Pseudo-cereals as a functional ingredient: effects on bread nutritional and physiological properties- Review

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ABSTRACT: Wheat bread represents the main source of carbohydrate, minerals and vitamins for most of the people. However, white breads are considered to be nutritionally poor, as the wheat proteins are deficient in essential amino acids such as lysine, tryptophan, and threonine. Pseudo-cereal can be classified as cereals, oil seeds, legumes and edible nuts. The main functional components of pseudo-cereal are dietary fibre, protein, vitamins, minerals polyunsaturated fatty acids and other phytochemicals. Therefore, aim of this study was to determine the effects of adding different of pseudo-cereals on the physicochemical, nutritional and physiological properties of bread.

INTRODUCTION

Breads are defined as a fermented confectionary product produced mainly from wheat flour, water, yeast and salt by a series of process involving mixing, kneading, proofing, shaping and baking (Dewettinck et al. 2008). Bread is an excellent source of numerous vitamins and minerals especially phosphorus and copper. This is considered to be nutritionally poor, as the cereal proteins are deficient in essential amino acids such as lysine, tryptophan, and threonine (Wrigley and Bietz, 1988). Composite breads improve the nutritional quality of bread and satisfy the increasing interest among vegetarians to consume protein-enriched food from plant sources, which are rich in lysine and have great potential in overcoming protein–calorie malnutrition. Composite breads are made from blend of non-wheat or pseudo-cereals flours and wheat flour (Fang, 2008).

Pseudo-cereals are defined as starchy food grains excluding those currently classified as cereals, legumes, oilseeds and nuts (Fletcher, 2004). These pseudo-cereals are an ancient crop cultivated in different countries in Africa, Asia, Central and South America, which has been rediscovered in the last thirty years (Cadden, et al. 1983). The use of pseudo-cereals for bread making is to fortify the deficiency of nutritional value in wheat flour. Other objective of supplementation pseudo-cereals in bread formulation is a very recent development across the globe owing to some economic reasons because wheat imports can be reduced and elevate the use of locally grown grains (Hugo, et al. 2003). Pseudo-cereals are being used extensively for the development of functional foods. The components of pseudo-cereals (cereals, oilseeds, legumes and nuts), identified to exhibit the health benefits are dietary fibre, proteins, lignans, essential amino acids, fatty acids, dietary fibre, minerals, phenolic compounds, vitamins and etc. Previous studies have shown that the nutritional quality of bread improved when wheat flour was supplement with oilseed/legume flours (Lazos, 1986). El-Soukkary, (2001) reported that increasing the protein content of the wheat flour by the addition of pseudo-cereals can improve the nutritional quality of bread, especially the lysine content. Clinical studies showed that the higher the unsaturated fatty acids diets the lower the total cholesterol, low density lipoprotein (LDL) and triglycerides, while maintaining beneficial high density lipoprotein (HDL) cholesterol, which is needed to carry the “bad” cholesterol away (Nadeem, et al. 2010). On the other hand, the addition of pseudo-cereals resulted in increasing dietary fibre. There are two reasons to add fibre to bread: the decrease of the caloric density of baked goods and the increase of dietary fibre intake (Stauffer, 1990). Effects of dietary antioxidants such as cereals, nuts, fruits and vegetables on cell signalling and gene expression, where effects can be demonstrated at low concentrations, may be more important for health benefits than direct antioxidant...
activity (Gordon, 2012). Therefore, pseudo-cereals due to measurement beneficial compounds can be used for enrichment of bread.

**Cereal grains**

Cereal grains (barley, corn, maize, millet, oat, rice, rye, and sorghum) have always been the most important plant group for the human diet. Sorghum is rich in potassium and phosphorus and has good amounts of calcium with small amounts of iron, sodium and riboflavin (Al-Dmoor, 2012). Besides the high starch content, cereals provide dietary fibre, protein and oils rich in essential fatty acids. On the other hand, micro nutrients present in cereals are antioxidants, minerals, vitamins especially B vitamins, and phytochemicals (Dewettinck, et al. 2008). Fatty acid compositions of cereal grains are available to the reader in standard reference (Morrison, 1978). The essential fatty acids in cereal lipids are almost invariably 16:0, 16:1, 18:0, 18:1, 18:2, and 18:3. Little amounts of other fatty acids may be presented highly unsaturated fatty acids are unusual, as are hydroxy acids (Becker, 2007). Tocopherols and tocotrienols are naturally occurring phytochemicals present in cereal and their health benefit are well documented including prevention of demand for nutritious cereal-based food products with minimal artificial an additive has been met with increased research and development from the food industry (Tiwari and Cummins, 2009). The main parameters that have to be considered are the composition and processing of the cereal grains in bakery products, the substrate formulation, the growth capability and productivity of the starter culture, the organoleptic properties, and the stability of the probiotic strain during storage, and the nutritional value of the bakery products. On the other hand, cereal grains can be used as sources of non-digestible carbohydrates that besides promoting various beneficial effects can also selectively stimulate the growth of bifidobacteria and lactobacilli in the colon human (Charalampopoulos, et al. 2002). Previous results reported that supplementation of bread wheat flour with rice (Sanchez, et al. 2002), corn (Alpaslan and Hayta, 2006.), pearl millet (Rathi, et al. 2004); barley (Alu'datt, et al. 2012; Knuckles, et al. 1997), sorghum (Abdelghafor, et al. 2011) and rye (Hongisto, et al. 2006) results in alteration in rheological and sensory properties of breads. According to Khalil, et al. (2000), flours from corn, barley are the most predominant cereal grains that have been studied in production of composite flour in breads.

Barley is rich in minerals such as manganese, selenium, phosphorus, copper, magnesium, iron, zinc, potassium, vitamin B6, thiamin, niacin, riboflavin and folate (Al-Dmoor, 2012). Additionally, barley and oat contain water-soluble fibre such as β-glucan. The β-glucan present in barley has been shown to regulate blood glucose levels (Bourdon, et al. 1999), minimize plasma cholesterol levels (Bourdon, et al. 1999) and also reduce glycemic index and reduce the risk of colon cancer (Brennan and Cleary, 2005). However, previous studies have indicated that the physiological effects of β-glucan are decreased when added into the bread (Åman, et al. 2004). On the other hand, the addition of barley flour resulted in increasing essential limiting amino acids in bread from 1.38 to 3.10 g/100 g for lysine and from 0.86 to 1.73 g/100 g for methionine as the ratio of fortification with barley flour and barley protein isolate increased from 0 to 15% (Alu'datt, et al. 2012). Knuckles, Hudson, et al. (1997) showed that breads and pastas containing up to 20% dry milled/sieved β-glucan-enriched barley have acceptable eating quality and are potentially healthful due to reduced calories per serving. Kilocalories in a serving of these pastas with 20% flour substitution were 11, lower than in the control samples.

**Oil seeds**

Oil seeds can be classified as soybean, flaxseed (linseed), safflower seed, sesame seed, , grape seed, African breadfruit seed, poppy seed, beniseed, coconut flour, cottonseed, black seed, Malaysian rubber seed and etc. Trade of oilseeds is substantial and involves most of the leading countries either as importers, exporters, or both. In 1994, world imports in oilseeds amounted about $16.4 billion, according to data of the Food and Agriculture Organization (FAO/WHO, 1994). Diverse bread types enriched with combinations of oilseeds flour are being readily accepted by consumers (Baljeet and Amarjeet, 2010). This tendency in oilseeds relates to their high content of polyunsaturated fatty acids, vitamin E, vegetable protein, niacin, iron, magnesium, phosphorus (Skrbic and Filipcev, 2008). For instance, soybean is one of the richest and cheapest sources of plant protein and plays a very important role in the enrichment of cereal-based baked goods (Fukushima, 1999). It is one such protein sources, which when used partially to replace or complement wheat flour in the production of bakery products such as breads, biscuit, pasta and other confectionery could go a long way in improving the nutritional status of bakery products. The enhancement of the nutritional value of breads with the addition of soybean flour could help to alleviate the problem of protein – energy malnutrition prevalent in Iran and other developing countries of the tropics.

Oilseed flours significantly improve the quality of wheat flour because of its high contents of essential fatty acids and essential amino acids especially lysine. This situation demands to explore the possibility of improving the bakery products with protein sources such as oilseed flours or synthetically produced lysine. This approach seems to be more feasible and exhibits advantages of substantial enhancement in the protein
content and at the same time it helps correcting the amino acid balance deficiencies. Diets rich in an oilseed fatty acid may provide potential prevention of a number of health problems or diseases. For example, unsaturated fatty acids may have physiological benefits including the prevention of cancer, heart disease, hypertension, and autoimmune disorders (Liangli, et al. 2005).


For example, the results showed that bread with the addition of grape seed extract (GSE) had stronger antioxidant activity than that of control bread, and increasing the level of GSE addition further enhanced the antioxidant capacity of the bread. However, thermal processing caused antioxidant activity of GSE added to bread to decrease by around 30–40%. Other benefits for grape seed extract (GSE) was reduction of carboxymethyl lysine (CML) in bread (Peng, et al. 2010).

Among oilseeds, flaxseed (Linum Usitatissimum), a member from the family Linaceae is gaining reputation as a versatile nutritional ingredient which can be easily incorporated into a number of foods as it contains proteins, dietary fibre, polysaccharides, polyphenolics, and essential fatty acids that promote health and may prevent certain diseases. In addition, it is contains 51-55% α-linolenic acid (ALA) which inhibits cardiovascular disease, inflammation, blood pressure, cancer, skin diseases, and immune disorders such as renal failure, rheumatoid arthritis, and multiple sclerosis (Kelley, et al. 1991). Chen, et al. (1992) reported that α-linolenic acid (ALA) remained stable during the processing and cooking of muffins fortified with ground flaxseed. Clinical study has done by Cunnane, et al. (1995) on the nine women consumed 50 grams milled flaxseed for 4 weeks two different ways. Five women ate the milled flaxseed raw, to their food of the choice, such as soup, breakfast cereal, yogurt, or juice and four women consumed bread baked with milled flaxseed in place of their usual bread. These show that baking process did not affect the bioavailability of flaxseed fatty acids because of plasma fatty acid profile were not significantly different between the two groups.

Legumes

The more important legumes are fenugreek, amaranth, cassava, quinoa, pea, chickpea, cow pea, pigeon pea, bean, faba bean, broad bean, lentil and lupin. These proteins should complement the protein in cereal grains since the chemical and nutritional characteristics of legumes make them natural complements to bakery products. Legume seeds provide valuable proteins, which are considered to be increasingly important in human nutrition. In addition, legume proteins in the form of flour, concentrate or isolate, are a good supplement for bread, since both legume and cereal proteins are complementary with regard to their essential amino acids (Abdelrahman, et al. 2012). Additionally, legumes are rich in lysine and deficient in sulphur-containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amounts of sulphur amino acids. Therefore, legume can be successfully used in bread, to obtain a protein-enriched product with improved amino acid balance. The potential use of legumes as protein-enriching agents of bakery products, mainly in the form of protein flours, has been reported by several authors. They have carried out studies on the preparation of the composite flours comprising wheat supplemented with protein rich materials of different products of legumes e.g fenugreek (Ibrahim and Hegazy, 2009), chickpea flour (Gomez, et al. 2008), germinated chickpea flour (Fernandez and Berry, 1989), germinated pea flour (Sadowska, et al. 2003), faba bean (Youssef and Bushuk, 1986) and lupin flour (Dervas, et al. 1999). In addition, these contain many health-promoting components, such as dietary fibre, abundance of carbohydrates, low fat, high concentration of polyunsaturated fatty acids, B complex vitamins, resistant starch, minerals, and numerous phytochemicals endowed with useful biological activities (Amarowicz and Pegg, 2008). The research work, tocopherols were quantified in lentil, pea, chickpea, common bean, broad bean, and three lupin species. Some samples of pea, chickpea and lupin inclusive over 10 mg/100 g seeds of total tocopherols. In order to estimate the nutritional value, the vitamin E activity was determined. Chickpea and, to a lesser extent, lupin, broad bean and pea may contribute in a relevant way to the daily intake of vitamin E (Boschin and Arnoldi, 2011). The selection of leguminous substrates based on their nutritional and healthy potential is also of key importance to get optimal technology, sensory and healthy properties. For example, the supplementation of wheat flour with high-protein-content legume flours (e.g., bean and chickpea) improves the nutritional quality of baked goods and satisfies the consumption of vegetarian people since legume flours are rich in lysine and have the potential to overcome protein-calorie malnutrition (Gomez, et al. 2008).

Fenugreek seed contains calcium (182 mg/100g), Iron (21 mg/100g), zinc (4.9 mg/100g) and other ingredients (El-Shimi, et al. 2003). Moreover, it also possesses hypocholesterolemic and hypoglycemic properties (Neeraja and Rajyalakshmi, 1996). Hence, development and consumption of such therapeutic bakery products such as bread, pasta and cookie would help to improve the nutritional status of population (Shalini and Sudesh, 2005). Information on incorporation of fenugreek seed flour in bread is rare (Ibrahim, &
Hegazy, 2009). Previous study showed that fenugreek seed (raw, soaked and germinated) significantly reduced serum total cholesterol, total lipids, LDL-cholesterol while serum HDL-cholesterol and triglycerides didn’t showed significant changes (Hussein, et al.2011). Ibrahim and Hegazy, (2009) reported that rate fed on fenugreek seed flour biscuit diets exhibited extremely higher values in weight gain, food intake as compared to rats fed on wheat biscuit diet. This study showed that biscuit diet containing 10% germinated fenugreek seed flour recorded the highest values of protein efficiency ratio (PER), net protein ratio (NPR) and net protein utilization (NPU) between all tested diets.

Amaranth is an excellent source of high quality balanced protein as it contains naturally high amounts of lysine, methionine and cysteine apart from large amounts of dietary fibre and minerals (Marcone, 1999). However, a negative correlation among phytate and Fe availability was found in high concentration of amaranth. Higher proportion of amaranth flour increased Fe concentration although there was not detected any increase in Fe uptake. A suitable crop to supplement wheat, significant for its nutritional factors and suitability to survive in the most wasteland is amaranth. In addition, this is good source of important minerals. Alvarez-Jubete, et al.(2010) reported that the amount of calcium, magnesium, iron and zinc in wheat grain are 5.2-, 2.9-, 2.8- and 1.3-fold lower than in amaranth seed, respectively. The lipids of amaranth are rich in squalene and tocotrienols, which are natural materials positively involved in lowering low-density lipoprotein blood cholesterol (Bodroza-Solarov, et al.2008). Several studies have shown that the nutritional quality of bakery product improved when wheat flour was supplement with amaranth (Alvarez-Jubete, et al.2010; Bodroza-Solarov, et al.2008).

Recent study showed that cowpea/plantain flour mixtures had some functional properties which would lend them to use in bakery product. The report showed that cowpea flour could be substituted for 80%of the wheat flour in biscuits without any adverse effecton product quality. It was shown that cowpea and plantain flours can be combined to produce acceptable cookies with good physical and sensory qualities and improved nutritional quality with respect to wheat flour cookies (Akubor, et al.2003). The protein contents of the cowpea flour /wheat flour ranged between 15.2 and 18.9%; values increased with increased levels of cowpea flour in the blend (Akubor, 2003).

**Edible nut**

Nuts are dry edible fruits or seeds which usually contain high amount of fat. Edible nuts have been segment of the human diet since prehistoric times (Salas-Salvado, et al.2011). These are probably the earliest foods consumed by humans and are considered to be important due to their nutritional attributes (Sharma, et al.2010). Nuts have also been used by several civilizations as drugs to prevent or treat various diseases (Salas-Salvado, et al.2011). Often consumed as snack foods in variously processed forms, edible nut seeds are also incorporated in a variety of foods to impart the desirable quality properties that include flavour and texture. The type of edible nut used in a food partly depends on the nut species and the final product quality attributes. For instance, almond, cashew nut, pistachio and peanut are widely used in dry or oil roasted, salted, or unsalted forms as snack food. Lipid and protein in edible nut account for the major portion, typically 50-90 % (dry basis) (Venkatachalam and Sathe, 2006), of seed weight and are therefore thought to significantly influence their properties. However, types of proteins present are dependent on the seed type, and typically these proteins are rich in acidic amino acids aspartic acid (Asx) and glutamine and glutamic acid (Glx) and the basic amino acids (Venkatachalam and Sathe, 2006). With the increased information of tree nut-induced allergies, tree nut proteins have received increased scrutiny in last years (Breitender, et al.2007).

Information on incorporation of edible nut seeds flour in bakery products is scanty. The interest in fortification using whole oilseeds relates to their high content of polysaturated fatty acids, vegetable protein, phosphorus, iron, magnesium, vitamin E, niacin, folate and phytoestrogens. For instance, sunflower seed is a complex containing approximately 20% protein, high levels of potassium (710 mg/ 100 g) and magnesium (390 mg/100 g) and are especially rich in polysaturated fatty acids (approximately 31.0%) in comparison with other oilseeds: soy (3.5%), peanut (13.1%), cottonseed (18.1%), flaxseed (22.4%), sesame seed (25.5%), and safflower seed (28.2%) (Skrbic and Filipcev, 2008).


Pumpkin seed is good sources of carotene, vitamins, minerals, pectin and dietary fibre (Djutin, 1991). Moreover, Pumpkin proteins exhibit good functional properties (high water and fat absorption as well as good emulsification properties) and high lysine content. Hence, incorporation of pumpkin flour would improve the nutritional quality of bread (El-Soukkary, 2001). Fluted pumpkin seed flour has been used as a protein supplement in a variety of native foods (Giami and Bekebain, 1992). Previous studies showed that in-vitro protein digestibility of bread improved with addition of pumpkin seed proteins (El-Soukkary, 2001). From the results it can be concluded that it is suitable to produce bread with good nutritional value and sensory
properties from wheat flour supplemented pumpkin flour. When wheat flour was incorporated with 10% pumpkin seed flour, there was an increase of 80.8% in crude protein, 43.9% in calcium, 71.9% in potassium and 63.0% in phosphorus contents of composite breads. Diets fortified with 5% and 10% fluted pumpkin–substituted breads showed significantly (p < 0.05) higher values for weight gain, protein efficiency ratio, apparent and true digestibility than diets formulated with 100% wheat flour bread, suggesting an improvement of the nutritional quality of fluted pumpkin–substituted composite breads (Giami, et al.2003). However, sensory evaluation also indicated that 5% pumpkin seed flour bread was the most acceptable bread (See, et al.2007). Clinical studies showed that a pumpkin-rich diet could reduce the blood glucose. The active polysaccharides from the pumpkin could obviously increase the levels of serum insulin and thus decrease the blood glucose levels which improve tolerance of glucose, and therefore could be extended as a novel antidiabetic agent (Yang, et al.2007).

Sunflower polyphenols including caffeic, chlorogenic and ferulic acids exert a high antioxidative potential, which might be useful both from technological and bio functional point of views (Maier, et al.2009). Fatty acid composition of sunflower seed oil strongly depends on where the crop is grown. Warmer climates produce higher amounts of the monounsaturated acid (MUFA) oleic acid compared with cooler climates, where the n-6 polyunsaturated fatty acid (PUFA) linoleic acid are more dominant (Morrison, et al.1995). However, near 90% of the oil in sunflower seeds is good unsaturated oil. Due to the role of tocopherols as natural antioxidant, it is believed that tocopherols decrease several human diseases especially caused by oxidative stress including coronary heart diseases, cancer and cardiovascular (Adams and Best, 2002). The antioxidant potential of oil sunflower seed is of great concern with ever increasing use of this oil seed in various food products. Bread is used as main supplementation vehicle for nutrition purposes. The obtained data were used to estimate the intakes of sunflower seeds and compare them to the dietary reference intakes (DRIs). The breads incorporated with sunflower seeds were sensorially acceptable, containing significantly more tocopherols, fat, essential fatty acids, crude fibre, copper and zinc. On the other hand, the addition of sunflower seed resulted in increasing chemical composition (crude fat, crude fibre and crude protein) of breads.

CONCLUSION

Bread is the main diet in the most of countries all over the world. It is an excellent source of minerals, especially phosphorus and copper, numerous vitamins, and carbohydrates. However, lysine and tryptophan are first and second limiting amino acids in the bread. Various sources of pseudo-cereal flour are used in bread making include oil seeds, cereals, legumes and edible nuts. These ingredients which are good sources of proteins, carbohydrates, dietary fibres, minerals and also rich in lysine, leucine and arginine can fulfill the amino acids requirement and provide beneficial physiological effects to consumers and also a lowering of bread making cost in countries wherever wheat is not a major domestic crop. Thus fortifying wheat flour with the pseudo-cereals is considered as one of the most effective and inexpensive ways of improving diet, while more researches are need to characterize features of fortified products.

REFERENCE