Chapter

Cereal Grain: A Vehicle for Improved Healthy Living

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Abstract

The increasing population of the world, emergence, and prominence of diseases coupled with side effects of drugs has led to the search of non-toxic, healthy foods products. Cereal grains are a stable food consumed by a large population of the world, containing an array of nutritional and bioactive compounds such as dietary fiber, protein, carbohydrate, vitamins, minerals, β-glucan, lignans, phytosterol, phenolics among others. These compounds proffer beyond basic nutritional needs as they also provide health benefits on consumption such asantioxidants, antidiabetics, antihypertension, antihyperlipidemic/anti-cholesterol, antimicrobial and anticancer with no side effects. Cereal grains canbe processed into divers of food products, singly or as multigrain food products in other to increases the bioavailability of its nutrients or bioactive compounds. Its by-products can further be used to enriched human diets or serve as animal feeds. Hence, this review addresses the needs for more processing, value additions and consumption of cereal grain as a vehicle to improved healthy livings.

Keywords: Cereal grains, processing, food applications, health benefits

1. Introduction

Cereals are grass-like crops cultivated for its grains consumption which comprises of endoderm, germ and sperm. The world top seven (7) most important cereal includes maize, wheat, rice, barley, sorghum, oats, and rye. Globally, world production of cereals grain varies from maize (1, 116.34), wheat (764.49), rice (495.78), barley (156.41), sorghum (57.97), oat (22.83) to rye (12.17) million metric tons, and these accounts for over 60% of the world food consumption [1]. Over the years, research has shown that consumers of food products are more concerns about diet and diseases relationship rather than satisfying abdominal emptiness [2, 3]. Cereal grains contain an array of nutritional and bioactive compounds such as dietary fiber, protein, carbohydrate, vitamins, minerals, β-glucan, lignans, phytosterol, phenolics among others [4]. These compounds have been shown to exhibits a positive effect on diseases management and improved healthy living.

Epidemiological studies have shown that constant intake of cereal grains rich in dietary fiber protects the human body from cardiovascular diseases such as

hypertension and diabetes [5–7]. Likewise, studies conducted in the United States shows that consumer of cereal whole grains are at 20–40% reduced risk of cardio-vascular diseases compared with non-consumer across all age group [8–10]. Jensen et al. [11] reported on a 14 years' research over 42, 850 male subjects aged between 40 and less than 80 years. They concluded that consumption of cereals wholegrains is attributed subjects' healthier lifestyle compared with other non-consumer subjects'. Therefore, this review focus on the dietary constituent, processing and applications of cereal grains as a vehicle for improved healthy living.

2. Global production of cereal grains

Cereals grains generally have been ofadvantage to humanity for decades [12]. Rice, wheat, and maize are the three major cereal crops in China (**Table 1**), and they play a key role in global cereal production (**Table 2**). China, with 565,754 hectares cropped by far the largest cereal areas in the world, followed by the USA which accounted for 328,474 hectares while other countries have cereal areas between 228,844 hectares (Canada) and 130,882 hectares (Kazakhstan) for India [14]. Cereal production in 2017 increased to about 2977.0 million tons, with China having over 617 million tons [15], which contributed to more than 40% of the global cereal production, while a sharp decline was observed in 2018, 2019 and 2020 as shown in **Figure 1**. The sharp decline observed was due to the reduced yield prospects for maize in the United States of America (USA) and in Ukraine, meager rains that

Countries	Metric tons in millions			World percentage
	2018	2019	2020	
China	610.04	613.7	669.49	20.75
India	259.6	263.14	273.5	10.53
Russian Federation	130.8	109.12	126	4.4
Brazil	226.34	242.07	246.63	3.96

Source: FAOSTAT [13], Food and Agriculture Organization of the United Nations.

Table 1.
Countries with high cereal production.

Cereal	Metric tons in millions	Country with the highest production (FAO, 2018)
Corn	1116.3	United States
Wheat	764.49	China
Rice (milled)	495.78	China
Barley	156.41	Russia
Sorghum	57.97	United States
Oats	22.83	Russia
Rye	12.17	Germany

Source: FAOSTAT [13], Food and Agriculture Organization of the United Nations.

Table 2.
Global production of cereal grains.

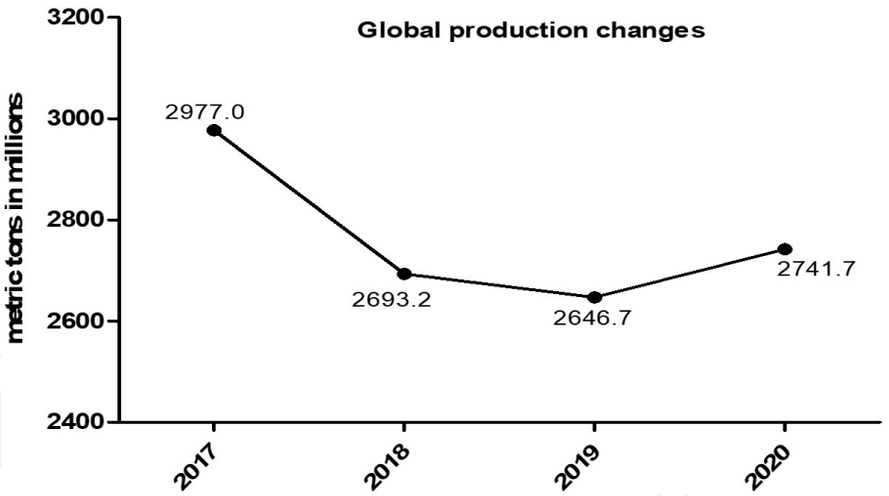

Figure 1.
Global production changes.

reduced yield expectations in Argentina, Brazil and Kazakhstan, which in turn affected the increase made to the production in the Russian Federation [16]. While rice production worsened in Bangladesh and Viet Nam due to the weather. Moving forward, the FAO has projectedthat the global average of cereal yields to increase by 1.1% per year (slower than the 1.9% seen in the previous decade), driven by advances in biotechnology, structural changes towards larger farms, and improved cultivation practices.

3. Dietary and nutrition composition of cereal grains

Cereals belong to the grass family, Gramineae. They are edible grains or seeds grown in several countries of the world. Some typical examples include oats, rye, maize, sorghum, barley and millet. Rice and wheat account for over 50% of the world's cereal production.

Cereals are a major and important aspect of the diets of the populace of both the developing and developed countries worldwide. Even with the food diversity prevalent in our present now, cereals remain an important contributor to the dietary pattern. Cereals are known to be a good source of food nutrients such as protein, carbohydrate, as well as having a range of micronutrients such as vitamins E, vitamins B, zinc, magnesium and iron.

Breakfast cereals and white bread are typical examples of fortified cereal products which are vital nutritional food products for children and adults, although there is the need to reduce the sodium levels of this processed foods product. Lignans and other types of bioactive compounds, which can improve health, have been reported in cereals and there are on-going researches on identifying other bioactive substances in underutilized cereals, their importance and bioavailability. Most studies have associated the health benefits accrued to cereal grains to its fiber contents, micronutrients, bioactive and resistant starch content. Several cereal products are usually fortified with a range of B complex vitamins, vitamin C, vitamin D, iron, vitamin E, zinc and beta-carotene [17]. The regular consumption of cereals, most especially whole grains have been deduced as having a role in halting the development of chronic diseases such as diabetics, colorectal cancer and coronary heart diseases though the precise mechanism is not yet fully understood. Whole pseudo-cereal grains such as quinoa, amaranth, and buckwheat are rich in bioactive

compounds like vitamins, trace element, phenolic acids, flavonoids, and fatty acids with knownabilities to prevent the onset of many degenerative diseases [18].

4. Processing techniques/methods of cereal grains

Cereals are been processed in different ways due to their specific characteristics and purpose. Their processing comprises an important part of the food production chain, but it is a complex procedure. The most common cereal processes include dry milling (wheat and rye), pearling (rice, oat, and barley), wet milling (corn and wheat), and malting (barley, corn, and wheat) [19]. However, certain general principles applied to most of them. Cereals undergo several processing stages between harvest, storage and consumption. Processing methods of cereal grains can be divided into two different methods, primary and secondary processing method. Primary processing includes cleaning and grading, hulling, milling and drying while the secondary process is the storage of the cereal grains for further processing.

4.1 Primary processing

4.1.1 Cleaning and grading

The first stage in cleaning is threshing, i.e. the removal of grains from the rest of the plant. It involves four different operations: Separating the grain from the panicle; sorting the grain from the straw; graded according to size; winnowing the chaff from the grain. Before cereal processing, the grains should be dried to 10–15% moisture before storage to avoid spoilage of the cereal grains.

4.1.2 Hulling

Grains have an unpalatable huskthat needs to be removed before processing. There are different kinds of de-hulling machines designed for this purpose, depending on the type of cereal grains.

4.1.3 Milling

This can be achieved using any of these cereal grains mill; Plate mill, hammer mill and roller mill. The type of mill to be used depends on the cereal grains. Roller mills are majorly used industrially due to its high cost and maintenance while hammer mill and plate mill can be used at home and all business scale level.

4.1.4 Drying

Before storage, the cereals grains should be dried to 10–15% moisture to avoid spoilage of the cereal grains.

4.2 Secondary processing

4.2.1 Storage

Dried grains are stored in much quantity until required for processing. The grains should be inspected regularly for signs of spoilage and the moisture content tested. If the grain has picked up moisture, it should be re-dried.

5. Cereal grains products and by-products

Cereal grains products are a staple in the diets of many cultures around the world forming the basic and essential supply of nutrients to humans as well as animals. Nutrients provided by cereal grain products include carbohydrate (as an energy source), minerals such as magnesium, phosphorus and zinc, proteins, vitamins, especially the B Vitamins (niacin, riboflavin, and thiamine) and fiber. Cereal grain products are extensive and are derived using indigenous as well as technologically enhanced procedures [20]. Cereal grains products include a wide range of products which are made out of grains such as quinoa, maize, rice, sorghum, rye, barley, millet and oats.

5.1 Products and by-products from Rice

Majorly, rice is consumed in cooked form. In addition to rice being eaten in the cooked form, lots of products and by-products are available as a consequence of its prevalent functional properties and less sensitivity to allergens. A major product from rice is rice flour, which is gluten-free and is used to make rice noodles, rice crackers, dumplings, bread, rice paper, breakfast cereals, pancakes, baby foods, cakes, waffles and wrappers for egg rolls. Other products include rice milk, puffed rice, rice starch, bran oil, vinegar and alcoholic beverages comprising rice beer and wine [20]. By-products from rice include rice bran, rice husk as well as rice straw which serves as feed for animals [21].

5.1.1 Rice noodles

Extruded and flat rice are noodles made out of rice flour that has been wet milled. They are consumed alongside soups and dishes. In Thailand, Japan and Chinese, it is called" senmee", "harusame" and "mi fen" respectively.

5.1.2 Rice flour dumplings and cakes

Dumpling is a ball of dough that is wrapped around a filling. Several methods are used in its preparation, including baking, frying, steaming, boiling or simmering and are found in a lot of world cuisines. In Asia, sweet dumplings and cakes from rice flour are readily available to buy in stores and stalls. Rice cake is a sticky, dense meal that is well known in parts of East Asia.

5.1.3 Rice alcoholic beverages

Rice beer is a major beverage produced from rice. It is produced by first boiling rice and then inoculating with some amount of yeast and the resulting mixture fermented for a few days. Sake (rice wine) is also a Japanese alcoholic beverage made from rice [22].

5.1.4 Rice starch

Rice starch is employed as a thickener in sauces, desserts as well as baby foods. Sweet syrup can also be made using rice starch.

5.1.5 Rice bread

A good replacement for other cereal flour containing gluten is rice bread, which is consumed as an alternative source for people that are allergic to other types of flour.

5.2 Products and by-products from wheat

5.2.1 Whole wheat

Whole wheat flour has none of its constituents (bran, endosperm and germ) removed. The Middle East and Southern Europeans commonly consume decorticated and pounded type of wheat. Pounded wheat is usually considered to possess a higher nutritional value at the same time having better retention of nutrients present in the aleurone layer in addition to its germ. Artificial or natural dehydration is usually carried on decorticated wheat grains [23]. Whole wheat lowers the possible adverse outcome of metabolic syndrome. Consumption of whole wheat has also been reported to support beneficial bodyweight [24]. It has a favourable nutrient profile as effective sources of magnesium, dietary fibre, pantothenic acid, copper and manganese. However, whole wheat is considered as one of the major causes of allergies in foods [25].

5.2.2 Wheat flour

The flour that is gotten when wheat (endosperm only) is ground into finer particles is called wheat flour. Depending on the gluten value, they are classified as weak/soft flour or hard/strong. Weak/soft denotes flour with low gluten value, while hard/strong flour denotes flour with high gluten value. Bread flour, cake flour and all-purpose flour are majorly the types of wheat flour consumed. Others include self-rising flour, pastry flour, gluten flour, durum flour and fortified flour. In most homes across the world, wheat flour is the most significant ingredient used in baking. It forms the framework of the majority of commercially available baked goods and pasta [26].

5.2.3 Durum flour

A by-product that is employed in the production of semolina, another form of pasta, durum bread and American noodles is durum flour which is gotten from durum wheat. Durum wheat falls under the category of hard wheat.

5.2.4 Semolina

Semolina is gotten from durum wheat that has been coarsely ground. Pasta with high protein value and are of great importance including spaghetti in addition to macaroni are made from semolina.

5.2.5 Wheat noodles

In most African countries, noodles made from wheat dominate about 30–40% of the cereal-based diet [27]. White noodles coated with salt are generally consumed in Japan White noodles coated with salt are generally consumed in Japan [27]. Noodles from wheat are produced from soft or hard wheat flour. It can also be produced from wheat flour that is intermediate between soft and hard wheat flour.

5.2.6 Spaghetti and macaroni

Spaghetti is a type of pasta made in the shape of long thin strings while macaroni is pasta usually in the form of short tubes.

5.3 Products and by-products from sorghum

Sorghum grains are utilized by lots of food industries for the production of flour, starch and alcohols which results in many by-products. By-products obtained from sorghum grains include sorghum wine, sorghum gluten meal, sorghum germ meal, sorghum distillers dried grains and solubles, sorghum brewers' grains, malted sorghum sprouts and sorghum bran [28]. Sorghum is also consumed in fermented forms. Fermented forms of sorghum include Injera, Nasha, Ting, Asida, Kisra, HumulurKhamir [29]. Sorghum wine is a by-product obtained from the fermentation of indigenous sorghum liquor. It is known as kaoliang in China.

5.4 Products and by-products from millet

Millet is usually dehulled and made to pass through several treatments before consumption to enhance their edibility and sensory attributes Millet is usually dehulled and made to pass through several treatments before consumption to enhance their edibility and sensory attributes [30]. The small nature of millet has relegated its use to products that are solely flour-based because of the difficulty in decortication. Several treatments for millet grains have however observed to improve its decortication [31]. Alcoholic beverages, distilled liquors and different types of meals are prepared from millet. Candied puffs called Awaokoshi in Japan are made from millet. In some parts of the world, sorghum flour is mixed with millet flour to produce a type of flatbread usually rolled by hand. Millet porridge is an indigenous meal eaten in China, Russia and Germany. A Vietnam snack is known as banh-da-ke also comprises of millet as a major ingredient.

5.5 Products and by-products from barley

Flour, flakes, grits, starch, malt and beverages are commercial products gotten from barley grain. Animals are mostly fed with whole grains of barley. Food products from barley are rich sources of minerals, fiber, proteins and B Vitamins. Pearled barley or pot is made by removing the outer layers of barley grain by the process of abrasion. Porridge and filing for pies are made from pearl or pot barley. They also serve as an alternative to potatoes, pasta, in addition to rice. Barley flour is used to produce bread, noodles, cakes, flatbreads, cookies and extruded snacks [32]. Sweeteners and binders are made from barley starch. Barley starch is also used besides with barley malt to produce beer. The primary use of barley is in the production of malt used in brewing, alcoholic and non-alcoholic beverages. Bakeries and distilling industries also utilize barley malt [33].

6. Diseases prevention/Management of Cereal Grains Products

Several cereal grains product has been developed and used in the prevention and management of diseases which includes diabetes, hypertension, inflammation and stroke.

Diabetes: Diabetes is a metabolic disease associated with high blood glucose level (hyperglycemia) usually treated using expensive synthetic drugs. Recently, scientific research focuses on the prevention and management of diabetes using cereal grains food products with high resistant starch, and low glycemic index (GI). Hefni et al. [34] developed a low GI cereal-based bread fortified with legume kernels in sourdough fermentation. Developed bread

samples resulted in the reduction of high blood sugar level (>250 mmol/dL) to normal (<100 mmol/dL) after 90 min of consumption in human subject aged between 29 and 62 years, at Linnaeus University, Kalmar, Sweden. Likewise, Olagunju et al. [34] developed a whole wheat multigrain bread with significant *in-vivo* α-amylase and α-glucosidase inhibitory activities which slow down the rates of metabolism of blood glucose level in experimental animals. Hence, developed whole wheat multigrain bread may serve as a potential food product for the management of diabetes.

Hypertension: It is also known as high blood pressure and its onset is associated with a high-risk factor of other cardiovascular diseases. Epidemiological studies have shown that consumption of diet from cereals grains such as oat, barley, rice and rye can reduce blood pressure [35, 36]. He et al. [37] conducted a meta-analysis on consumption cereal grains fiber and found a significant reduction in high blood pressure of subjects. Clinical evidence has also shown that constant consumption of cereal whole grains (oat fiber) in less than 9 weeks by 88 human subjects significantly reduced subject blood pressure [38, 39]. Recently, Odebode et al. [40] developed a dough meal samples enriched with cereal fiber (rice bran). Developed products exhibit antihypertensive potentials in experimental animals fed for four weeks which is attributed to a high content of high-density lipoprotein in developed dough meal.

Inflammation: Inflammations refers to the autoimmune ability to fight against germs and diseases. Cereal grains such as maize contains an anti-inflammatory compound called *Ferulic acids*. This derivative is responsible for the production of macrophages which plays a crucial role in the secretion of mediators such as pro-inflammatory and inflammatory cytokines. Productions of these compounds prevent the body against chronic diseases which includes cancer, atherosclerosis, diabetes, among others [41–43].

Stroke: Stroke is a cerebrovascular disorder due to shortage of blood (oxygen) reaching the brain which could results in difficulties in walking, talking, and body paralysis. Scientific evidence has shown that the consumption of cereal grains exhibits possible potentials of risk reduction against stroke [9, 10, 43–45]. Mozaffarian et al. [9] conducted a cross-sectional analysis of over 8 years on both male and female stroke subject, aged 65 and above based on cereals grain fiber consumption. The results show that higher consumption of cereal grains fiber is associated with lower risk and recovery of the partial and total cerebrovascular disorder. In the same vein, Fung et al. [46] analyzed the correlation between dietary consumption pattern and stroke in women between 40 and 60 years of age for 14 years. Calculated dietary pattern score shows that subject with higher consumption of processed animal protein and full fats are at higher risk of stroke compared with subjects with higher consumption of cereal grains fiber, fruits and vegetables.

7. Summary and future applications of cereal grains products

Human populace exposed to a series of health complications due to urbanization and industrialization. Synthetic drugs used in the management of these health challenges are linked with side effects, thereby instigating the application of plants in disease management. Cereal grains are food crops with immeasurable nutritional and functional benefits. Regular consumption could enhance better dietary lifestyle and healthy living. Nevertheless, the development of varieties of novel cereal grain food products, encapsulation, and application of cereal grain bioactive compounds in nanotechnology will further reduce menace caused by a widespread of diseases on human populace.

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References

[1] Statista (2020). Worldwide production of grain in 2019/2020. Accessed 23/12/2020 https://www.statista.com/statistics/263977/world-grain-production-by-type/

[2] Horn, L.V. Nutrition Month: An Overview. J. Am. Dietet. Assoc. 2006, 106 (3), 339.

[3] Jiwan S. Sidhu, Yearul Kabir & Fatma G. Huffman (2007) Functional Foods from Cereal Grains, International Journal of Food Properties, 10:2, 231-244, DOI:10.1080/10942910601045289

[4] Flight, I., & Clifton, P. (2006). Cereal grains and legumes in the prevention of coronary heart disease and stroke: a review of the literature. European journal of clinical nutrition, 60(10), 1145-1159.

[5] Nettleton, J. A., McKeown, N. M., Kanoni, A., Lemaitre, R. N., Hivert, M.-F., Ngwa, J., et al. (2010). Interactions of dietary wholegrain intake with fasting glucose- and insulinrelated genetic loci in individuals of European descent. A meta-analysis of 14 cohort studies. Diabetes Care, 33. doi:10.2337/dc10e1150.

[6] Olawoye, B., & Kadiri, O. (2016). Optimization and response surface modelling of antioxidant activities of Amaranthus virides seed flour extract. Annals Journal of Food Science and Technology, *17*, 114-123.

[7] Poutanen, K. (2012). Past and future of cereal grains as food for health. Trends in Food Science & Technology, 25(2), 58-62.

[8] Jacobs Jr DR, Meyer HE, Solvoll K (2001). Reduced mortality among whole grain bread eaters in men and women in the Norwegian County Study. Eur J Clin Nutr 55, 137-143.

[9] Mozaffarian D, Kumanyika SK, Lemaitre RN, Olson JL, Burke GL, Siscovick DS (2003a). Cereal, fruit, and vegetable fiber intake and the risk of cardiovascular disease in elderly individuals. JAMA 289, 1659-1666

[10] Mozaffarian D, Kumanyika SK, Lemaitre RN, Olson JL, Burke GL, Siscovick DS (2003b). Cereal, fruit, and vegetable fiber intake and the risk of cardiovascular disease in elderly individuals. JAMA 289, 1659-1666.

[11] Jensen MK, Koh-Banerjee P, Hu FB, Franz M, Sampson L, Gronbaek M et al. (2004). Intakes of whole grains, bran, and germ and the risk of coronary heart disease in men. Am J Clin Nutr 80, 1492-1499.

[12] Borg, J., Kiær, LP., Lecarpentier, C., Goldringer, I., Gauffreteau, A., SaintJean, S., Barot, S., Enjalbert, J. (2018). Unfolding the potential of wheat cultivar mixtures: A meta-analysis perspective and identification of knowledge gaps. Field Crop Res. 221, 298-313.

[13] FAOSTAT, 2020. Available from: http://www.fao.org/faostat/en/#data/QC/visualize[accessed Jan 24 2021].

[14] IFOAM (Research Institute of Organic Agriculture FiBL), 2016 edition of "The World of Organic Agriculture". Available from: https://www.organicworld.net/yearbook/yearbook-2016.html. [accessed Jan 24 2021].

[15] Yunqi W., Fuli G., Guoying G., Jianyun Z., Xiaoge W., Rui Z. (2019) Production and Cultivated Area Variation in Cereal, Rice, Wheat and Maize in China (1998-2016). Agronomy. 9: 22.

[16] FAO, 2020. Available from:http://www.fao.org/worldfoodsituation/csdb/

en/#:~:text=Nonetheless%2C%20global%20 cereal%20production%20is,million%20tonnes%20month%20on%20month.

[17] Buttriss J (1999) Nutrition and Food Processing. British Nutrition Foundation, London.

[18] Tomotake, H., Yamamoto, N., Kitabayashi, H., Kawakami, A., Kayashita, J., Ohinata, H., et al. (2007).Preparation of tartary buckwheat protein product and its improving effect on cholesterol metabolism in rats and mice fed cholesterol enriched diet. Journal of Food Science, 72(7), 528 –533.

[19] Sanaa R., Koushik S., El-Sayed M., Abdel-Aal. (2014). The Impact of Milling and Thermal Processing on Phenolic Compounds in Cereal Grains, Critical Reviews in Food Science and Nutrition, *(PDF) Effects of Processing on Nutritional and Functional Properties of Cereal Products*. Available from: https://www.researchgate.net/publication/286319129_Effects_of_Processing_on_Nutritional_and_Functional_Properties_of_Cereal_Products[accessed Jan 24 2021].

[20] Price, R. K., & Welch, R. W. (2012). Cereal Grains. In (pp. 307-316).

[21] Esa, N. M., Ling, T. B., & Peng, L. S.(2013). By-products of rice processing: An overview of health benefits andapplications. *Rice Research: Open Access*.

[22] Olawoye, B., Kadiri, O., Fagbohun, O. F., &Oluwajuyitan, T. D. (2021). Celiac Disease Management through Gluten-Free Diets. In *Celiac Disease*: IntechOpen.

[23] Bayram, M., &Öner, M. D. (2005). Stone, disc and hammer milling of bulgur. Journal of Cereal Science, *3*(41), 291-296.

[24] Liu, S., Willett, W. C., Manson, J. E., Hu, F. B., Rosner, B., & Colditz, G. (2003). Relation between changes in intakes of dietary fiber and grain products and changes in weight and development of obesity among middle-aged women. The American journal of clinical nutrition, *78*(5), 920-927.

[25] Allen, K. J., Turner, P. J., Pawankar, R., Taylor, S., Sicherer, S., Lack, G., . . . Mills, E. C. (2014). Precautionary labelling of foods for allergen content: are we ready for a global framework? World Allergy Organization Journal, *7*(1), 1-14.

[26] Kanojia, V., Kushwaha, N., Reshi, M., Rouf, A., & Muzaffar, H. (2018). Products and byproducts of wheat milling process. IJCS, *6*(4), 990-993.

[27] Fu, B., Assefaw, E., Sarkar, A., & Carson, G. (2006). Evaluation of durum wheat fine flour for alkaline noodle processing. Cereal foods world, *51*(4), 178-183.

[28] Lazaro, E., & Favier, J. (2000). Alkali debranning of sorghum and millet. Cereal chemistry, *77*(6), 717-720.

[29] Adiamo, O. Q., Fawale, O. S., & Olawoye, B. (2018). Recent Trends in the Formulation of Gluten-Free Sorghum Products. Journal of Culinary Science & Technology, *16*(4), 311-325. doi:10.1080/15428052.2017. 1388896.

[30] Liu, J., Tang, X., Zhang, Y., & Zhao, W. (2012). Determination of the volatile composition in brown millet, milled millet and millet bran by gas chromatography/mass spectrometry. Molecules, *17*(3), 2271-2282.

[31] Shobana, S., &Malleshi, N. (2007). Preparation and functional properties of decorticated finger millet (*Eleusine coracana*). Journal of Food Engineering, *79*(2), 529-538.

[32] Capettini, F., Ceccarelli, S., &Grando, S. (2010). Barley production,

improvement, and uses. In (pp. 210-220).

[33] Menrad, K. (2003). Market and marketing of functional food in Europe. Journal of Food Engineering, *56*(2), 181-188. doi: https://doi.org/10.1016/S0260-8774(02)00247-9.

[34] Mohammed E. Hefni, Anette Thomsson& Cornelia M. Witthöft (2021) Bread making with sourdough and intact cereal and legume grains – effect on glycaemic index and glycaemic load, International Journal of Food Sciences and Nutrition, 72:1, 134-142, DOI:10.1080/09637486.2020.1769568.

[35] Appel LJ, Brands MW, Daniels SR, Karanja N, Elmer PJ, Sacks FM. Dietary approaches to prevent and treat hypertension: a scientific statement from the American Heart Association. Hypertension 2006;47:296-308.

[36] Alan J Flint, Frank B Hu, Robert J Glynn, Majken K Jensen, Mary Franz, Laura Sampson, Eric B Rimm, Whole grains and incident hypertension in men, The American Journal of Clinical Nutrition, Volume 90, Issue 3, September 2009, Pages 493-498.

[37] He J, Whelton PK. Effect of dietary fiber and protein intake on blood pressure: a review of epidemiologic evidence. ClinExpHypertens 1999;21:785-796.

[38] Saltzman E, Das SK, Lichtenstein AH, et al. An oatcontaining hypocaloric diet reduces systolic blood pressure and improves lipid profile beyond effects of weight loss in men and women. J Nutr 2001;131:1465-1470.

[39] Pins JJ, Geleva D, Leemam K, Frazer C, O'Connor PJ, Cherney LM. Do whole-grain oat cereals reduce the need for antihypertensive medications and improve blood pressure control? J Fam Pract 2002; 51:353-359.

[40] Odebode, F. D., Ekeleme, O. T., Ijarotimi, O. S., Malomo, S. A., Idowu, A. O., Badejo, A. A., ... &Fagbemi, T. N. (2018). Nutritional composition, antidiabetic and antilipidemic potentials of flour blends made from unripe plantain, soybean cake, and rice bran. Journal of Food Biochemistry, 42(4), e12447.

[41] Sakai S, Kawamata H, Kogure T, Mantani N, Terasawa K, Umatake M, et al. Inhibitory effect of ferulic acid and isoferulic acid on the production of macrophage inflammatory protein-2 in response to respiratory syncytial virus infection in RAW264.7 cells. Mediators Inflamm. (1999) 8:173-175. doi: 10.1080/09629359990513.

[42] Walsh LJ. Mast cells and oral inflammation. Crit Rev Oral Biol Med. (2003) 14:188-198. doi: 10.1177/154411130301400304.

[43] Kim EO, Min KJ, Kwon TK, Um BH, Moreau RA, Choi SW. Antiinflammatory activity of hydroxycinnamic acid derivatives isolated from corn bran in lipopolysaccharide-stimulated Raw 264.7 macrophages. Food ChemToxicol. (2012) 50:1309-1316. doi: 10.1016/j.fct.2012.02.011.

[44] Liu S, Manson JE, Stampfer MJ, Rexrode KM, Hu FB, Rimm EB et al. (2000). Whole grain consumption and risk of ischemic stroke in women: a prospective study. JAMA 284, 1534-1540.

[45] Steffen LM, Jacobs Jr DR, Stevens J, Shahar E, Carithers T, Folsom AR (2003). Associations of whole-grain, refined-grain, and fruit and vegetable consumption with risks of all-cause mortality and incident coronary artery disease and ischemic stroke: the Atherosclerosis Risk in Communities (ARIC) Study. Am J ClinNutr 78, 383-390.

[46] Fung TT, Stampfer MJ, Manson JE, Rexrode KM, Willett WC, Hu FB (2004). Prospective study of major dietary patterns and stroke risk in women. Stroke 35, 2014-2019.