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Status and Market Potential of Oats-Based Fermented Milk Products

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Abstract

Fermented milk is considered best career of probiotics with its nutritive composition and natural buffering capacity. Positive health effects of fermented foods and especially of those with probiotic microorganisms are reported in many recent publications. Most common food matrices used to deliver probiotic are dairy-based products; plant-based foods, dried formulations and blended products. In connection with these health effects of probiotics ingredients such as WPC, WPI, and Na-Cn improve nutritional values and biological effects of yogurt on health. It could be interpreted that nutritional components from milk, oat (Avena sativa L.) and probiotic bacteria could be a novel concept of designing a functional food. Limited reports are available with regards to the development of fermented product using oat components and milk to produce yoghurt-like products.

Keywords: *Oats, fermented milks, market, health benefits, β-glucan*

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INTRODUCTION

Fermentation is a biochemical process in which the primary food matrix is modified by microorganisms and their enzymes. For cereals deficient in some basic components (e.g., essential amino acids), fermentation can provide a simple and economical method for improving nutritional value, sensory properties, better preservation and functional attributes. In addition, inclusion of probiotics or live microorganisms can increase the nutritional and therapeutic value of fermented food products [1].

Present demand for functional food in the developed countries of the world is in exponential phase, because it relates to the prevention of widespread diseases such as cardiovascular, high blood pressure, diabetes, obesity, etc. Therefore, the development, production and presentation of new products with biologically active substances for consumers' choice are especially important. Oats nowadays are acknowledged for their healthy properties in functional and fermented milk products category. Oat protein is a good quality protein. They are rich in antioxidants and β-glucan, a water-soluble dietary fiber which exhibits cholesterol lowering properties. Many oats-based milk alternatives with a mild taste and flavour are known and getting consumed globally. It may replace dairy milk partly and or fully in a range of applications. Though segment of milk-based oats products are limited and mainly in research laboratories but have exhibited its premium importance with additional benefits.

OAT (*Avena sativa*): GENERAL ASPECTS

Oat (*Avena sativa*) is a species of cereal grain and the seed of this plant. The main oat species include *Avena abyssinica*, *A. byzantina*, *A. fatua*, *A. nuda*, *A. sativa* and *A. strigosa*. *Avena sativa* making up more than 75% of the world's cultivars is by far the most popular cultivated species [2]. The first evidence of oats was found in Egypt and among the lake dwellers of ancient Switzerland. Nowadays, oats are grown as a multipurpose crop throughout the world. Agronomically, oat has been used as a nurse crop to establish small seeded legumes and grasses and are major pasture crops in many of the cattle raising areas of the world including India. However, it has multiple uses in baby foods, breakfast cereals, and animal feed. Oats rank around sixth in world cereal production

statistics, following wheat, maize, rice, barley and sorghum. The European Union was ranked first amongst the world oat producers during the year 2013 with 75.81 million metric tons oats per year followed by Russia (40.27 mmt/year), Canada (26.8 mmt/year), Australia (10.5 mmt/year) and United States (9.29 mmt/year) contributing to 2.08 mmt of oat production in 2013 throughout the world. Among all, Sweden and Finland are the two major exporting countries [3]. In India, oat is a crop of minor importance and is grown mostly for the fodder purpose. It is grown in Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, Himachal Pradesh, Rajasthan, Bihar, Gujarat, Andhra Pradesh and Tamil Nadu [4].

Although oats have been part of the human diet for centuries, the principal use of oats has been as a feed grain. Their superior nutritional content and ready availability made oats the feed grain of choice until the mid-1900s. Oats usage in human foods has increased as information on oats' beneficial nutritional properties has come to light. In this context, a polysaccharide β-glucan is one of the most effective ingredients for foodstuffs which can be directly attributed to the cholesterol lowering effect. β-glucans are non-digestible polysaccharides, which contain D-glucose monomers as structural components and are linked with β-glycosidic bonds. In nature, β-glucans naturally occurs as cellulose in plants, the bran of cereal grains (oats, barley), the cell wall of yeast, certain fungi, mushrooms and bacteria. In 1997, the U.S. Food and Drug Administration approved a health claim for the reduction of heart disease risk with a daily consumption of 3 g of β-glucan (a minimum of 0.75 g per serving) originating from oat-formulated products that include oat bran, rolled oats and whole oat flour. In 2010, the European Food Safety Authority has also authorized health claims according to which oat β-glucan ingestion leads to reduction of blood plasma cholesterol concentrations, which is a major risk factor for the development of coronary heart disease and the recommended daily intake was 3 g oat β-glucan and the claim can be used for the food products (portion) containing at least 1 g [5].

NUTRITIONAL COMPOSITION OF OAT

Oat products are well accepted in human nutrition. Recently, nutritional and health benefits of oats as whole grains and its fraction for development of value-added food products have been extensively reviewed [6]. Proximate composition of oat is given in Table 1. Apart from major nutrients, oat contains 50 mg calcium, 380 mg phosphorus and 3.8 mg iron per 100 g. It also contains 0.98 mg thiamine, 1.1 mg niacin and 0.16 mg riboflavin per 100 g. It provides about 374 kcal calories per 100 g [7]. It contains relatively high concentrations of protein, lipids, energy in the form of carbohydrate and oil, vitamins, antioxidants, phenolic compounds and minerals [8]. Oat proteins are a rich source of several essential amino acids such as lysine, leucine, isoleucine and valine in contrast to other cereals. However, oat flour is lower in both methionine and threonine as compared to corn. In contrast to other cereals, such as barley, wheat and rye, oats are now on the verge of being officially recognized as safe for individuals with gluten intolerance. This is due to the fact that oat proteins have a structure different from those in cereals.

Table 1: *Proximate Composition of Oat Flour and Bran [9].*

Constituent	Whole grain oat flour	Oat bran
Protein (%)	15–17	15–18
Starch and sugars (%)	59–70	10–50
Fat (%)	4–9	5–10
Total dietary fibre (%)	5–13	10–40
β-Glucan (%)	2–6	5–20

There are many types of dietary fibers present in oats—cellulose, arabinoxylans and β-glucans. Cellulose is a (1→4)-β-D-glucan, where the β-glucoside bond makes the cellulose indigestible and insoluble. The mixed linked (1→3), (1→4)-β-D-glucan are composed of β (1→4) linked glucose units with a single β (1→3) linked glucose every two or three units [10]. Phenolic compounds with antioxidant activity, such as phytic acids, flavonoids and derivatives of cinnamic and benzoic acids have been identified in oats, but little quantitative data are available. These antioxidants are concentrated in the outer layers of the kernel and help to maintain the stability of processed oat products, as well as to stabilize oils and fats against rancidity [8].

BENEFICIAL HEALTH EFFECTS OF OATS

Several epidemiological or observational studies have reported that diets rich in whole grains may protect against hypertension [11],

cardiovascular disease [12], and type 2 diabetes [13]. De Groot *et al*. [14] were the first to report cholesterol reduction in humans. Davidson *et al*. [15] reported that total cholesterol and density lipoprotein (LDL) cholesterol of men and women were significantly lower as compared to a farina control after subjects consumed 28–84 g (1–3 oz) of oat meal or oat bran for six weeks [16]. A purified oat isolate providing 5.8 g of β-glucan per day significantly lowered serum total and LDL cholesterol of mildly hypercholesterolemic subjects [17]. Consumption of oat milk providing 3.8 g of β-glucan per day (no soluble fiber) for five weeks lowered LDL cholesterol by 6% in moderately hypercholesterolemic men [18]. Many studies have investigated the effectiveness of soluble fibers in improving glucose tolerance in normal and/or type 2 diabetic subjects depending upon age, gender and level of obesity of subject. Soluble fiber and or from oats have generally been reported to improve glucose and insulin responses [18]. Short chain fatty acids (SCFA) metabolic end products in particular acetic, propionic and butyric acids, are helpful in maintaining gut function and enabled gut modulation primarily by lowering the intracolonic pH [19].

Many observational and clinical intervention studies suggested that oats are effective in lowering blood cholesterol levels. The U.S. Food and Drug Administration [20] has allowed a health claim for oats and soluble fibers from oats. The recommended effective level of consumption is a minimum of at least 0.75 g of the soluble fiber β-glucan per serving and a daily intake of at least 3 g (four servings).

REASONS FOR PREFERRING OATS FOR LACTOFERMENTATION

The beneficial lactic acid bacteria acts on the starches and sugars in the oats, producing lactic acid and helping in breaking down the tough structure of the oats. Fermenting with liquid oats really amplifies the flavor and makes for a much more interesting bowl of oats. There is a nutritional benefit also as soaking grains reduces their phytic acid, which can make them easier to digest. Breaking down phytic acid is actually better as a whole phytic acid blocks mineral absorption in the intestines and after fermentation; this helps body to absorb minerals properly [21].

FERMENTED FOODS FROM OAT-DERIVED INGREDIENTS

Increasing awareness among consumers about the health benefits of high fiber diets has emphasized the importance of developing enriched fiber food products. Cereals contain biologically active ingredients such as dietary and functional fibers, contributing to about 50% of the fiber intake in the western countries [22]. Cereals are one of the most suitable substrates for the development of foods containing probiotic microorganisms (in most cases lactic acid bacteria or bifidobacteria) and may also have prebiotic properties due to the presence of nondigestible components of cereal matrix [23]. During cereal fermentations several volatile compounds are formed which contribute to a complex blend of flavours. The presence of aromas such as diacetyl, acetic acid and butyric acid make fermented cereal-based products more appealing [24]. Among the cereals, the interest in oats as a food ingredient has increased in recent years due to different dietary fiber types, such as mixed-linked β-glucan, arabinoxylans and cellulose, in addition to relatively high levels of protein, lipids (unsaturated fatty acids), vitamins, antioxidants and phenolic compounds [22]. Considering positive physiological effects of oat consumption, development of food products from its fermentation have received considerable attention.

OATS GLOBAL MARKET

As per Technavio's market research analyst predicts the global oatmeal market to grow at a slow but modest CAGR of more than 1% by 2020. In terms of geography, Europe will be the largest market for oatmeal during this forecast period. This region will envisaged to account for more than 36% of the total market share by 2020 due to concern for healthcare and for a healthy lifestyle. The global market for oatmeal is a moderately fragmented market. Oatmeal market comprises of whole oat groats, steel cut oats, Scottish oats, regular rolled oats, quick rolled oats and instant rolled oats. The leading vendors in the oats market are Abbott Nutrition, General Mills, Kellogg's, Nestle, Quaker Oats and the Weetabix Food Company. Archer Daniels Midland, Armenia Feed, Associated

British Foods, Cargill, Cereal Ingredients, Limagrain, Redeye Feed, Thinkthin and others are prominently following the same track [25].

OATS MARKET IN INDIA

The market of oat-based products is growing rapidly and consumers prefer it as breakfast cereals. This showed now 38% growth, which now constitute 26% of the Rs. 720 Cr ($120 m) [26]. The market of oats-based breakfast is now getting stronger based on increasing consumer awareness. Many food companies are trying to establish their foot in Indian soil such as Saffloa, Kellogg's, Nestle and Quaker Oats, etc. [27].

PRODUCTS PORTFOLIO OF OATS IN COMBINATION WITH MILK FERMENTATION

'Oatrim', a US-based brand, contains 5–10% β-glucan and is made from oat bran or oat flour treated with thermostable α-amylase. It also contains small amounts of amylodextrins, lipid, protein and minerals. Beta-glucan contained in the 'trim' preparations lower blood cholesterol and glucose concentrations [28]. Recently, a very successful method has been developed for the extraction of β-glucan from oat flour and the addition of this water soluble fiber to dairy products [29]. Because of their ability to increase viscosity of aqueous solutions, β-glucans can be used as thickening agents or as fat mimetics in the formulation of reduced calorie foods. They can control food texture and have been used to replace all or part of the fats in dairy, meat, and bakery products. C-trim is used in the preparation of a low-fat cheddar cheese [30].

One of the largest areas for potential use of β-glucan is in the dairy industry. Incorporation of β-glucan with other soluble fiber into low-fat dairy products, such as ice cream and yogurts, can improve their mouth feel, scoopability and other sensory properties to more closely resemble full-fat products [31]. In addition, when β-glucan is added to milk, the curd cutting time is reduced and curd yields are increased as a result of its ability to form a structured and elastic casein-protein-glucan matrix. For example, an oat β-glucan added to a low-fat white brined cheese at 0.7% and 1.4%, reduced the hardness of cheese and lead to a product which more closely resembled the full fat control [32]. The addition β-glucan preparations also improved the quality of egg yolk stabilized emulsions, reduced fat breakfast sausages, and lactose free, non-dairy milk substitutes such as yogurt, ice cream, oat-based cream, whipped cream and buttermilk [33].

Walsh *et al.* [34] studied consumption of a food product containing prebiotics and probiotics that has been recognized as an important factor in lowering the risk of intestinal cancer and gastrointestinal diseases and risks associated with high cholesterol. An oats-based symbiotic yogurt-like product (Oagurt) was developed using oats and probiotics *Lb. acidophilus*, *Lb. casei*, and *Bifidobacterium*, with prepolymerized whey protein as a gelation agent. Singh *et al.* [35] evaluated the effect of oat β-glucan on the fermentation of set-style yogurt by incorporating oats of 0%, 0.1%, 0.2%, 0.3%, 0.4%, and 0.5%. It was found that levels up to 0.3% resulted in yogurts with quality characteristics similar to the control yogurt. Examination of the morphologies of yogurt with and without β-glucan revealed that β-glucan formed aggregates with casein micelle and did not form phase separated domains.

The effects of cooking, baking, fermentation and drying on the extractability of β-glucan isolated from porridge, bread and ferment both fresh and dry were studied by Johansson *et al.* [36]. They confirmed that processing did not affect the structure of soluble β-glucan. However, cooking was shown to increase the amount of soluble β-glucan while baking decreased.

FUTURE PROSPECTS

The opportunity to expand utilization of oat mainly in soluble fiber form in the human diet has increased due to consumer demand and race to get better for healthier life. Numerous scientific benefits are the major stimulators for increase in many variants of oats-based products and developing counties could trigger this trend. Future for such products mainly milk-based fermented products would gear up considering additional benefits.

CONCLUSION

Recent increase in health consciousness and changes in lifestyle among population have

propelled the demand for oatmeal in the form of oats-based dairy and nondairy fermented products. Oatmeal has high nutritional value and hence, is best suited for consumption while traveling, between meals, and before a gym workout. Many oats-based products are dominating in this segment in the form of nondairy-based products but lactic acid fermented oats products maintained decorum of truly functional application of oats fiber and real benefits of milk fermentation.

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