Cereals as Functional Ingredients in Meat and Meat Products

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Abstract

With the increasing awareness among consumer regarding food they eat, researchers shifted their focus from conventional foods to functional foods. Reasons being the studies showing various health risks associated with various food items like meat and poultry. Meat products have suffered the most due to their negative impact on health. Despite being one of the most nutritious food items in terms of proteins with high biological value, mineral content, vitamins, etc., it is not appreciated quite often as there are evidences relating meat consumption especially red meat to colorectal cancers, type 2 diabetes, cardiovascular diseases, hypertension, etc. With all these apprehensions in mind, researchers are looking for other sources which could be incorporated in meat products to reduce these health issues. Cereals happen to play a promising role in addressing all these concerns as they are rich in various phytochemicals, dietary fiber, etc. which have positive impact on health and physiological characteristics of meat. Non-starch polysaccharides (NSP) such as β glucan, arabinoxylans, arabinogalactans, and phenolics of cereals have acquired much importance because of their potential to act as prebiotics, antioxidants, immunomodulators, anticancer agents, cardio-protectors and anti-diabetic. Cereal germ is an important ingredient for the development of functional meat products because of its rich nutrient content and antioxidant property. They also contain minerals like Mg, K, Ca, and P, and they can also help in maintaining blood pressure. The aim of this chapter is to highlight the various components of cereals (oats, barley, wheat, rye, etc.) which can be used in meat products to improve their quality.

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7.1 Introduction

With the increase in demand for healthier foods by consumers, food sector needs to redirect its new product development to the area of functional food development by incorporating various functional ingredients in food items like meat products, baby foods, and bakery (Charalampopoulos et al. 2019). Meat as defined by various authors is the flesh of an animal like cattle, poultry, and fish and is the most nutritious food in terms of protein quality as it contains proteins with high biological value. It contains all the essential amino acids or indispensable amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) which are not synthesized by the human body and has to be supplied to the human body through the food. Especially red meat is an important source of vitamins (vitamin B-6) and minerals, in particular zinc and iron (Boyle 1994). Despite its nutritional properties, consumption of meat and meat products has adverse effect on the human health, and strongest evidence of its adverse effect on health is increased risk of developing colorectal cancer with high consumption of processed meat (Godfray et al. 2018). Processed meat has been categorized as carcinogenic to human because of its links to colorectal cancer, whereas red meat is categorized as probably carcinogenic to humans by the World Health Organization's International Agency for Research on Cancer (IARC) (Bouvard et al. 2015). However, it is not yet clear how high intake of processed meat increases the risk of developing colorectal cancer. Elements like polycyclic aromatic hydrocarbons (PAH) and N-nitroso compounds formed during cooking of processed meat products might be the carcinogenic agents in meat (Bouvard et al. 2015). Some researchers argue since meat contains saturated fatty acids and high quantity of salts which increases the low density lipoprotein (LDL) cholesterol and blood pressure leading to various cardiovascular diseases. Trimethylamine N-oxide generated from L-carnitine in meat may also be involved in the development of adverse health effects in humans (Wolk 2017; Wang et al. 2011). High meat consumption is also associated with the risk of developing many other chronic diseases like obesity and diabetes (type 2 diabetes). These health hazards associated with meat have forced consumers to look for health-oriented functional meat products.

Functional meat products are developed by incorporating health-benefiting ingredients like dietary fiber, antioxidants, proteins, and polyunsaturated fatty acids. Meat is devoid of fiber, and meat products incorporated with ingredients containing dietary fiber are considered as better substitutes due to their functional and health effects (Hur et al. 2009). Cereal grains like oats, barley, wheat, quinoa, and psyllium are good sources of dietary fiber which helps to improve or maintain the gut health and are also good sources of other phytochemicals (β glucans, lignans, phytic acid, terpenes, ferulic acid, etc.). They contains good amount of vitamins like

Vitamin E, B, B_2, and B_3, and minerals (potassium, phosphorous, magnesium, calcium, etc.) because of the presence of all these components cereals could be used as potential ingredients in developing meat products with better quality and shelf life.

7.2 Status of Meat Production Industry in India

Livestock sector is an important sector of Indian economy as it provides livelihood to most of the population in rural areas. India has huge resource of livestock and poultry which play an important role in ameliorating the social and economic status of farmers and weaker sections of society in rural areas (Kumar et al. 2018). It provides employment to about 8.8% of the population in rural areas and also contributes 4.11% of gross domestic product (GDP) and 25.6% of total agriculture GDP. Livestock population in India is highest in the world and accounts 11.54% of total in the world. India is also the largest exporter of buffalo meat in the world. Total livestock population excluding poultry in India was 512.05 million out of which buffalo population was 108.70 million (Singh 2018) and currently it stands at 535.78 million as per 20th livestock census (Table 7.1). Meat production has increased appreciably to 7.0 million tonnes in 2015–2016 from 5.9 million tons in the 2012–2013. Annually meat production in India grows at a rate of 4%. Buffalo meat, poultry and marine processing rate is 21%, 6% and 8%, respectively. The livestock in India contributes considerably in the production of leather, wool, etc. while as leather is the most valuable product having very high export potential. India produced about 41.5 million kilograms of wool per annum during 2017–2018 (annual report DADF 2018–2019).

India's total import and export of livestock and livestock products in 2016–17 was Rs 257,742,166 and Rs 185,233,966, respectively (Singh 2018). India has taken lead in the export of buffalo meat and dethroned Brazil which was its largest exporter of buffalo meat as per United States Department of Agriculture (USDA) and exports meat to around 65 countries in the world.

Table 7.1 Livestock population in India

Census year	Buffalo	Sheep	Goat	Pigs	Poultry	Cattle
Livestock census 2003 (millions)	97.90	61.50	124.40	13.50	489.00	185.20
Livestock census 2007 (millions)	105.30	71.60	140.5	11.10	648.80	199.10
Livestock census 2012 (millions)	108.70	65.07	135.20	10.30	729.20	199.90
Livestock census 2017 (millions)	109.85	74.26	148.88	9.06	851.81	192.49

Sources: Annual report 2017–18, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India

7.2.1 Constraints to Meat Industry

Despite leading the world in livestock population, India has not fully been able to increase the meat processing industry as hardly as 1% of total meat produced in India is subjected to commercial processing. There are various factors responsible for this limited growth of meat industry as discussed below.

- Feed and fodder shortage: The livestock is mainly reared by people in rural areas, and they depend entirely on common grazing lands. Area under grazing lands has been decreasing quantitatively as well qualitatively due to increasing livestock population and ineffective policies of government.
- Diseases: Diseases in cattle like foot and mouth, and black quarter are common in India causing death of considerable population of animals leading to decrease in meat production.
- Unhygienic conditions: Due to unhygienic conditions in slaughter houses, transportation of meat from Indian meat industry is below par with the international standards, thereby hampering meat export from India.
- Sociocultural factors also affect the meat consumption as various sections of society do not eat meat products, e.g. Muslims do not eat pork and Hindus do not eat beef because of religious beliefs.
- Poor infrastructure regarding cold chain storage contributes to the decrease in meat production because of limited shelf life of meat.

7.3 Cereals in Meat Products

Regarding meat products, recent studies have revealed that frequent consumption of meat products leads to prevalence of several diseases like coronary heart disease, diabetes, cancer, and obesity (Boada et al. 2016). Due to growing evidence on detrimental effects of consumption of meat products on human health, international and national nutrition program and policies have been designed to formulate the meat products by incorporating bioactive components from various sources like cereals, fruits, and vegetables to satisfy the need of health-conscious consumers. World Health Organization has recommended that fat in the meat products should be limited to 15–30% of calories in the diet in which saturated fat should not be more than 10% (Grasso et al. 2014). Research has shown a relationship between the diets rich in energy and various chronic diseases, thereby recommending diet high in dietary fiber level (Kaeferstein and Clugston 1995; Johnson and Southgate 1994). Cereals find a suitable role in the development of meat products with health benefits as they contain bioactive components like fiber, phytochemicals, and phytostereols. Cereal polysaccharides can improve the technological and nutritional qualities of meat products as they can serve as in the form of prebiotics and dietary fiber. It is confirmed that cereal polysaccharides like arabinoxylans and beta glucans maintain the proper levels of blood glucose, insulin, and cholesterol and positive impact on health because of being good source of dietary fiber (Cui and Wang 2009). Cereal polysaccharides have various functional characteristics and can act as stabilizers, thickeners, emulsifiers, and gelation in dairy, meat, and bakery products (Ahmad and Kaleem 2018; Nakashima et al. 2018; Sandford and Baird 1983).

7.3.1 Cereal Polysaccharides

Polysaccharides are polymers of carbohydrate molecules consisting of long chains of monosaccharide units linked by glycosidic α (1→4) bonds and yields constituent monomers and oligosaccharides upon hydrolysis by amylases. They are present in plants, animals, and microorganisms. Polysaccharides may contain all the monosaccharaides of same type (homopolysaccharide) or of different types (heteropolysaccharides). Polysaccharides in cereals have been divided into two different classes, namely starch and non-starch polysaccharides (NSP). Starch is mainly present in endosperm part while as non-starch polysaccharides are present in both cell wall of endosperm and bran layers of cereals (Hamaker et al. 2019). Starch is the major carbohydrate in grains making 65–70% of total carbohydrate followed by other polysaccharides like β glucans and arabinoxylans. Structural characteristics are attributed to the non-starch polysaccharides as they have the capability to interact with each other and also with other non-carbohydrate entities like lignans and proteins (Hamaker et al. 2019). Due to health beneficial potential of these bioactive polysaccharides in cereals, they are receiving much attention from researchers and scientists all over the world. Studies conducted by various researchers substantiated their role on health by acting as antidiabetic, antioxidant, and anticancer agents (Khan et al. 2019; Li et al. 2017; Chen and Raymond 2008). The bioactivity of cereal polysaccharides is influenced by the shape and size of polysaccharide in solution, linkage pattern of monomers, solubility, gelation, and viscosity (Wang et al. 2017, Zhang et al. 2017).

The non-starchy polysaccharide portion forms the dietary fiber part of cereal grains as Cordex Alimentarius Commission (CAC) defined dietary fiber as polysaccharide which cannot be absorbed by small intestines of humans. In order to stay healthy, WHO has recommended that a person should get 25 g of dietary fiber in everyday diet as it reduces the chances of developing diabetes, cardiovascular diseases, and colorectal cancer. Since meat is deprived of dietary fiber, it becomes one of the best options to incorporate cereals in meat and meat products to improve its health profile. Apart from health properties, cereal polysaccharides have gained a specific place from industrial point of view for their well-documented applications as thickeners, emulsifiers, gelation agents, and textural agents in various food formulations (Ahmad and Kaleem 2018; Nakashima et al. 2018). Cereal dietary fiber in meat can also enhance its textural characteristics like juiciness by improving water-holding capacity and reduction in cooking losses (Chevance et al. 2000). There are various mechanisms through which cereal polysaccharides ameliorate the technological functionalities of meat as shown (Fig. 7.1).

Various low-fat reformulated meat product like restructured meat emulsions incorporated with cereal dietary fibers along with other ingredients have been

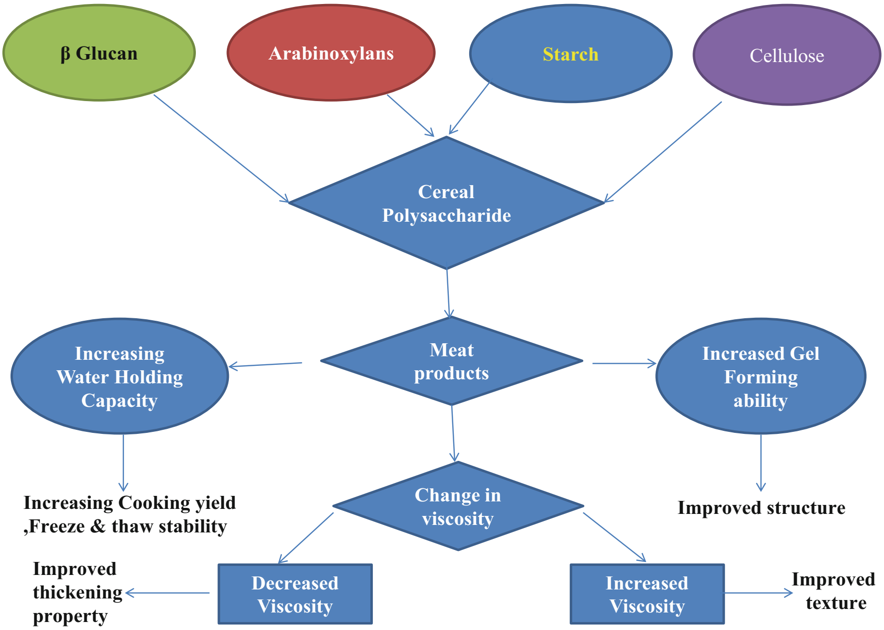

Fig. 7.1 Main mechanisms of improving various technological functionalities of meat products by different cereal polysaccharides (Adopted from Kaur and Sharma 2019)

studied (Sandford and Baird 1983). In this chapter, we will discuss some cereal polysaccharides like cellulose and hemicelluloses, especially β glucan and various other phytochemicals.

7.3.1.1 Starch

In cereals and grains, starch is the major polysaccharide among other carbohydrates (Pietrasik et al. 2012) with a calorific value of 4 cal/g and is easily digested in human gastrointestinal tract. Starch exists in plant tissues as granules of size 1–100 μm in diameter. Starch is composed of amylose and amylopectin both containing same monomers (D-glucose) but with different molecular weights and shape due to which they exhibit different functional properties (Petracci et al. 2013). Amylose being linear in shape can dissolve easily in solutions and can also align themselves by joining with each other through hydrogen bonding in gel matrix on heating, thereby providing enhanced gel strength in various food products and texture to the meat products with amylose-rich starches, while starches with high amylopectin are not able to align themselves as effectively as amylose, resulting in firm hydrogen bonding and less gel strength in food products. Starch can be isolated or extracted by adopting numerous methods like dough hand washing method in case of wheat enzymatic methods (Bechtel and Wilson 2000) and chemical buffer method (Zhao and Sharp 1996). In food industries, starch is most commonly used because of its good stabilizing effect and easy modification using various physical or chemical

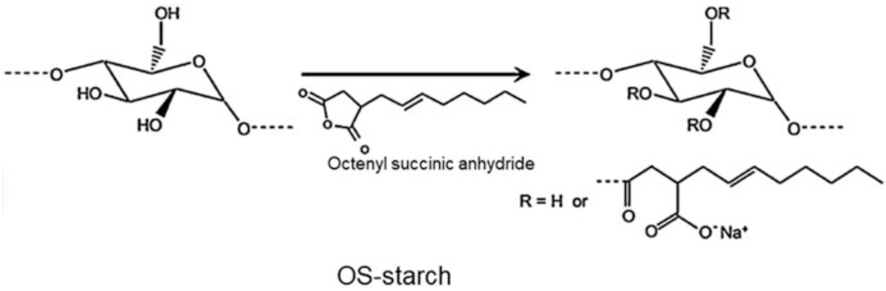

Fig. 7.2 Structure of starch modified with 2-Octen-1-yl succinic anhydride (OS-starch) (Adapted from Sweedman et al. 2013)

treatments. Starch acts as multifunctional ingredient in meat product development because of its wider applications like fat replacer (Jairath et al. 2018), emulsifying agent, water retention agent, and adhesive (Song et al. 2010).

Studies have shown that addition of cereal starch to meat products resulted in the decline in the cooking losses, leaching out of proteins and increased meat thaw stability (Li and Yeh 2003; Skrede 1989). Starch has found wide application in meat products as fat replacers as studies have suggested that starches having granular size same as that of fat emulsions can replace the fat in low-fat food without compromising the quality and sensory characteristics (Lindeboom et al. 2004; Malinski et al. 2003). This property of starch as fat replacer can be exploited in formulation of meat products by incorporating starch in native or modified form in them, for example corn starch was used as fat replacer in meat sausages which increased its water-binding capacity as starch has the ability to absorb water (Jairath et al. 2018). Starch in its native form is not as effective as it is in its modified form because it undergoes process of retrogradation on cooling, thereby affecting the quality of end products. So it becomes imperative to alter the chemical conformation of starch by physical or chemical means to overcome its limited applications in food industry, e.g. octenyl succinic anhydride (OSA) starch was modified by esterifying starch with octenyl succinic anhydride (Fig. 7.2). OSA starch has better functional properties as compared to native starch in terms of increased emulsifying ability and providing more compact structure with minimum pores in sausages (Song et al. 2010). Chemically modified starches on account of high hydration properties decreased purge and cooking losses in meat blocks which in turn improved color and textural properties. Some portion of starch which is not hydrolyzed to D-glucose in the intestines and is fermented in the colon is termed as resistant starch and is mostly present in legumes. Resistant starch present in unripe banana, rice, and potatoes comes under the category of dietary fiber. Resistant starch has the positive impact on colon as it increases the bulk in stool, lowers the pH of colon, and increases the cryptic cell production rate (Slavin et al. 2009). Resistant starch is metabolized by the micro flora of colon to short chain fatty acids like butyric acid and propionic acid which are in turn metabolized by the colonocyte especially butyric acid as energy source (Elmstahl 2002).

Resistant starch has several other beneficial effects on human health like

- Hypoglycemic effects (Sajilata et al. 2006)
- Acts as prebiotic
- Inhibits the accumulation of fat
- Hypocholestrolemic effect
- Reduction in gall stone formation (Sajilata et al. 2006)
- Enhances mineral absorption (Morais et al. 1996)

7.3.1.2 Cellulose

Cellulose finds an important application as food additive in various food formulations (Moncel 2019) and is one of the most abundant biomaterials on earth. Cellulose is present not only in plants but several bacteria also synthesize cellulose, of which most important and most extensively studied is *Acetobacter xylinum*. Bran layers of cereals like oats, rice, sorghum, and wheat contain large proportion of non-digestible cellulose (Claye et al. 1996). Cellulose extracted from cereals by alkali method is water-insoluble. Water-soluble carboxymethyl cellulose (CMC) is prepared from cellulose by heating with alkali, but it contains various other salts also, so for purification it is further treated with monochloroacetic acid which on esterification substitutes various hydroxyl groups with methyl carboxyl groups (Gibis et al. 2015). CMC has been approved as a food additive to be used in food products. One more common form cellulose called microcrystalline cellulose has been studied as a fat replacer in meat products (Barbut and Mittal 1996; Mittal and Barbut 1993) and in beef patties where its incorporation resulted in better textural and sensory profile in comparison to control samples (Gibis et al. 2015). It was also reported that MCC has more water-holding capacity as compared to CMC (Mittal and Barbut 1993), whereas another study showed only CMC was able to decrease the loss of moisture in frankfurters with low fat, with no considerable change in the color of reduced fat frankfurters by any of the cellulose forms (CMC, MCC); however, sensory scores were in the range of acceptance (Barbut and Mittal 1996). It has been suggested that while incorporating CMC and MCC in food products, their concentration and molecular weight may change the structural and quality of characteristics of these products quite considerably as CMC decreases the firmness of texture while as MCC maintains the coherence in protein gel network. Both these properties of cellulose can be exploited in the formulation of healthier reduced fat meat sausages (Schuh et al. 2013).

Other forms of cereal cellulose like amorphous cellulose when incorporated in meat products like sausages replaced with other fat enhanced the sensory and physiochemical properties due to its better water-retention ability (Torres 2002). Nowadays cellulose nanofibers owing to their good rheological, high strength, and good emulsifiability properties have got regenerated cellulose when incorporated into the reduced fat emulsified sausages provides more elastic and compact structure along with reduced cooking loss and high moisture content because of rheology of cellulose nanofibers and stabilizing effect of regenerated cellulose (Wang et al. 2018).

7.3.1.3 Hemicellulose

Cereal brans from Rye and wheat have gained tremendous interest for human consumption because of hemicellulose-rich dietary fiber. Hemicellulose is a non-starch polysaccharide present in bran layers of various cereals like rye, wheat, and barley as cell wall polysaccharide and accounts for 20–30% of total mass of plants (Spiridon and Popa 2008). Hemicellulose contain β(1–4) glycosidic bonds and include xylans, arabinoxylans, glucomannans, and β glucans. Hemicelluloses have been categorized into soluble and insoluble hemicelluloses as their extraction can be carried out in alkaline or neutral medium based on solubility (Vuorinen and Alen 1999). Very less proportion, 20–30%, of hemicellulose can be extracted by water because hemicelluloses are mostly linked to lignin via ferulic acid bridges and hydrogen bonding among non-substituted xyloses and cellulose chains (Nilsson et al. 1996; Maes and Delcour 2002).

Hemicelluloses from the bran of rice are said to have effect on the lowering of cholesterol level, thereby helping in removing the colon cancer (Hu and Yu 2013; Hu et al. 2007). It also has many industrial applications like gelling agent, tablet binder, and viscosity modifier (Revanappa and Salimath 2010). Hemicelluloses like arabinoxylans and β glucans have been used in many meat products.

β Glucans

Cereals as mentioned earlier are rich sources of dietary fiber with different concentrations in different cereals. β glucan is an important phytochemical in cereals mainly present in the aleurone and endospermic cell walls of cereals. Oats contain highest concentration of β glucan 14% on basis of dry mass followed by barley and wheat with 10% and 12%, respectively (Charalampopoulos et al. 2002). Beta glucan present in the cell walls of both endosperm and aleurone layers of barley contain levels up to 75% and 26%, respectively (Fincher 1992, Lazaridou et al. 2008). β glucan of barley is of high molecular weight (about 4 × 107 Da) with peptide sequence as part of its complex structure because of this proteolysis is the first step in its breakdown during digestion. β glucan from cereal grains contains *β*-(1→3) and *β*-(1→4) in an irregular fashion while as baker's yeast β glucan consists of *β*-(1→3) as well as (1→6) linkages (Gardiner 2004). Structurally β glucan is almost similar to cellulose with only difference of the twist provided by *β*-(1→3)-linkages in beta glucan thereby providing integrity to its structure and decreasing the tendency to form lumps. It is also advocated by some researchers that increased (1→4) linkages affect the solubility of β glucan owing to its intermolecular conglomeration (Staudte et al. 1983). β glucan is said to have effect on the viscous properties of the products in which it is added and usually depend on the solubility and molecular weight of the β glucans. Barley contains various endogenous enzymes which influence the viscosity of the products incorporated with barley flour slurries. On germination of barley endoenzymes *β*-(1→4)-glucanase is produced which hydrolyses the β glucan (Hrmova et al. 1997). Molecular weight of β glucan and melting temperature has been found to have direct relationship. Stabilizing the effect of temperature on viscosity of barley flour was also reported by some studies. Researches have pointed out that β glucan acts as immune system stimulator, antioxidant (Slamenova et al. 2003), anti-tumor agent (Chen 2013), antidiabetic, and hypo-cholesterol agent (Liatis et al. 2009). Owing to viscous behavior of β glucan in the human intestine, it has been reported to control blood sugar and cholesterol level. Intake of 5.8 g of β glucan on daily basis for 1 month through diet has been shown to reduce the cholesterol (LDL) levels in hypercholesterolemic persons (Braaten et al. 1994). Cholesterol-lowering ability of β glucan from oats has been attributed due to its ability of using cholesterol from the body for the synthesis of bile acids for restoring requisite levels of bile acids in the body (Drzikova et al. 2005). β glucan is helpful for diabetic patients as it has been suggested that it slows down the rate of stomach emptying, thereby delaying sugar absorption and thus helps in lowering blood sugar levels after taking meals (Braaten et al. 1994). β glucan from barley has been shown to make the human body resistant to insulin, thus helping diabetic patients in maintaining proper sugar levels (Ostman et al. 2006; Brennan and Cleary 2007; Hlebowicz and Darwiche 2008). Health claim about β glucan from oats that daily intake of 3 g β glucan per day lowers medical-related cholesterol concentration in serum, which have been approved by Food and Drug Administration (FDA 1997).

β glucans can be incorporated in various food items like sauces and beverages because of their various functionalities like emulsification, stabilizing, gelation and thickening and can also be used in meat products as hydrocolloids (Dawkins and Nnanna 1995; Burkus and Temelli 2000). Because of the health benefits attributed to the β glucan, cereals like barley and oats find a promising role in improving the quality of meat products in terms of health.

Arabinoxylans

Arabinoxylans (AX) categorized as dietary fiber are non-starch polysaccharides forming 70% cell wall NSPs. They form the component of cell walls of all major cereals like wheat, rye, sorghum, oats, and rice (Maes and Delcour 2002; Kaczmarek et al. 2016; Saulnier et al. 2007) with higher concentrations in rye and wheat. Structurally they have backbone of xylose residues associated with ferulic acid moieties, because of these moieties they possess antioxidant properties and therefore can be used in food products like meat to improve their quality by suppressing oxidative spoilage. Arabinoxylans have the distinctive ability of forming gels which have better water retention power and great stability against iconic charges and pH as they are formed by association of ferulic acid and arabinoxylans (Izydorczyk and Biliaderis 1995). Supplementation of meat sausages with 0.15% and 0.30% arabinoxylans leads to the formulation of product with improved antioxidant power, water-holding capacity, pH, titrable acidity, etc. (Herrera-Balandrano et al. 2018). It is also reported that arabinoxylans act as prebiotics by stimulating the growth of certain beneficial bacteria (*Bifidobacterium longnum*) in the human intestine (Mendis et al. 2016; Ou and Sun 2014). They may be helpful in preventing colon cancer by improving mucosal health as micro biota of intestines break them to short chain fatty acids which serve as energy reservoir for colon endothelial cells

(Loosveld et al. 1998). Arabinoxylans possess many other functions such as the following:

- They act as immune modulators by affecting various immune cells to increase their response (Mendis et al. 2016).
- They can lower glycemic index and cholesterol level owing to their high viscosity and solubility, thereby reducing chances of diabetes.
- Because of their ability to act as prebiotics, they lower the rate of cardiovascular diseases (Huang et al. 2015).

7.4 Other Phytochemicals in Cereals

7.4.1 Phenolics

Most of the phytochemicals in cereals are in bound form due to which they are mostly undermined and not counted in total phenolics. Among various other phytochemicals in cereals, phenolics are the most studied phytochemicals. Phenolics contain aromatic benzene ring with one or more hydroxyl groups attached to it, e.g., flavonoids, alkylresorcinols, phenolic acids, tocopherols, and avenanthramides (Slavin 2004). Oats contain a peculiar phytochemical avenanthramides which is a group of *N*-cinnamoylanthranilate alkaloids. Cereals are also rich in antioxidants which are mostly concentrated to bran layers. Antioxidants in cereals may be either water-soluble and fat-soluble (tocotrienols, flavonoids, tocopherols) or insoluble (cinnamic esters). Phenolics present in the bran layers of cereals have been found to have antioxidant properties in combination with other components present in them. Buckwheat contains a phenolic compound rutin mainly present in its leaves, and clinical data has shown its efficacy as antioxidant, edema protection, anti-inflammatory, and reduction of atherosclerosis.

Wheat bran insoluble fiber contains 0.5%–1.0% phenolics. Wheat bran has high antioxidant potential due to its high concentration of phenolics present in it such as alkylresorcinols, ferulic acids, ρ-coumaric acids, protocatechuic acid, and sinapic acids (Onyeneho and Hettiarachchy 1992). Most of the phytochemicals in cereals may be helpful in preventing various types of cancers especially colon cancer as they are not digested in the intestines because of being in bound form and therefore reach the colon where they can act as prebiotics (Kroon et al. 1997) Ferulic acid in addition to its antioxidant property has been shown to have the property of scavenging nitrites in acidic conditions (Moller et al. 1988) and therefore finds an important application in the cured meats where nitrites are said to be cancer-causing agents.

Proanthocyanidin (procyanidins and prodelphinidins) polyphenols present in bran layers of barley possess higher degree of antioxidant activity. The free radical scavenging property of Hordeumin, a polyphenolic (anthocyanin-tannin) purple pigment (Deguchi et al. 2000), produced during the fermentation of barley bran can be utilized in the prevention of free radical-mediated lipid peroxidation in meat products.

7.4.2 Lignans

Lignans are phenolic compounds which exist as secondary metabolites in various vascular plants. Lignan-rich foods like whole grain cereals are considered as protective foods having wide range of health benefits like reducing the chances of cardiovascular diseases (Adlercreutz 2007; Peterson et al. 2010). Lignans are diphenolic compounds formed by the association of two phenylpropanoid C6–C3 units and possess optical activity. Various lignans have been reported from wide range of foods like lariciresinol, matairesinol, pinoresinol, sesamin, syringarecinol, and secoisolariciresinol (Thompson et al. 2006; Milder et al. 2005). Oilseeds are the richest sources of lignans followed by cereal grains like oats and wheat barley. Among oil seeds, flax seed is the richest source of lignans especially secoisolariciresinol diglucoside and alpha linolenic acid (ALA). It has been found that colonic bacteria are able to convert plant lignans to enterodiol and enterolactone which are mammalian lignans by the process of de-glycosylation (Axelson et al. 1982; Borriello et al. 1985). Enterodiol is also converted to enterolactone and vice versa upon oxidation. Structurally enterodiol and enterolactone also called as enterolignans are analogous to estrogen hormone, thereby exhibiting estrogenic effects. Enterolignans are said to have several health-benefitting effects such as reduction in cardiovascular and hormone-initiated cancer (Webb and McCullough 2005). Flaxseed contain lignans and can be used in meat products as binders, thereby providing dual purpose of improving physiological characteristics as well as health profile of meat products.

7.4.3 γ Oryaznol

Earlier the husk from rice was discarded or burnt or used as animal feed, but with the advancement in science and technology the rice industry by-products like rice bran oil and rice bran have gained tremendous attraction among researchers for their high phytochemical content, e.g. γ oryzanol, carotenoids, and tocopherols. γ oryzanol has been reported from wheat bran rye bran also, but the concentration of γ oryzanol in rice bran is very high, 3000 mg/kg (Xu and Godber 1999). γ oryzanols are phenolic acids esterified to sterols and γ oryzanol from rice bran differ from that of wheat bran as sterols in rice bran oryazanols are dimethyl sterols, while oryzanols in wheat or rye are lacking in dimethyl groups. (Nystrom et al. 2005). The major components of γ oryzanol include 24-methylenecycloartanylferulate, campesteryl ferulate, and cycloartenyl ferulate. γ oryzanols have antioxidant, anticancer, and antitumor properties. It has been found that γ oryzanols have more antioxidative power than vitamin E as it prevented oxidation of cholesterol more convincingly (Xu et al. 2001). The antioxidant activity by γ oryzanols is attributed to the radical scavenging property of 24-methylenecycloartanyl ferulate and hampering of UV-assisted oxidation by campesteryl ferulate component (Yagi and Ohishi 1979). γ oryzanol has been shown to lower the cholesterol level in the human body as it has been reported that rice bran oil (RBO) can covert cholesterol into bile acids and also decrease dietary cholesterol absorption, thereby increasing high-density lipoprotein (HDL) and lowering low-density lipoprotein (LDL). Using proper food processing technologies, rice bran oil can be stabilized and latter incorporated into various food products like meat and bread, thereby preventing rancidity.

7.5 Conclusion

Cereals being staple component of the human diet worldwide contribute largely to the nutritional requirements of the population. Cereals contain significant amount of various phytochemicals including phenolics, carotenoids, lignans, and oryzanols. Cereals have been shown to have tremendous potential to act as antioxidant, thereby ameliorating the oxidative stability of the products containing them and consequently stalling the occurrence of various chronic diseases as free radicals formed on lipid peroxidation have been found to be the cause of various diseases. Meat is devoid of dietary fiber and various dietary fiber sources have been tried successfully in meat such as mousambi peel and apple pomace. Cereals contain good amount of dietary fiber especially β glucan in oats and have been shown to decrease the cholesterol levels in the body and also providing bulk to the fecal matter, thereby helping in the reduction in incidents of colorectal cancers which are the main concerns regarding meat consumption. Proper processing of cereal grains will also increase the bioavailability of phytochemicals in cereals. Much research is needed in the field of cereals to make them suitable for the development of functional meat products with health-benefitting properties. Further research is needed in investigating the ways to enhance the bioavailability cereal phytochemicals in meat products, thereby subduing the health implications associated with meat products.

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