khattak et al. (2007), germination profoundly affects many of these compounds. But there is also degradation of some compounds like beta-glucans, vitamins. Therefore, germination has benefits in breweries and distilleries and helpful in the production of various products with health-promoting factors.

Soaking also reduces the toxin content (Prado et al., 2008) and surface contamination. Time of soaking varies with each parameter like species and variety and with length and conditions of storage. The soaking time is usually about 8-16 hours in cold or warm water. High-temperature soaking has been found to speed up the process of hydration. The leaching of soluble sugars and minerals occurs in legumes, resulting in losses due to soaking (Spengler, 2019). Short period germination (24 hours) reported increases in the pasting viscosities in legumes such as yellow pea, and faba bean flours. But an increase in the duration of germination of more than 48 hours or beyond causes a decrease in the pasting viscosities (Setia et al., 2020).

Germinated products are usually consumed as sprouts, or these sprouts are further converted to dried or roasted form. Germination brings about alterations in the sensory parameters as well as nutritional value. As recently observed in oats, levels of sterols were increased by germination (Oksman-Caldentey et al., 2001). Plant sterols have proved to lower LDL cholesterol levels and their antioxidative function and are hence used to enrich products like margarine. Plant sterols are added to food products and various beverages such as fruit juices and dairy-based functional drinks. Many workers have reported a decrease in CHO and reducing sugar, a source of energy during the germination process. The reduction in the legume content was 35% to 40% on germination.

Role of enzyme and enzyme activity

The mechanism of germination is still not wholly reported. But reports are available explaining the transcriptional and translational changes and genetic manipulation, which further improves their improvement (Nonogaki et al., 2010). Seed germination initiates the process of radicle development from the seed coat. A massive breakdown of the reserved substances in the seeds begins. Nutrients play significant roles during the various stages of seed germination. These changes occur in storage materials during germination. The hydrolases, proteinases, lipases, and phosphatases are hydrolytic enzymes responsible for these changes. These processes of nutrients lysis occur with the help of various lytic enzymes, and the remains are proteins composed of enzymes required for further metabolism (Rahman et al., 1970)

High enzyme activities, particularly amylase and protease, are observed in germinating seeds. The fundamental cause is a plant's demand for food, which necessitates the mobilization of stored food with the help of these enzymes. Germination has proved to induce many changes in wheat necessary for grain growth, especially in starch characteristics. Wheat germination has also been found to speed up the alterations in the starch properties, including viz; physicochemical α-amylase activities (Baranzelli et al., 2019).

Table 1. Processing effect and nutritional significance of germinated grains

Cereals/ legumes	Process	Parameters	Processing Effects	Nutritional Significance	References
Beans	Soaking	8-16 hours in cold water	• Moisten and soften the seeds • Reduces cooking times • Act as aids in seed coat removal	Hydration of the starch–protein matrix influences the cooking rate and final texture of cooked beans	(Spengler, 2019)
Horse gram	Soaking	Temperature (27 °C) for 12-18 hours	• An increase in water absorption, oil absorption, solubility index, swelling power and foam capacity of flour	Reduce anti nutritional factors like phytic acid and proteolytic enzyme inhibitors	Panghal, Suri, & Kaur, 2017)
Cereals and legumes	Germination	30°C for 8 hours soaking in water	• Sensory quality of probiotic drinks improved	More nutritious, rich in digestible energy drink, minerals bioavailable vitamins, proteins amino acids, and phytochemicals	(Chavan *et al.*,2018) (Aboulfazli, Shori, & Baba, 2016)
Soybean	Germination	8 hours soaking in water	• Endoenzymes such as proteases and amylases are activated, leading to the decomposition of macromolecular substances like proteins, carbohydrates	Rich in proteins, vitamins, minerals, amino acids antioxidants Decrease anti-nutritional factors trypsin and urease	(Ma et al., 2020)
Flaxseed	Soaking	30°C for 2 hours soaking in water	• organoleptic scores and textural properties improved in muffin • Increased in dough development time and water absorption	Fatty acid profile (palmitic acid, oleic acid, linoleic acid, and linolenic acid) gets improved	Kaur et al, (2018)
Oats	Germination	24 hours soaking in water	• Intensify both flavour and colour. • Produce secondary metabolites	Enhances the nutrients accessibility of seeds. Better sensory attributes. Act as bioactive or functional compounds in foods.	(Wilhelmson et al., 2001)

The germination brought about a significant reduction in total starch content, which could be due to the breakdown of starch into its fractions viz; oligosaccharides in cereal grains (wheat, rice, oats, and maize) as into monosaccharides. The depolymerization of starch molecules into its maltose and maltotriose fraction because of the enzymatic activity of enzymes (amylase and pullulanase) has been reported by Kaur and Gill, (2020).
Maize seeds germination has been reported by Dure (1960) and they have studied the site of origin and the amylase activity extent. Frydenberg and Nielsen (1965) have investigated the germination pattern in barley seed and reported diverse amylase types, including β-amylase isozymes and α -amylase isozymes. Many studies reported the presence of proteases and peptidases in the majority of grains, especially during germination. These might be because of the disappearing characteristics of the proteinaceous inhibitors (protease and amylase inhibitors) during germination progress (Chrispeels & Baumgartner, 1978; Ryan, 1973)

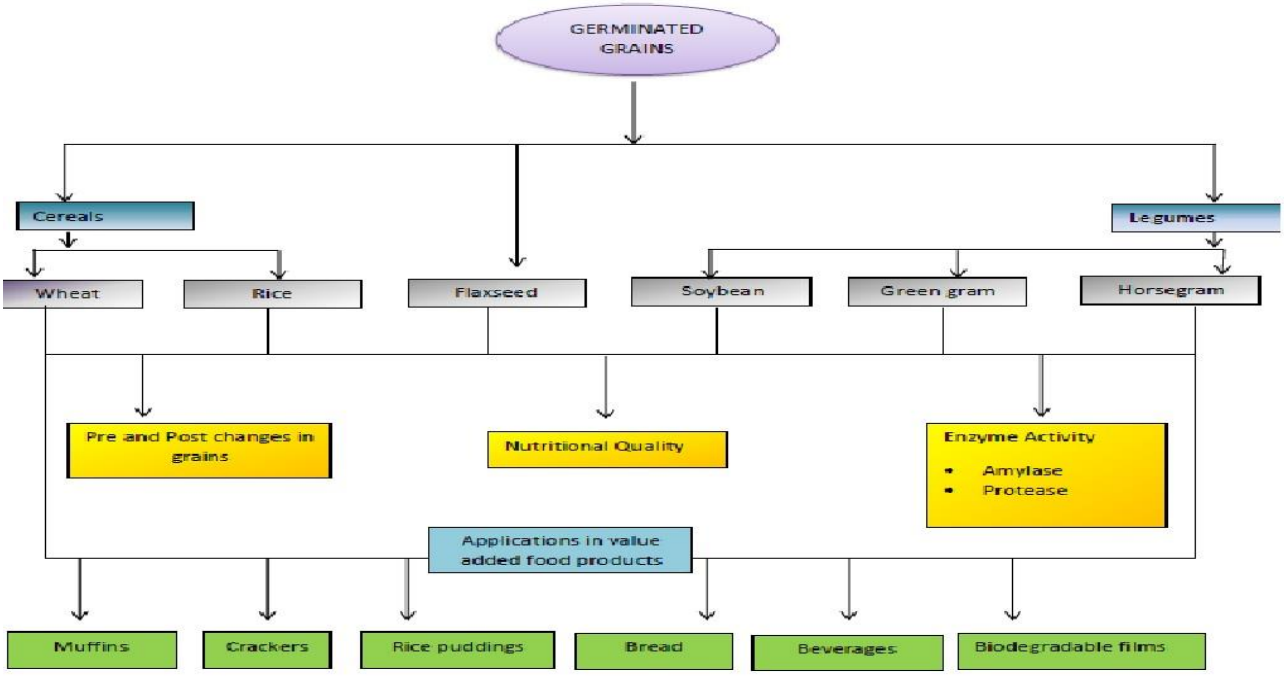

Fig 1: Overview of germinated grains

2. APPLICATIONS OF GERMINATED GRAINS IN VALUE-ADDED FOOD PRODUCT DEVELOPMENT

2.1. Muffins prepared from germinated flaxseed

Flaxseeds are smaller seeds that are unique owing to their specific nutrients content. Flaxseeds have found a diverse range of applications in today's foods. Flaxseed form an essential part of diet and nutrition, in which soy products are not much used and for individuals with low vegetable oil consumption (Alshafe et al., 2015). Chetana et al. (2010), Lagrange (1995), Ramcharitar et al. (2005), Shearer and Davies (2005) had studied the incorporation of flaxseed into different bakery products. It also contains both plant lignans and α-linolenic acid (Alshafe et al., 2015). For the preparation of muffins, both germinated and non-germinated flaxseeds were used, which were grounded and dried. The different formulations made of flaxseed meals in wheat flour and atta (5 to 30 %). The increase in density of flaxseed improved the texture and specific volume of the muffins.

There were also significant changes in weight and volume for both germinated and ungerminated meal muffins. The addition of flour from germinated flaxseeds led to the development of tender and softer muffins. Flaxseed proteins have an excellent capacity to absorb water. Muffins containing germinated flaxseed meal retained more moisture content than the muffins containing nongeminated flaxseed meal. With the addition of flaxseed at different levels into muffins became softer in texture. Germinated flaxseed addition led to an increase in the proportions of certain nutrients of muffins compared with nongeminated flaxseed added muffins. Increased water activity and peroxide value were noted due to variations in temperature and pH during storage. According to sensory scores, a 10% flaxseed meal was more acceptable. The shelf life of muffins prepared with germinated flaxseed was more as compared to nongeminated flaxseed (Kaur et al., 2020).

2.2. Crackers using germinated lentil extract

Crackers can be made by using different formulations like sugar-free, fermented, or unleavened dough and incorporate varied ingredients. Similar crackers were prepared using germinated green lentils *(L. culinaris subsp. Orientalis*). They grew seeds at 20°C by maintaining relative humidity (85%) for five days, which were carried under dark conditions. Those were further dried for 48 hrs followed by sieving and storage. The mixture of 100g flour, 25ml canola oil, 0.7g baking powder, 1g salt, and 30ml tap water was prepared (control). Germinated lentils extract (GLE) was made with distilled water. The beakers were covered in ice to prevent heating during ultrasound treatment. Extracts obtained were freeze-dried. These freeze-dried GLE were incorporated in crackers as a flour substitute (5%). The nutritional quality is enhanced with the addition of GLE into the extract. Hydroxymethyl furfural (HMF) is a compound obtained due to the Maillard reaction wherein amino groups reduce sugar at high temperatures. The GLE extracted samples showed an increase in HMF content than control due to the Maillard reaction. But until now, it is not clear whether it adds potential risks to human health. Also, the crackers with GLE extracted samples produced harder crackers. Crackers with 5% GLE were most acceptable by the consumers, as shown by sensory analysis. An increase in protein content, ash content, total phenolic content, and antioxidant activity was observed in GLE enriched crackers. They concluded that these crackers could be considered crackers with better functional properties (Polat et al., 2020).

2.3. Rice puddings with germinated legumes

Rice pudding is a viscous paste that is produced when rice is boiled along with milk and sugar. It is locally called *Kheer* (Moin et al., 2017). It is thought to be originated in China because of its ancient rice culture. It is commonly combined with a sweetener, such as sugar, to make it a dessert. Such desserts are found on many continents, especially in Asia, where rice is a staple. Sattar et al. (2017) replaced the rice in the pudding to some extent with lentils, the green gram, and the black gram. Rice pudding was prepared with other constituents, including full-fat milk powder, distilled water, rice flour, corn starch, sugar, and germinated/non-germinated legumes 15 % in viscoamylograph bowl. This mixture was evenly added, and the pasting profile was studied with a temperature profile as 40°-95°-30°C. During the storage and also with increasing the concentration of non-germinated legumes and germinated legumes puddings showed the hardness of the product increases after three days of storage owing to the complex forming ability of starch with emulsifiers which ends up in formation of helical amylose complexes (Sattar et al., 2017). The firmness of starch gels increases as a result of the aggregation of these unique helical amylose complexes. As legumes naturally provide an additional source of starches and lipids/emulsifiers, more complexes result in harder puddings. The fortification of germinated legumes shows that the sensory quality of rice pudding is improved; the antioxidant activity of the product is also enhanced with the storage. The nutritional characteristics compared with the rice puddings could improve the consumption rate among the population; these could fall as an appetizing nutraceutical (Sattar et al., 2017).

2.4. Bread from germinated wheat

Germinated wheat is traditionally used as fresh sprout grain (Dhillon et al., 2020) or formulated into flours for various foods like casseroles, salads, breakfast items, pasta, soups, and baked products. One such product was the production of bread from germinated wheat by Dhillon et al. (2020). Germination of grain was carried out at a temperature of 30 °C. The kernels were then dried using a drier at 50°C and then further milled to obtain flour. Thus, the flour obtained was also sieved. 50% of germinated wheat flour was used to replace whole wheat flour to prepare bread. Bread prepared with germinated wheat flour (50%) was found to have high moisture content owing to its high WAC (water absorption capacity). The ash content of the bread for all formulations ranged from 1.96 to 2.71%. No significant changes in fat content were observed. In terms of protein content, it shows low protein content compared to other samples. The range for crude fiber content was between 1.82 to 2.11%. Through sensory evaluation, the germinated wheat flour with 50% found its acceptance (Dhillon et al., 2020).

2.5. Use of germinated seeds for the preparation of a beverage

The advancements in the lifestyle and socio-economical status and population's food habits are posing towards consumption of high calorie, low fiber diets. In some undeveloped countries, nutrient deficiency needs to be brought to the limelight, particularly among the younger, older, and infant populations. Germinated cereals consumption is gaining importance across the globe (Oluwajoba et al. 2013) due to the increase in health-conscious people (Fernandes et al., 2018).

As a result, the market demands more manufacturers and suppliers for more healthy foods, particularly beverages (owing to their convenience) with functional benefits (Waters et al., 2015). Various studies have been carried out to develop probiotic beverages with non-dairy sources (Fernandes et al., 2019). Thereby there was a prevalence of non-dairy milk in the market. Dairy-based drinks contain whey and casein protein, which leads to allergies in many people. Non-dairy milk obtained from soy, almond, and coconut is advantageous over dairy milk concerning its absence of lactose sugar and cholesterol. Such dairy-free probiotics are taking over the market not only for being vegan but also owing to the increasing lactose-intolerant population (Granato et al., 2010).

Beverages, traditional formulations, and those made from cereals, and other food substrates are becoming a vegan part of the daily diet of the population, which possess the main advantage of being allergen-free (Peyer et al., 2016). Various underutilized grains, including certain cereals, are gaining importance for the development of beverages since they are characterized by their specific nutrients composition and are called gluten (Peyer et al., 2016). Majorly, in such non-dairy beverages, the dry matter consists of grain origin, particularly rice or soy. The main challenge is the retention of suspension of these solid particles during the length of the storage period to maintain the quality of the beverage.

Various functional components can be added to beverages for enabling the seeds to use methods like germination and fermentation. A non-dairy fermented drink from germinated cereals and legumes was prepared by Chavan et al. (2018) by using cereals barley, finger millet, and moth bean. For the drink preparation, the grains were soaked (8 hours) and germinated at 30 °C. The control batch consisted of all nongeminated grains. Sprouted grains were dried at 55 °C and roasted at 130°C, further ground, and sieved. Non-dairy milk sources were milk of soybean, almond, and coconut were used to prepare this drink. The probiotic culture used was the lyophilized *Lactobacillus acidophilus* (Chavan et al., 2018). In addition, they added sugar and cardamom in drink preparation to enhance flavor. All drinks were incubated for 6 hours at 37°C. With the increase in the concentration of drink mixtures, a significant increase in acidity was observed for germinated and nongeminated drinks. But acidity was seen more of germinated drink than that of nongeminated drink. In almond milk, the probiotic drink had the highest acidity in germinated drinks and coconut milk in terms of nongeminated drinks. The increase in acidity may be due to the rise in the supplement of nitrogen source with a simultaneous increase in the concentration of lactic acid (Kwon et al., 2000). The non-significant difference observed for germinated and non-germinated drinks are observed for pH values due to the hydrolysis of starch into sugars in the germination period, which are utilized by microorganisms converting them to lactic acid. The Trolox equivalent antioxidant capacity of all the germinated drinks increased with an increase in legumes.

In contrast, soymilk probiotic drink (germinated and non-germinated) was the lowest but further increased with an increase in the concentration of grains. The same pattern was seen for polyphenol content. The sensory scores of germinated probiotic drinks were highest compared to non-germinated drinks. The probiotic count was higher in germinated probiotic drinks than in non-germinated probiotic drinks with increased legumes concentration (Chavan et al., 2018).

Bean-based beverage were prepared by Ziarno et al. (2019) from germinated white kidney beans and yogurt starter cultures Yo-Mix 205 LYO and FD-DVS ABY-3. The seeds were germinated at 25 °C for 72 hours, then properly blended and allowed for starch gelatinization by boiling the obtained mixture. The beverage was then filtered and sterilized, and allowed to cool. Then beverage fermented along with starter cultures for 4 hours and some fruit flavors like strawberry, peach-mango, apricot, forest fruits, banana kiwi, and red-orange and control without fruit flavors. On physical and chemical analysis, lowered content of oligosaccharides was observed due to fermentation. The more moderate content of B-group vitamins, riboflavin, niacin, and pyridoxine may be due to the microorganism like LAB or *Bifidobacteria* capable of synthesizing B vitamins. Reduction in pH values observed in the fermented drinks because of the activity of the α-galactosidase enzyme. Sensory scores proved that the flavor added germinated bean beverage gained more acceptability than the non-flavor added beverage (Ziarno et al., 2019).

2.6. Application in the preparation of biodegradable packaging film from germinated grains

Various synthetic polymers produced today have an undesirable impact on the environment and may lead to problems with waste disposal and its utilization. The development of biodegradable polymer is one way of solving this problem (del Valle et al., 2016). Such biopolymers can be used for the following consumer goods; razor handles, fast food, containers, tableware, toys, and agricultural tools, mulch films, and planters (del Valle et al., 2016). And also for packaging materials like wrappings, loose-fill foam, trash bags, film wrapping, laminated paper, food containers. Coatings and films prepared from biodegradable materials are in high use in the food packaging industry (del Valle et al., 2016). It may sometimes help increase the shelf life of food products and maintain the freshness and quality of the product. Protein-based material is best suitable for making such a film that had high durability, excellent barrier properties. Biodegradable films made from soy protein isolate, whey proteins, and milk proteins all had excellent and acceptable properties. But these films for food packaging are limited because of weak mechanical properties and poor barrier properties shown by natural polymers. (del Valle et al., 2016). Therefore, it is needed to check the utilization of germinated grains in the development of biodegradable films.

Such biodegradable polymers were made from germinated wheat starch by Baranzelli et al. (2019). Induced germination (IG) of wheat at 24, 48, and 72 hours were followed, and starch extracted from non- germinated wheat was used as control. Casting techniques were employed for film formation with a solution of starch, glycerol, and water, which was further subjected to heat treatment followed by homogenization. Aliquots (20g) formed were then mirrored into Petri plates. The pellets were further dried in an oven at 30 °C circulating air for about 16 hours. Again, the starch extracted from non-germinated wheat was used as a control. The characterization of wheat starch films showed that the germination led to increased swelling power, enzymatic activity, and solubility of starches, and decreased relative crystallinity. These enhanced tensile strengths and elongation properties (Baranzelli et al., 2019).

3. CONCLUSION AND FURTHER ASPECTS

Legumes and cereals in the human diet confer various profound nutritional benefits through its consumption. Food products, flours, or concentrates made from such legumes and cereal have not gained its importance until now. Germination can act as an effective method for adding up more nutritional and functional benefits to the grains. Germination grains can be converted to the production of various value-added products. This value-added product using legumes, cereals, or pseudocereals may be highly beneficial for this health-conscious population, providing wholesome nutrition to them. Oilseeds, spices, or any other seeds of a similar line can be germinated and incorporated in producing such products that are not much popular in the market. Several studies have needed to be carried out to popularize the benefits of germination techniques and find out their benefits in various food products. Germination can, therefore, act as a natural technique to produce different kinds of food products; modified cereal flours rich in nutritional properties. Germinated grains are alternatives to reduce waste, which occurs through natural climatic conditions by developing value-added food products at minimal cost to fulfill the growing population's demand.

4. REFERENCES

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