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Review Article

Studies on the Development of Nutraceutical Foods Using Extrusion Technology – A Review

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Abstract

The concept of nutraceutical started from the survey in U.K, Germany and France, but it was originally defined by Dr. Stephen L De Felice. The nutraceutical sector is still more a concept than a reality, but talking about today's food industry, undoubtedly, nutraceuticals represent one of the fastest growing segments. Ignorance and lack of adequate knowledge about the nutraceutical attributes of such food ingredients have actually kept a wide range of population across the globe devoid of the utilization of these nutraceuticals in basic food materials. Due to this ignorance and wide spread outbreak of several chronic and degenerative diseases, public health authorities do consider firmly that prevention and treatment with these nutraceuticals can be exploited as a powerful tool in ensuring protection against nutritionally induced acute and chronic ill health symptoms. Hence, keeping this in mind, an attempt has been made on the incorporation of these health friendly ingredients into the base materials and subjecting them to extrusion processing technology. Out of a wide range of nutraceuticals from various natural sources, few nutraceuticals selected for the inclusion in extruded products were Gamma oryzanol from rice bran, Beta glucans extracted from barley flour; lignans concentrate from flaxseed and phenolic compound extract from cereal brans. All these selected nutraceuticals are powerful health friendly ingredients serving manifold functional properties and impart immense protection against several degenerative diseases. Incorporation of these nutraceuticals in the extruded products is an authentic and an innovative step towards the development of food products having health and medicinal benefits that can act as a powerful instrument to ensure health and longevity of life.

Keywords: Nutraceuticals; Isolation Procedures; Benefits; Incorporation in Food

Abbreviation

FIM: Foundation of Innovation Medicine; RBO: Rice Bran Oil; SDG: Secoisolariciresinol diglucoside; LDL: Low Density Lipoprotein; HDL: High Density Lipoprotein; SC-CO2: Supercritical Carbon Dioxide; MG: Mono Acyl Glycerol; FFA: Free Fatty Acids; USFDA: United States Food And Drug Administration; DAD: Diode Array Detection; HTST: High Temperature Short Time Processing

Introduction

The credit for the discovery of the term nutraceutical goes to none other than Dr. Stephen L De Felice, founder and Chairman of the Foundation of Innovation Medicine (FIM), Crawford, New Jersey. But the meaning of this term has been modified by Health Canada which describes nutraceutical as: "a product isolated or purified from foods, and generally sold in medicinal form not usually associated with foods and demonstrated to have a physiological benefit or provide protection against chronic disease". The nutraceutical sector is still more a concept than a reality. It can be considered as an evolving concept with varying definitions. Canada defines them as "Natural Health Product" Japan calls them "Foods for special Health use" whereas it is the U.S, being the leader in nutraceutical sector and processed products such as cereals, soups and beverages refers them as "Dietary Supplements". A potential nutraceutical is one which holds the promise of a particular health on medical benefit and if a potential nutraceutical has to become an established one, it has to possess sufficient clinical data to demonstrate such a benefit.

At present, nutraceuticals represent the fastest growing segment of today's food industry. They may vary from isolated nutrients, dietary supplements to genetically engineered designer foods [1]. Across the globe, US Is the largest nutraceutical market. It is expected that the market will double over the next five years. As far as Indian scenario is concerned, nutraceutical still remains an untapped opportunity in India, where nutrition is a poorly understood concept. The percentage of people who are properly nourished is very small. There is a great dearth of knowledge about healthy diet patterns and this has kept a wide range of population across the globe devoid of the utilization of several nutraceuticals from natural sources. Hence, public health authorities do strongly lay a great emphasis on the inclusion of these health friendly ingredients in various food formulations for the prevention of several acute and chronic degenerative diseases like cancer, cardiovascular diseases thus ensuring health and longevity of life [1]. The presence of these bioactive ingredients in the processed foods has become quintessential in order to satisfy the demands of health conscious consumers. Inclusion of these nutraceuticals in the extruded products is an innovative step and is untaken to enrich the functional properties of extruded products. In fact, it is the extrusion

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cooking which is reported to be not only useful for the pasteurization but also for the fortification of the nutritional or the bio functional ingredients [2]. The first selected nutraceutical to be incorporated into the extruded product is Gamma-Oryzanol extracted from rice bran. In fact, Gamma-oryzanol is one of the principal components of rice bran oil (RBO) and its content varies with the range of 1.5 – 2.9% (w/w).

Gamma oryzanol, one of the major components of rice bran oil has immense potential as a potent antioxidant, cholesterol reducing agent, tumor inhibiting agent and an efficient prohibiting agent in menopausal syndrome treatment [3]. Another nutraceutical to be included in the extruded product is beta glucans extracted from barley flour. These beta glucans are linear homopolymers of d-glucopyranosyl residues linked by beta (1→4) linkages. Out of cereals, the highest amount of beta-glucans is found in barley and oat grains. Barley has in fact a long history of food use and even in the ancient world, it was grown mostly to provide staple food for human nutrition. Barley beta glucans have shown its functional properties by improving lipid metabolism, reducing the glycaemic index and lowering plasma cholesterol [4]. In fact, these days, the addition of barley or barley constituents to foods targets mainly at increasing the content of total and soluble fiber in foods improving their physiological efficacy and providing tremendous health benefits [5]. Incorporation of barley beta glucans have been conducted in various food products like bread, muffins, pasta, noodles, salad dressing, beverages, soups and meat products [6]. There are certain documented evidences which reveal that inclusion of isolated barley beta glucans into pasta and bread lowers glycaemic index [4]. Apart from beta glucans, cereal grains are also an abundant source of phenolic compounds. These are mainly concentrated in the outer layers, that is, bran portion. In fact, these phenolic compounds are one of the strongest sources of naturally occurring antioxidants which provide resistance against free radical damage and several degenerative human diseases like cancer and cardiovascular diseases [7].

Another nutraceutical to be incorporated in the extruded product is the lignans from flaxseed which is known as a great functional food and a rich source of alpha-linolenic acid (ALA) and principal Lignan component, Secoisolariciresinol diglucoside [8]. SDG is the principal lignan present in flaxseed. The first report of SDG occurring in flaxseed was made by Bake and Klostermann. In fact, flaxseed hull which comprises about 40% of the seed is enriched in SDG [9]. All of these selected nutraceuticals perform manifold functional properties related to health. Incorporation of these health friendly ingredients into extruded products can be a powerful instrument in ensuring a safe and a healthy life.

Gamma Oryzanol

Rice bran oil (RBO) is a valuable by product of the rice processing industry. RBO extracted from the grain and inner husk of rice is rich in Gamma Oryzanol, essential Vitamin E complex, tocotrienols and β-sitosterol. The oryzanol content is about 2% in crude rice bran oil. RBO, being the richest source of Gamma oryzanol can be extracted from rice bran by solvent extraction using food grade n-hexane or by supercritical fluid extraction technology. Oryzanol, present at a level of 1-2% is that component of RBO which is used in nutraceutical, pharmaceutical and cosmoceutical preparations [10]. Gamma oryzanol was considered as a single compound, but of late, it has been revealed to be a mixture of ten phytosterols ferulate esters. Out of them, the three major components are cycloartenyl ferulate, 24-methylenecycloartanyl ferulate and campestenyl ferulate. Gamma-oryzanol has been purified and identified as having ten components: Delta [7] stigmastenyl ferulate, stigmasteryl ferulate, cycloartenyl ferulate, 24-methylene cycloartanyl ferulate, Delta [7] sitostenyl ferulate, sitosteryl ferulate, compestanyl ferulate and sitostanyl ferulate [11].

Nutraceutical Profile of Gamma Oryzanol

Gamma oryzanol was first identified in rice bran oil in 1955 by Kaneko and Tsuchita [12]. In Japan, one of the strongest contenders in nutraceutical world, gamma oryzanol has immense significance as a food as well as a medical antioxidant [13]. Rice bran contains 3000 mg/Kg gamma oryzanol and 300 mg/Kg of vitamin E. These two components have been considered as potent antioxidants and may be bioactive in the prevention of certain chronic disease [3]. Gamma oryzanol was used to decrease plasma cholesterol, platelet aggregation and Cholesterol absorption from cholesterol lowering effects. Gamma ozyzanol also has pharmacological effects such as regulation of the estrous cycle, growth accelerating action, and the ability to promote skin capillary circulation. Results from a number of animal studies have demonstrated the cholesterol lowering benefits of RBO or gamma oryzanol and identified its hypocholesterolemic activity. In one such study conducted by [14], effect of different concentrations of gamma oryzanol extracted from rice bran oil on total cholesterol levels of rats was evaluated and came out with the conclusion that serum total cholesterol increased in the control group whereas there was a decline in the oryzanol-fed groups. With this study, it was also reported that gamma oryzanol could be recommended as a natural cholesterol-lowering agent. Gamma oryzanol may be used to inhibit tumor promotion, reduce serum cholesterol levels, and to treat nerve imbalance and disorders of menopause.

The credit for the first scientific communication of the antihyperlipidemic property of rice bran oil in humans goes to Suzuki. In this study, young women were the target individuals who were subjected to a combination of rice bran oil and safflower oil (70:30). This study concluded with the fact that incorporation of rice bran oil in the other oils could prove to be a better plasma and total cholesterol lowering agent as compared to individual oils [15]. There have been several investigations in literature reported by [3] depicting the cholesterol lowering action of gamma oryzanol. In one study conducted by Sharma and Rukmini, an increased excretion of faecal total sterol and total bile acids occurred when oryzanol was added to the diet fed to the mice. Another study in which gamma oryzanol (300 mg/day) was administered for three months to hyperlipidemic individuals resulted in a decrease in low density lipoprotein cholesterol and total cholesterol was observed without producing any side effects. A single administration of gamma oryzanol (100/200 mg/Kg) to rat's models reduced the incident rate of gastric lesions. In another study conducted by Sasaki, oryzanol exhibited hypocholesterolemic activity when patients suffering from schizophrenia were administered gamma oryzanol at a dosage of 100mg three times per day for a period of 16 weeks. Administration of gamma oryzanol at a dosage rate of 300mg/day to post menopausal women led to an overall decrease in total cholesterol and LDL cholesterol without producing any side

effects study conducted on post menopausal women. In fact, several studies have demonstrated that the major ingredient responsible for the hypocholesterolemic activity of RBO is oryzanol. A significant reduction in total and plasma non-HDL cholesterol level was observed along with a decrease in cholesterol absorption in hamsters was observed when they were fed a hypercholesterolemia diet of 5% coconut oil and 0% cholesterol to which either no or 1% oryzanol was added [15-17].

Another major breakthrough in the identification of nutraceutical profile of oryzanol took place when it was reported to possess anti cancerous activity. As per Parrado, one of the significant contributions of oryzanol towards the nutraceutical properties was in the form of a water soluble oryzanol enzymatic extract. This extract, being a powerful antioxidant is extremely useful in the prevention of several chronic diseases primarily cancer, arthrosclerosis etc [3].

Extraction/Isolation of Gamma Oryzanol from Rice Bran

The nutraceutical properties of oryzanol on human health have generated global interest in developing facile methods for its separation from natural sources such as crude RBO, rice bran oil soap stock, rice bran acid oils or bio diesel residue from RBO. There are several valuable substances such as Vitamin E (α-tocopherol and tocotrienol) and gamma oryzanol in rice bran. Both these components serve manifold functions for the human body. Several methods have been devised for the extraction/isolation of gamma oryzanol and α-tocopherols from rice bran. In one such study by [18], effects of the different extraction conditions on the composition and yield of rice bran oil was evaluated using ethanol as solvent. Ethanol has in fact gained immense attention as potential solvents for vegetable oils. The extraction conditions were ethanol hydration (0-24% of water), temperature of extraction (69-90°C) and ethanol: rice bran mass ratio. This study yielded 1527-4164 mg of oryzanol per Kg of fresh rice bran. It was also concluded with this study that the levels of the nutraceutical compounds can be controlled by the process temperature and proper selection of solvent.

Various investigations have been performed to study the effect of different processing steps of refining on the retention or the recovery of gamma oryzanol. Out of all these studies, it was mainly the degumming and de waxing of crude RBO which removed only 1.1 and 5.9% of oryzanol while the alkali treatment removed 93.0 to 94.6% of oryzanol from crude rice bran oil [10]. Another study conducted by [19] evaluated the efficiency of SC-CO2 method for extracting lipids and gamma oryzanol from rice bran in comparison with conventional method of solvent extraction. This study resulted in a much better extraction yield of oryzanol. A major isolation process for gamma oryzanol from rice bran oil involving a two step crystallization process was developed by [20]. In the first crystallization step, oryzanol was concentrated in the liquid phase along with free fatty acid (FFA), mono acyl glycerol (MG), tocols and phytosterols whereas the solid phase contained mainly triacyl glycerol (TG) and steryl esters. This was followed by second crystallization step where the oryzanol rich product was kept at room temperature for 24 hrs. This method yielded oryzanol with purity levels of 93-95%. Apart from this, various solvents like isopropanol and hexane were evaluated by Weicheng. As extraction solvents for the isolation of vitamin E and oryzanol from stabilized rice bran and came out with the concept of using isopropanol as a promising solvent for the extraction of oil from stabilized bran. An attempt was also made in order to compare the efficiency of different organic solvents for the extraction of oryzanol from rice bran [10]. Of late, owing to health and environmental aspects more stress has been laid on the usage of alternative solvents.

Inclusion of Gamma Oryzanol in various food products

Rice bran oil (RBO) and its major components are non toxic and non carcinogenic. As a functional ingredient oryzanol has not been thoroughly evaluated but it has shown its mettle as a potent antioxidant, cholesterol lowering agent and tumor prohibiting agent as well [3]. Gamma oryzanol has a great potential in providing various functional properties having huge antioxidant and cholesterol lowering effects. Since oryzanol is a heat labile component, therefore in order to obtain its functional benefits a few methodologies need to be adopted to protect it against oxidative degradation which is one of the principle factors leading to its poor availability and low absorption. One of the best possible methods to acquire the benefits of oryzanol is the encapsulation technology which works by protecting the entrapped ingredient and enhancing the shelf life thereby increasing the solubility followed by enhanced bioavailability. One of such an attempts involved the encapsulation of oryzanol using Chitosan [21]. Optimization of coating conditions including Chitosan concentration and coating time was done and in vitro release and bioavailability of gamma oryzanol loaded calcium pectinate micro particles, reinforced with Chitosan was evaluated in this particular study. There was a remarkable achievement in the bioavailability of oryzanol following oral administration after undergoing the encapsulation process. Apart from this, solid liquid nanoparticles have achieved a lot of attention as colloidal dry carriers for effective controlled release and enhancing the stability of drugs. Gamma oryzanol was also incorporated into one such solid nanoparticle, glycerol behenate (Compritol 888 ATO) at 5 and 10% (w/w) of lipid phase [22]. Another micro encapsulation study of gamma oryzanol involved the usage of emulsions like agar and waxy corn starch as a coating material and one of Tween 20, Tween 80 as an emulsifier. This study analyzed the anti oxidative activity and structural stability of microencapsulated oryzanol in heat treated lards and came out with this conclusion that this technique could be a great tool for protecting oryzanol from heat related processing [13].

Owing to is functional properties, gamma oryzanol has a great potential in providing various functional foods having huge antioxidant and cholesterol lowering effects. Since, it a heat labile component and is prone to thermal degradation, there are few studies which report about the fate of oryzanol during high processing temperature as in extrusion cooking. One of such studies conducted by [2] revealed that the extruded and puffed pre-germinated brown rice contained more oryzanol than the UN extruded polished rice, but as extrusion temperature approached 170°C, oryzanol began to decrease.

Beta Glucans

Beta glucans (1→3, 1→4) are the predominant components of cell walls of cereal grains such as barley and oats and are mainly concentrated in the internal aleurone and sub-aleurone endosperm cell walls [5,6]. In barley, the level of beta glucans varies from 5-11%.

The levels of beta glucans can vary dramatically between varieties, but usually range from 2 to 6% dry weight [5]. An increase in beta glucans is seen if barley is grown in hot and dry conditions [4]. As per FDA, 2001, it is claimed that foods containing 0.75 g of beta glucans or 1.7 g of soluble fiber per serving can reduce the risk of heart disease [23].

β-glucans as potent nutraceuticals

As far as the functionality is concerned, the acceptance of β-glucans has gained immense popularity and this has encouraged the consumption of various cereal based goods fortified with concentrates and isolates of β-glucans. A health claim was approved by the USFDA (1997) for the use of oat-based foods for lowering the risk of cardiovascular diseases. A review by [24] reported that oat-bran, being a great source of beta glucans was recommended at a dosage of 3g on daily basis for cholesterol lowering purpose and 0.75g of β-glucans per serving. These major fiber constituents of barley have shown implications in reducing the glycaemic index, improving plasma cholesterol. A sharp decline in the post prandial blood glucose level was observed upon the consumption of oat porridge enriched with isolated β-glucans [5].

Some studies were also conducted to evaluate the effectiveness of beta glucans against several infections. Beta glucans extracted from oats proved quite effective in providing resistance against infections produced by Staphylococcus aurous. The administration of beta glucans immensely enhanced the activity of phagocytes thereby increasing the resistance. The potential of beta glucans was also evaluated for the prevention of colonic diseases, ulcerative colitis and colon cancer [6]. The total and the LDL cholesterol in both men and women can be lowered by the consumption of barley flakes, pearled barley in cookie bars, hot cereal etc [5].

Extraction/Isolation of beta glucans from cereal grains

It is the localization of beta glucans in various grains which influence the isolation and purification processes for the production of beta glucans fractions. In fact, the wide spread acceptance of the inclusion of beta glucans in various fortified cereals have guided to obtain several fractions of this very nutraceutical by several processes such as sieving, air classification processes or by solvent-extraction protocols [24]. The various extractions methods for β-glucans can be broadly categorized from traditional methods to simplified and less expensive methods. It is found that beta glucans extracted by traditional methods has been proven to be successful in reducing blood cholesterol and glucose in human subjects. Several studies involve the traditional methods which involve three major steps: (a) Inactivation of the endogenous enzymes in the grain. (b) Extractions with water or alkali solutions. (c) Using hydrolytic enzymes to remove protein and starch. (d) Precipitation of β-glucans from purified solutions followed by freeze-drying of the solutions [4]. In one of the most convincing studies related to beta glucan extraction, it was found that solvent system comprising 4% sodium hydroxide proved to be the most efficient solvent for beta glucan extraction and purification from barley brans [25].

Incorporation of beta glucans into different food stuffs

Beta-glucans from barley is considered as an important functional ingredient to reduce glycaemic response and lowering plasma cholesterol. Due to its immense nutraceutical properties, efforts are being made on wide spread basis to isolate and purify it from its natural sources like barley and oats and then its inclusion in various foods. There have been successful incorporation of several fractions of this very nutraceutical or its purified form into various products like pasta, noodles and breakfast cereals and dairy products as well [4,24]. Addition of 10% oat β-glucan to noodles significantly enhanced the soluble dietary fiber content as well as the total dietary fiber content. Pearled barley, which is enriched with beta glucans fractions after undergoing further milling-sieving process, was incorporated into durum wheat semolina and the pasta so produced exhibited good cooking quality with respect to its firmness and cooking loss [4]. Development of high fiber white bread to inhibit the incidence of various diseases primarily the coronary heart disease has led to the increased rate of dietary fiber intake. One of such an attempts was made by [5] which involved the inclusion of Glucagel, a rich β-glucan isolate from barley into the traditional white bread to raise its nutritional profile. In this study, Glucagel was incorporated into bread at inclusion rates of 2.5 and 5%. A noticeable improvement in the content of dietary fiber can be made by the inclusion of barley into foods generally made from white bread flour.

Lignans

Lignans were first defined in 1936 as phenylpropanoids dimmers where two phenyl propane units are linked by the central carbon (C8) of their side chains [26]. Flaxseed has been proven to be the richest source of principal lignan component, SDG (Secoisolariciresinol digluco side). SDG is present in flaxseed and defatted flaxseed powder to a level of 0.2-0.3% and around 1.5% respectively. Lignans are found in a wide variety of foods. These are the most important type of phytoestrogens present in the western diet. There are numerous evidences which indicate that lignans and their metabolites may be protective against certain chronic diseases. Due to immense pharmacological potential of lignans, flaxseed has gained immense importance. Flaxseed has great therapeutic effects as an anti cancerous agent, as an antioxidant, antibacterial, antiviral as well as an anti-inflammatory agent [27].

Nutraceutical Profile of Lignans

Lignans have antiviral, antifungal and anti-bacterial properties. A report on flaxseed by [9] stated that it is the SDG, principal content of lignans and omega-3 fatty acids which are responsible for flaxseed's growing popularity. Touill and observed a significant reduction in the risk of postmenopausal breast cancers in French women was observed with higher dietary intake of flaxseeds. Flaxseed and its lignan content impart immense protection against cardiovascular disease. Flaxseed can protect against atherosclerotic plaque deposition in carotid arteries and show anti-atherosclerotic effects in the aorta. Some studies have also indicated that administration of plant lignans delay the growth of mammary cancer. Apart from this, hepatoprotective action of flaxseed has been reported by Baiker. As per [28], a big contribution of the anti cancerous activity of flaxseed may be given to these lignans which possess extreme antioxidant activity. In one study, it was reported that with the daily consumption of 30g of flaxseed, there was a remarkable decrease in the proliferation of the prostate cancerous cells. As per Diane H. Morris, lignans, one of the principal anti cancerous agents in flaxseeds help in providing immense resistance against breast cancer by influencing estrogen metabolism.

There are several clinical evidences supporting this fact. In one such study, a diet supplemented with 10 g or 25 g of milled flax for few weeks was fed to women suffering from menopause. This resulted in an increase in the excretion of 2-hydroxyestrone in their urine other than 16α hydroxyestrone which enhances the estrogen activity and is responsible for the proliferation of cells leading to tumor production. Apart from anti cancerous activity, flaxseeds have been reported to be helpful in maintaining plasma glucose equilibrium. One of such studies was depicted by [28] conducted on rats revealed that when rats were fed 22mg of SDG/ Kg and treated with diabetes- promoting chemical streptozotocin, there was a noticeable decrease in type 1 diabetes as compared to the control group.

Lignans also provided protection when purified SDG was used in the mouse model. It is because of the presence of these lignans, flaxseed has gained immense importance with respect to its pharmacological potential. One of the pivotal studies determining the nutraceutical potential of flaxseed was conducted on rats by [27] which evaluated the cardio protective activity of flaxseed lignan concentrate extracted from flaxseed in isoprenaline induced myocardial necrons. This concluded with the emergence of cardio protective effect of flaxseed lignan concentrate in isoprenaline induced cardio toxicity.

Extraction of Lignans from flaxseed

There is an abundant literature available for the extraction of lignans in flaxseed using many extraction solvents. Determination of Secoisolariciresinol diglucoside in flaxseed oil was done by a high performance liquid chromatographic separation technique using diode array detection (DAD) system [8]. In this analytical study, sample extraction was done with methanol/water (80:20, v/v) followed by sample purification and analysis by HPLC for the determination of SDG. Since a wide variety of extraction solvents were employed for the isolation of lignans from flaxseed. The most important breakthrough in this field involved the optimization of different ethanol-water extraction variable conditions by [29]. The three independent variables studies were: ethanol concentration (%), extraction temperature (C°) and extra time (h) were evaluated for the acquired ratio of lignans. It was concluded from the study that the best extraction conditions were ethanol concentration (70%), extraction time (28 hrs) and extraction temperature (40°C) were the optimal conditions for extracting lignans. Another method for the extraction of these phytonutrients was formulated in the form of a patent by Westcott et al. This extraction procedure involved the solvent hexane for defeating of flaxseed powder followed by extraction with either aqueous methanol or ethanol (55-75% v/v) yielding a crude extract which after undergoing an alkaline treatment with (IN NaOH/KOH) released free SDG [26].

Incorporation of Flaxseed Lignans in various food formulations

Addition of components with nutritional and functional properties to various food products is essential for the production of functional foods imparting several health benefits. The utilization of flaxseed or flaxseed meal has gained tremendous increase in various cereal based products like bread, muffins and other bakery products. Since, SDG is present abundantly is flaxseed hull, extracts of flaxseed hull blended with barley hull extracts rich in phenolic compounds were included in Chinese steamed bread to enhance its phytochemical content of steamed bread [9].

Phenolic Compounds from Cereal Brans

Phenolic compounds are aromatic secondary plant metabolic products and have wide spread distribution throughout the plant kingdom and exhibit multiple biological effects primarily antioxidant effects as well as antimicrobial effects [30]. Wheat bran is composed of different types of phenolic antioxidant compounds such as ferulic, vanillic, caffeic, coumaric and syringic acids [31]. The various beneficial effects resulting from the consumption of various whole grains is attributed to these phenols. High phenol consumption has been correlated with reduced risk cardiovascular disease and cancers.

Nutraceutical Profile of Phenolic Compounds

The various chemo protective and antioxidant properties of cereal bran rich diets are attributed to these phenolic compounds. Phenolic acids or compounds are unique set of phytochemicals present in several cereal grains. There are various types of phenolic compounds like ferulic, vanillic, p-coumaric, caffeic and cholorogenic acid and these are mainly concentrated in the bran layer of kernels of cereals. These plant phenolics exhibit tremendous beneficial effects. These are naturally occurring products are commonly prevalent in several cereal grains, higher concentrations being in outer bran layers. As per Andresen, these phenolic compounds possess strong antioxidant activity against free radicals and other reactive oxygen species which are major cause of chronic human diseases like cancer and cardiovascular diseases. Out of various cereal brans, wheat bran extract having higher concentration of phenolic acids have proven to exhibit strong antioxidant activity than other fractions of wheat. In fact, wheat bran extracts comprise of several phenolic acids like vanillic, p-coumaric acid but the major fraction is of ferulic acid [7]. According to Bonoli, phenols are associated with the beneficial effects derived from the consumption of whole grains, fruits and vegetables. These compounds have both in vitro and in vivo antioxidant activities linked with their ability to scavenge free radicals, break radical chain reactions. Numerous studies have been conducted to ascertain that the phenolic compounds found in the insoluble bound fraction of whole grains provide immense protection against colon cancer, thus exhibiting anti proliferative activity. One of such studies involved the evaluation of the anti proliferative activity of phenolic acids/ extracts from the insoluble bound fraction of two commercial blends of whole wheat and their refined flours using the Methylene blue stain assay. It was mainly p-coumaric acid, ferulic acid and caffeic acid which were found to be responsible for inhibiting the proliferation of Caco-2 cells. Another study reporting the anti proliferative activity of phenolic acids/extracts from brown rice was conducted by Hudson. This work revealed that caffeic acid, methoxycinnamic acid, ferulic acid and sinapic acid inhibited the proliferation of colon cell lines. Investigations were carried out in order to identify an inverse relation between phenolic extract (whole grains) and colorectal cancer. In one such investigation, 490,000 subjects aged 50-71 yrs were selected and their diet was evaluated with a self-administered food- frequency questionnaire. During the five year follow up, 2974 incidences of colorectal cancer cases were identified [32].

Extraction of phenolic compounds from wheat bran

The antioxidant activity of wheat and other cereal grains has been attributed to their phenolic acid content to a considerable content.

In fact, these are the extracts from wheat bran which possess high concentration of phenolic acids exhibiting ample antioxidant activity. Several studies have been carried out to extract these phenolic acids from various cereal brans primarily wheat bran and characterizing them through various analytical techniques. In one study, four different wheat brans were extracted using hexane and analyzed for phenolic acids using Folin-Ciocalteu method and HPLC followed by evaluation of their antioxidant activities. The wheat bran bearing red color showed a higher phenolic content as compared to white bran. The phenolic acids so detected were ferulic acid, vanillic acid and syringic acids [7]. Another method involving the ultrasound assisted extraction of phenolic compounds from wheat bran using ethanol as the extracting solvent. The solvent concentration being 64%, extraction temperature being 60°C, and extraction time being 25 minutes were concluded as the optimized extracting parameters [33].

A study conducted by [31] analyzed the content of antioxidant levels in corn germ wheat grain and wheat bran as well by using the traditional solvent extraction and microwave assisted solvent extraction method. Solvent extraction method was done by using three different solvents like acetone, hexane and methanol at 60°C while as methanol was the only solvent used for the extraction in microwave assisted method at four different temperatures, 60, 80, 100 and 120°C. This study revealed that with each increase in temperature there was a significant improvement in antioxidant and phenolic content for both wheat bran and corn grain as well.

Inclusion of phenolic compounds in various foods products

As per Peterson, 1995, several cereals like barley, oats are armed with endogenous antioxidant compounds. These endogenous phenolics provide some protection but extrusion processing may damage these compounds. According to [34], phenolic compounds derived from natural sources proved as great antioxidants in extruded foods and imparted immense protection against lipid oxidation which is one of the major factors leading to food deterioration. In this particular study several phenolic compounds like benzoin, catechin, chlorogenic acid and ferulic acid were mixed with rolled oats. Addition of these natural antioxidants prior to extrusion resulted in more stable products, but the total phenolic content of rolled oats decreased by 24-26% but with a significant retardation in hex anal formation and peroxide value.

Extrusion is a high temperature short time processing technology. Much of the work needs to be done in future to analyze the fate of phenolic compounds during extrusion [34]. As per Borelli, during the manufacturing process of pasta, the presence of oxygen, water and heat treatment induces the oxidative degradation of certain antioxidants like carotenoids, pigments and polyphenols. In fact, this study noticed the very fact that during extrusion processing in pasta, it is the oxidizing reactions triggered by water, oxygen and heat which lead to a reduction in phenolic acids [35].

Conclusion

There are several methods which are used in the processing of this health friendly ingredients. Out of the fastest growing segments in the food industry, extrusion technology plays a pivotal role in the processing of these nutraceuticals. The concept of extrusion is not a new one. It was initially applied in the plastic processing area and now it has been exploited as great tool with technical solution available for other field's primarily pharmaceutical industry. As per Faraj, extrusion of cereal-based products has advantages over other common processing methods because of low cost, speed, high productivity, versatility and energy savings as well [36]. It is a modern high temperature short time (HTST) processing technology resulting in a beneficial heat treatment of foods. Incorporation of these selected nutraceuticals in the base materials and subjecting them to extrusion processing is an authentic step towards the development of food products having manifold functional properties.

References

1. Andlauer W and Furst P. Nutraceuticals: a piece of history, present status and outlook. Food Research International. 2002; 35: 171-176.
2. Ohtsubo K, Suzuki k, Yasui y, Kasumi t. Bio-functional components in the processed pre-germinated brown rice by a twin-screw extruder. Journal of Food Composition and Analysis. 2005; 18: 303-316.
3. Gutierrez M A. Quality Evaluation of Cheddar Cheese containing Gamma-oryzanol (Dissertation). Louisiana State University, 2004.
4. Izydorczyk M S and Dexter J E. Barley?-glucans and arabinoxylans: Molecules structure, Physiochemical Properties, and uses in food products – a Review. Food Research International. 2008; 41: 850-868.
5. Brennan C S and Cleary L J. The potential use of cereal (1?3, 1?4)-ß-D-glucans as functional food ingredients. Journal of Cereal Science. 2005; 92, 1-13.
6. Havrlentova M, Petrulakova Z, Burgarova A, Gago F, Gago F, Hlinkova A et al. Cereal ?-glucans and their significance for the preparation of Functional Foods – A Review. Journal of Food Science. 2011; 29: 1-14.
7. Kyung-Hee Kim, Rong Tsao, Raymond Yang, Steve W Cui. Phenolic acid Profiles and antioxidant activities of wheat bran extracts and the effect of hydrolysis condition. Food Chem. 2006; 466-473.
8. Elisabetta Bravi, Giuseppe Perretti, Ombretta Marconi, Elisa Patrizi, Paolo Fantozzi. Secoisolariciresinol diglucoside determination in flaxseed (Linum usitatissimum L.) oil and application to a shelf life study. Food Chemistry. 2011; 8: 1553-1558.
9. HaO M and Beta T. Development of Chinese Steamed bread enriched in bio-active compounds from barley hull and flaxseed hull extracts. Food Chemistry. 2012; 133: 1320-1325.
10. Patel M and Naik S N. Gamma-oryzanol from rice bran oil. Journal of Scientific and Industrial Research. 2004; 63: 569-578.
11. Xu Z1, Godber JS . Purification and identification of components of gamma-oryzanol in rice bran Oil. J Agric Food Chem. 1999; 47: 2724-2728.
12. Azrina A and Maznah. Extraction and Determination of oryzanol in rice bran of mixed Herbarium UKMB; AZ 6807: MR 185, AZ 6808: MR 211, AZ 6809: MR 29. ASEAN Food Journal. 2008; 15: 89-96.
13. Mun-Hee Suh Sang-Ho Yoo, Hyeon Gyu Lee. Antioxidative activity and structural stability of microencapsulatedY-oryzanol in heat treated lards. Foods chemistry. 2007; 100: 1065-1070.
14. Rahman S N A E. Extraction and Separation of –oryzanol from rice bran oil by HPLC and studying its effect on rats fed on a high cholesterol diet. International Journal of Food, Nutrition and Public Health. 2010; 3: 119-132.
15. Cicero, AFG and Derosa G. Rice Bran and its main components: Potential Role in the Management of Coronary Risk factors. Current Topics in Nutraceutical Research. New Century Health Publishers. 2005; 3: 29-46.
16. Pramote Khuwijitjaru, Nichchima Taengtieng, Suchaya Changprasit. Degradation of Gamma oryzanol in Rice bran oil during Heating: An Analysis Using Derivative UK Spectrophotometry pp. 154-165.
17. Gillispie M S. Metabolic aspects of Oryzanol in Rats [Dissertation]. Louisiana State University, 2003.

18. Ramon Oliverira, Vinicius Oliveira, Keila Kazue Aracava, Christianne Elisabete da Costa Rodrigues. Effects of the extraction conditions in the yield and composition of rice bran oil extracted with ethanol – A response surface approach. Food and Bio products processing. 2012; 90: 22-31.

19. Xu Z and Godber J S. Comparison of supercritical Fluid and Solvent Extraction Methods in extracting?-oryzanol from Rice bran. Journal of the American Oil Chemists? Society. 2000; 77: 547-551

20. Zullaikah S1, Melwita E, Ju YH . Isolation of oryzanol from crude rice bran oil. Bioresour Technol. 2009; 100: 299-302.

21. Kim JS1, Lee JS, Chang PS, Lee HG . Optimization, in vitro release and bioavailability of gamma-oryzanol-loaded calcium pectinate microparticles reinforced with chitosan. N Biotechnol. 2010; 27: 368-373.

22. Seetapan N1, Bejrapha P, Srinuanchai W, Ruktanonchai UR . Rheological and morphological characterizations on physical stability of gamma-oryzanol-loaded solid lipid nanoparticles (SLNs). Micron. 2010; 41: 51-58.

23. Choo C L and Aziz N A A. Effects of banana flour and?-glucan on the nutritional and sensory evaluation of noodles. Food chemistry. 2010; 119: 34-40.

24. Lazaridou A and Biliaderis C G. Molecular aspects of cereal ß-glucan functionality: Physical properties, technological applications and physiological effects. Journal of Cereal Science. 2007; 46: 101-118.

25. Bhatty R.S. Extraction and Enrichment of (1?73) (1?4) – ?-D-Glucan from barley and oat brans. Cereal Chemistry.1993; 70: 73-77.

26. Sainvitu P, Nott k, Richard G, Blecker C, Jerome C, Wathelet JP, et al. Structure, Properties and obtention routes of flaxseed lignan secoisolariciresinol: a review. Biotechnical. Agron. Soc. Environ. 2012; 16: 115-124.

27. Zanwar AA1, Hegde MV, Bodhankar SL . Cardioprotective activity of flax lignan concentrate extracted from seeds of Linum usitatissimum in isoprenalin induced myocardial necrosis in rats. Interdiscip Toxicol. 2011; 4: 90-97.

28. Toure A and Xueming Xu. Flaxseed Lignans: Source, Biosynthesis, Metabolism, Antioxidant Activity, Bio- Active Components, and Health Benefits. Comprehensive Reviews in Food Sciences and Food Safety. Institute of Food Technologists. 2010; 9: 261- 269.

29. Zhen-Shan Zhang, Dong Li, Li- Jun Wang, Necati Ozkan, Xiao Dong Chen, Zhi- Huai Mao et al. Optimization of ethanol-water extraction of lignans from flaxseed. Separation and Purification Technology. 2007; 57: 17-24.

30. Charalampos Proestos, Michael Komaitis. Application of microwave-assisted extraction to the fast extraction of plant phenolic compounds. LWT-Food Science Technology. 2008; 41: 652-659.

31. Oufnac D S. Determination of antioxidant capacity in corn germ, wheat germ and wheat bran using solvent and microwave-assisted solvent extraction [dissertation]. Nicholls state university, 2006.

32. Okarter N. Whole Grain Consumption and Health of the Lower Gastrointestinal Tract: A Focus on Insoluble- Bound Phenolic Compounds. Dr. Jaouad Bouayed. Nutrition, Well Being and Health. In Tech. 2012; 49-72.

33. Wang J, Sun B, Cao Y, Tian Y, Li X. Optimization of ultrasound-assisted extraction of phenolic compound from wheat bran. Food Chemistry. 2008; 106: 804-810.

34. Viscidi K A, Dougherty M P, Briggs J and Camire M E. Complex phenolic compounds reduce lipid oxidation in extruded oat cereals. Department of Food Science of Human Nutrition. 2004; 37: 789-796.

35. Fares C, Platani C, Baiano A, Menga V. Effects of processing and cooking on phenolic acid profile and antioxidant capacity of durum wheat pasta enriched with debranning factions of wheat. Food Chemistry. 2010; 119: 1023-1029.

36. Zhang M, Bai X, Zhang Z. Extrusion process improves the functioning of soluble dietary fiber in oat bran. Journal of Cereal Science. 2011; 54: 98-103.

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