Potential Application of Yeast β-Glucans in Food Industry

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Summary

Different β-glucans are found in a variety of natural sources such as bacteria, yeast, algae, mushrooms, barley and oat. They have potential use in medicine and pharmacy, food, cosmetic and chemical industries, in veterinary medicine and feed production. The use of different β-glucans in food industry and their main characteristics important for food production are described in this paper. This review focuses on beneficial properties and application of β-glucans isolated from different yeasts, especially those that are considered as waste from brewing industry. Spent brewer's yeast, a by-product of beer production, could be used as a raw-material for isolation of β-glucan. In spite of the fact that large quantities of brewer's yeast are used as a feedstuff, certain quantities are still treated as a liquid waste. β-Glucan is one of the compounds that can achieve a greater commercial value than the brewer's yeast itself and maximize the total profitability of the brewing process. β-Glucan isolated from spent brewer's yeast possesses properties that are beneficial for food production. Therefore, the use of spent brewer's yeast for isolation of β-glucan intended for food industry would represent a payable technological and economical choice for breweries.

Key words

β-glucan, food production, food properties, polysaccharides

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Introduction

β-Glucans are biopolymers of glucose that are widely distributed throughout the biosphere. The term β-glucan includes number of polysaccharides that can be produced by many prokaryotic and eukaryotic organisms.

β-Glucans are reported to have several beneficial properties and because of that they have found a wide variety of uses in human and in veterinary medicine, immunopotentiation, pharmaceutical, cosmetic and chemical industries as well as food and feed production (Zeković et al., 2005; Laroche and Michaud, 2007). The properties of different β-glucans beneficial for food industry are discussed in this paper.

In food production there is always attendance in finding new healthy components, which can reduce the price and improve the value of products. Many studies have demonstrated that β-glucans from different sources have such properties (Reed and Nagodawithana, 1991; Thammakiti et al., 2004; Douaud, 2007). At the same time, consumers expect more healthy food with the specific characteristics. Therefore, the relationship between health and nutrition became nowadays very important field of research. Such trends stimulate food industry to offer products, which contain lower amounts of calories and energy, but sufficient part of natural fibers.

Different polymers have interesting physico-chemical properties, especially gelling and stabilizing capabilities, leading to intensive use in food production. Many polysaccharides isolated from natural substrates are already used in food industry, such as carrageenan, guar gum, xanthan gum, alginate, pectin, agar, starch and different β-glucans (Jamas et al., 1989; Wylie-Rosett, 2002; Thammakiti et al., 2004). Use of β-glucans in food production is very interesting and broad area.

β-Glucans from different sources have potential application as food thickeners or fat replacers, supplier of dietary fiber (Sucher et al., 1975; Douaud, 2007; Lee et al., 2009), viscosity imparting agents, emulsifiers, fibers and films (Laroche and Michaud, 2007), water-holding and oil-painding agents (Thammakiti et al., 2004).

The goal of this review is to give an outline of the current state of knowledge on β-glucans from different sources and their recent and potential applications in food industry. This paper is focused primarily on yeast β-glucans, especially those isolated from spent brewer's yeast.

Chemical structure and sources of β-glucans

The natural sources of β-glucans are bacteria, yeast, algae, mushrooms, barley as well as oat. The native chemical structure of β-glucans depends on the source they are isolated from. Each type of β-glucan, generally derived from different sources, has an unique structure in which glucose units are linked together in different ways (Stone and Clarke, 1992; Stone, 2009). β-Glucans from different sources have different chemical structures as can be seen in Table 1.

Table 1. Examples of β-glucans with different structures, isolated from different natural sources (Stone and Clarke, 1992)

Type of β-glucan (structure description)	Natural source – trivial name of β-glucan
(1,3)-β-glucans (linear, homogeneous)	– bacterium *Alcaligenes faecalis* – curdlan – algae *Euglena gracilis* – paramylon – *Poria cocos* – pachyman – *Vitis vinifera* – callose – tamarack (*Larix laricina)* – laricinan
(1,3),(1,6)-β-glucans (linear with (1,6)-linked β-glucosyl side branches)	– algae *Laminaria sp.* – laminarin – *Claviceps purpurea* – wall glucan – *Sclerotinia sclerotiorum* – wall glucan
(1,3),(1,6)-β-glucans (linear with (1,6)-linked β-glucosyl or β-gentobiosyl side branches)	– brown algae *Eisenia bicyclis* – laminarin – mushroom *Lentinula edodes* – wall glucan
(1,3),(1,6)-β-glucans („branch on branch" structure)	– yeast *Saccharomyces cerevisiae* – cell wall glucan – mushroom *Schizophyllum commune* – wall glucan
(1,3),(1,4)-β-glucans (linear)	– cereal β-glucans – Iceland moss *Cetraria islandica* – lichenin
(1,3),(1,4)-β-glucans (linear with (1,4)-linked β-glucosyl side branches)	– oyster mushroom *(Pleurotus ostreatus)* – wall glucan

Properties of β-glucans beneficial for food production

Some applications of different β-glucans in food production are given in Table 2. The examples are listed according to the function of β-glucans in different foodstufs and not according to their natural sources or different chemical structures.

Isolation of β-glucan from yeast biomass

Yeast is a well known microorganism that is used in biotechnology since ancient times. Therefore it is a good source of β-glucan. β-Glucans in yeast ceel walls are branch-on-branch molecules containing linear (1,3)-β-glucosyl chains that are joined through (1,6)-linkages (Osumi, 1998; Kath

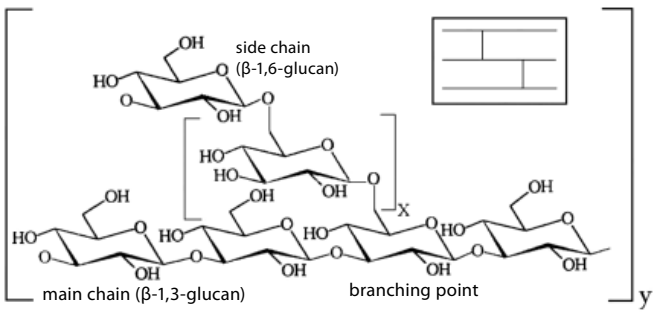

Figure 1. Chemical structure of β-glucan in yeast *Saccharomyces cerevisiae* (Kath and Kulicke, 1999)

Table 2. Potential and current applications of different β-glucans in food production

Function in food	β-glucan name	Biological origin	References
Noncaloric food thickeners	curdlan yeast glucan	bacterium *Alcaligenes faecalis* yeast *Saccharomyces cerevisiae*	Jezequel, 1998 Shukla and Halpern, 2005a; Reed and Nagodawithana, 1991
Fat replacers	β-glucans from cereals	cereals, e.g. barley	Laroche and Michaud, 2007; Brennan and Tudorica, 2007
	yeast-glucan	spent brewer's yeast	Worrasinchai et al., 2006
Emulsifiers	extracellular polysaccharides (EPS)	variety of bacteria	Laroche and Michaud, 2007
	yeast glucan	spent brewer's yeast	Thammakiti et al., 2004
Water holding	yeast glucan	spent brewer's yeast	Thammakiti et al., 2004
Oil binding	yeast glucan	spent brewer's yeast	Thammakiti et al., 2004
Film properties (edible film production)	curdlan	bacterium *Alcaligenes faecalis*	Konno, 1988; Laroche and Michaud, 2007
	β-glucan	mushrooms	Laroche and Michaud, 2007
Lowering LDL cholesterol	β-glucan	oat	Nicolosi et al., 1999; Keller, 2000; Kim et al., 2006; Queenan et al., 2007
Reducing of blood sugar	β-glucan	yeast	Kida et al., 1992; Keller, 2000; Bell et al., 2001
Dietary fibers	β-glucan	baker's yeast	Sucher et al., 1975
Prebiotic application	β-glucan hydrolizates	oat	Laroche and Michaud, 2007
	β-glucan	oyster mushroom (genus *Pleurotus*)	Synytsya et al., 2009

and Kulicke, 1999; Clavaud et al., 2009) (Figure 1). These molecules occur as complexes with other polysaccharides and proteins (Osumi, 1998) (Figure 2).

Seeley (1977) described fractionation of baker's yeast in order to isolate proteins, yeast extract and β-glucan intended for use in food industry. The properties of yeast β-glucan compared with other food yeast products are illustrated in Table 3. The isolated yeast β-glucan showed better water absorption and thickening abilities, than dried yeast and other fractionated yeast components. At the same time, yeast β-glucan is dispersible ingredient with neutral flavour, able for fat binding and gelling (Table 3).

Spray-dried yeast β-glucans showed to be suitable for food production, and can be used as food thickeners with neutral flavour, characterized by a smooth and creamy mouthfeel, as fat replacers, dietary fibers (Sucher et al., 1975), emulsifiers and films (Reed and Nagodawithana, 1991; Thammakiti et al., 2004; Laroche and Michaud, 2007). Furthermore, yeast glucan has water-holding, fat-binding and oil-binding chracheristics (Reed and Nagodawithana, 1991; Wylie-Rosett, 2002; Thammakiti et al., 2004) as well as gelling property. Its viscosity decreases by heating and increases by cooling. Among others, viscosity of β-glucans depends on the yeast strain used for isolation (Thammakiti et al., 2004). Yeast β-glucan can be easily dispersed in cold and hot systems (Seeley, 1977; Reed and Nagodawithana, 1991; Wylie-Rosett, 2002; Thammakiti et al., 2004). It is safe for oral application and has a GRAS (Generally Recognized As Safe) status. Together with soluble colour, particulate yeast β-glucan can form insoluble colouring agent used as food additive (Hobson and Greenshields, 1996; Hobson and Greenshields, 2001). Different production

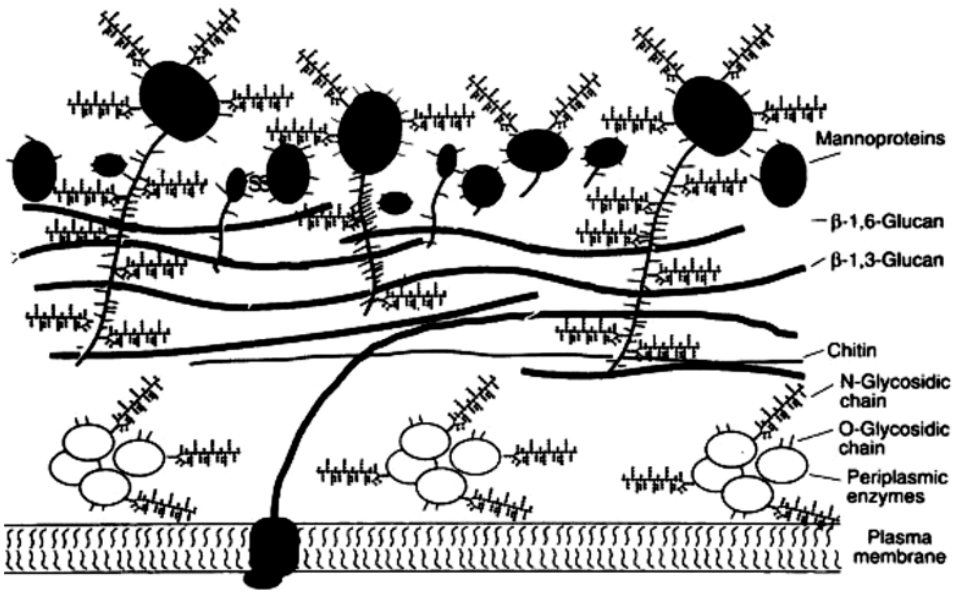

Figure 2.
Structure of the cell wall of yeast *Saccharomyces cerevisiae* (Osumi, 1998)

Table 3. Some characteristics of dried yeast and yeast derivates (Seeley, 1977)

Physico-chemical characteristics	Dried yeast	Yeast proteins	Yeast β-glucan	Yeast extract
Water absorption	+	+	++	
Fat binding		+	+	
Dispearsiblity		++	+	
Gelling properties		+	+	
Texture improving		+		
Forming of fibers		+		
Thickener			++	
Neutral flavor		+	+	
Flavor	+			+++
Flavor enhancer	+			+++

+ slightly, ++ very well, +++ excellent

Table 4. The application of β-glucan in food products

Food products	References
gelling thickeners for functional food products	Shukla and Halpern, 2005a; Laroche and Michaud, 2007
biscuits and cookies	Seeley,1977; Shukla and Halpern, 2005b
meat products	Thammakiti et al., 2004; Shukla and Halpern, 2005c
soft cheese	Shukla and Halpern, 2005d
bread, bread mixture, pancakes, toast, dough	Shukla and Halpern, 2005e
nibbling food (salty and sweety)	Shukla and Halpern, 2005f
ice creams, yogurts, milk drinks	Shukla and Halpern, 2005g,h; Tudorica et al., 2004
salad dressings (creamy, vinegar, mayonnaise) and their ready mixture for use	Shukla and Halpern, 2005i,j Worrashinchai et al., 2006
sauces and mixture for their preparation	Shukla and Halpern, 2005k,l
soups and mixture for soups, concentrates for soups	Shukla and Halpern, 2005m,n,o,p
beverages, including juices and dairy drinks	Neumann et. al., 2006

procedures were patented for many food products containing yeasts β-glucan (Lazzari, 2000; Van Langerich et al., 2004, Shukla and Halpern, 2005 a-p).

β-Glucans isolated from baker's or brewer's yeast can be used in the production of salad toppings (dressings), frozen deserts, sauces, yogurts and other milk products, soft doughs and paning doughs, conditories and mixture for cake filling (Seeley, 1977; Read and Nagodawithana, 1991). The ability of β-glucan to retain water can be also used in the production of sausages and other meat products (Thammakiti et al., 2004). Its gelling, water-holding and oil-binding characteristics make it suitable for many food products (Reed and Nagodawithana, 1991; Lazzari, 2000; Wylie-Rosett, 2002; Thammakiti et al., 2004), such as the production of mayonnaise and sausages. The possible use of yeast β-glucans in the different food products is illustrated in Table 4.

Bell et al. (2001) described production of fibers (β-glucan and glucomannan) from yeast *S. cerevisiae* and the other yeast species (*Schizosaccharomyces, Kluyveromyces, Candida* and *Hansenula*). Described supplements contain small amounts of proteins and carbohydrates, and also some vitamins and minerals. Yeast-derived fibers effectively improve the serum lipid profile in humans, when provided as a dietary supplement. Such food products can be in the form of solid or semi-solid foods (food bars, puddings, or spreads).

As a source of β-glucan, baker's yeast is more often mentioned in literature than brewer's yeast. Spent brewer's yeast is produced in huge amounts as a secondary product in breweries all around the world. Most of it is usually sold after heat inactivation as a cheap feed supplement (Marić and Štefanić, 1987; Hayen and Pollman, 2001; Wheatcroft et al., 2002; Cook et al., 2003). The rest of it ends in waste water disposal and pollutes the natural water sources with organic material (Thammakiti et al., 2004). On the other hand, spent brewer's yeast could be a good source for isolation of high-value products such as β-glucan (Seeley, 1977; Suphantharika et al., 2003; Thammakiti et al., 2004; Liu et al., 2008).

β-Glucan preparations extracted from spent brewer's yeast, showed high apparent viscosity, water holding, oil binding, and emulsion stabilizing capacities (Thammakiti et al., 2004) and could be used in food products as a thickener and fat replacer. Few authors such as Worrasinchai et al. (2006), Santipanichwong and Suphantharika (2007) and Satrapai and Suphantharika (2007) performed their research using β-glucan isolated by Thammakiti et al. (2004) and applied it later in different food systems (for example mayonnaises with reduced fat amounts).

The extraction of soluble and insoluble β-glucans from spent brewer's yeasts is of great interest. It is the way to obtain high valuable product from a cheap raw-material (Worrasinchai et al., 2005). In spite of the fact that large quantities of brewer's yeast are used as a feedstuff, certain quantities are still treated as a liquid waste. β-Glucan is one of the compounds that can achieve a greater commercial value than the brewer's yeast itself and maximize the total profitability of the brewing process.

Conclusions

β-Glucans are industrially produced from different sources (bacteria, grains, baker's and brewer's yeasts, mushrooms and algae) and are already used in food industry, mostly as supplement for various purposes, as was already mentioned in this review. On the other hand, β-glucans, especially those from yeasts and mushrooms, have healthy functional as well as biological activity. Therefore, the use of β-glucans in food is greatly supported from nutritional, but also from medical point of view. As a result of extensive research, one could expect increasing application of β-glucan in food production in the near future. β-Glucan obtained from spent brewer's yeast possesses properties that are beneficial for food production. The use of spent brewer's yeast for isolation of β-glucan intended for food industry would represent a payable technological and economical choice for breweries.

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