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REVIEW ARTICLE

RADICAL SCAVENGING ACTIVITY OF BIOPOLYMERS FROM NATURAL SOURCES

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Abstract

Biopolymers from natural sources specially polysaccharides along with phenolic glyco conjugates show radical scavenging activity in vitro. Furthermore, interest in employing antioxidants from natural sources to increase shelf life of foods is considerably enhanced by consumer preference for natural ingredients and concerns about the toxic effects of synthetic antioxidant. Recent study shows that arabino galactans & arabinogalactan proteins from different plants show antioxidant activity. Using chemical, chromatographic, and spectroscopic methods established that the structure of the polymer contains mainly (1→5)-/(1→3,5)-linked α-arabinosyl, (1→3)-/(1→3,6)-linked-galactosyl residues. The antioxidant capacity of the biopolymers was studied by ferric reducing antioxidant power (FRAP) and DPPH radical assays. Based on fluorescence quenching study also reports that the biopolymers interact with bovine serum albumin (BSA).

INTRODUCTION

Studies over the past few years have demonstrated that reactive oxygen species (ROS) actively participate in a diverse array of biological processes, including normal cell growth, induction and maintenance of the transformed state, programmed cell death and cellular senescence (Finkle, 2003). Although ROS are crucial for life to maintain normal cell functions but their damaging effect can lead to many diseases like cancer (Paz-Elizur *et al.*, 2008), liver disease (Preedy *et al.*, 1998; Harrison *et al.*, 2003), Alzheimer's disease (Moreira *et al.*, 2005; Mucke, 2009), aging (Finkel & Holbrook, 2000), arthritis (Colak, 2008), inflammation (Mukherjee *et al.*, 2007), diabetes (Lee et al., 2003; Naito *et al.*, 2006; Jain, 2006), Parkinson's disease (Beal, 2003; Chaturvedi *et al.*, 2008), atherosclerosis (Heinecke, 1997), ischemic heart disease (Hertog et al., 1997) and AIDS (Sepulveda & Watson, 2002). Antioxidants are important for bodily protection against such ROS. In recent years, a number of polysaccharides containing fractions isolated from various sources as for example,

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marine algae (Wang *et al.*, 2009a, 2009b; Je *et al.*, 2009; Chattopadhyay *et al.*, 2010), plants (Aguirre *et al.*, 2009; Chatterjee *et al.*, 2014), and fungi (Wu *et al.*, 2014), bacteria, and animal possess antioxidative activity (Wang *et al.*, 2013). Some of them, in particular the sulfated polysaccharides from marine algae such as fucoidan (Zhao *et al.*, 2005; Rocha de Souza *et al.*, 2007; Wang *et al.*, 2010), sulfated galactan *(*Barahona *et al.*, 2011), sulfated polysaccharide fractions containing galactose and xylose residues as constituent sugar, and rhamnose-rich polysaccharide fractions showed considerable antioxidative properties (Yang *et al.*, 2011). Most of the studied antioxidative polysaccharides from higher plants had arabinogalactan structure (Zhou *et al.*, 2009; Lin *et al.*, 2011) either as arabinogalactan protein or as highly branched pectic arabinogalactan containing phenolic compounds (Fig. 1). Other antioxidative polysaccharides from plant origin are xyloglucan (Tommonaro *et al.*, 2007), highly branched heteroxylan (Hu *et al.*, 2014), neutral heteropolysaccharide (Yang *et al.*, 2014) and pectic heteropolysaccharide (Zhang *et al.*, 2014). The polysaccharides from animal sources such as heparin and chondroitin sulfate also exhibit hydroxyl radical scavenging activity (Ajisaka *et al.*, 2009).

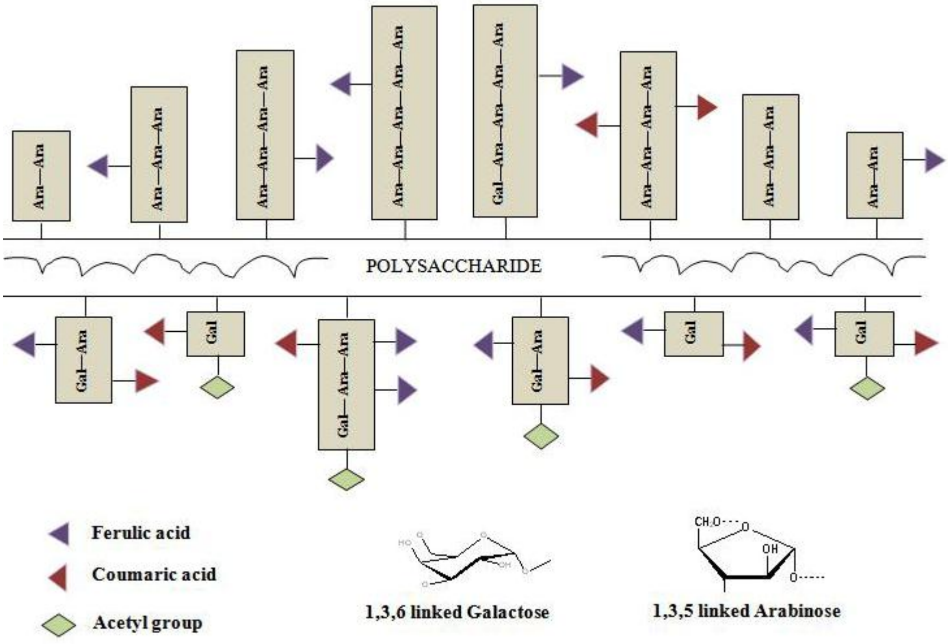

Fig. 1. A model showing the structural features of an arabinogalactan from the Indian medicinal plant *Eugenia jambolana* (Bandyopadhyay *et al.*, 2012).

Structure-activity relationships. In case of sulfated polysaccharides, antioxidative potency depends upon their sulfate content (Qi *et al.*, 2005; Hu *et al.*, 2010). For example, sulfated polysaccharides from *Undaria pinnitafida* had stronger antioxidant abilities than their de-sulfated derivatives (Wang *et al.*, 2008). Literature data also shows that some sulfated polysaccharides have higher antioxidative potency than the others. For example, the antioxidative potential of sulfated polysaccharides from the brown seaweed *Fucus vesiculosus* was higher than that of agar-like sulfated galactans from the red seaweed Nori (Ruperez, 2001). In a more recent study this group (Ruperez *et al.*, 2002) found that antioxidative potency of fucoidan containing fraction from the brown alga *Fucus vesiculosus* was higher than that of glucan and alginic acid containing fractions isolated from the same source. Similar result was reported by Chattopadhyay *et al*., 2010 for sulfated polysaccharide of *Turbinaria conoides*. Ponce, *et al*., (2003) stated that both sulphate content and high molecular weight of fucoidans are required for their bioactivity. The molecular weight was likely to be related to the antioxidative potential of sulfated polysaccharides. An earlier study reported that crude fucoidan derived from *Padina gymnospora* had the strongest inhibiting activity when using superoxide and hydroxyl radicals compared to its purified fractions due to higher amounts of sulfate and a larger molecular mass. Although sulfate content and molecular weight are important parameter for regulating bioactivity, still other factors such as the position of sulphate groups, monosaccharide content and the linear backbone of the polysaccharide (Li *et al*., 2008; Skriptsova *et al*., 2009) may all contribute to the higher antioxidative potential of fucoidan.

The antioxidative property of non-sulfated polysaccharides depends upon its monosaccharide composition, i.e., neutral sugar (Ji *et al.*, 2014) as well as uronic acids (Fan *et al.*, 2012; Wu *et al.*, 2014). For example, Ji *et al.*, 2014 had shown that the antioxidative activities of four water extracted polysaccharides from *Chinese angelica* after processing such as *Chinese angelica* parched with alcohol (ACAP), *Chinese angelica* parched with soil (SCAP), *Chinese angelica* parched with sesame oil (OCAP) and charred *Chinese angelica* (CCAP) were significantly increased with increasing arabinose content compare to its native polymer. Some reports explained that rhamnose and arabinose are associated with the antioxidant activities of polysaccharides. (He *et al*., 2012; Kang *et al*., 2014). The increasing rhamnose and arabinose in the monosaccharide composition might lead to strong antioxidant activity. Another important parameter is molecular mass (Qi *et al.*, 2005). Some researchers reported that high molecular weight polysaccharides would be helpful to the enhancement of antioxidative activity (Song *et al*., 2010; Lv *et al*., 2014), while other investigators showed this activity was dependent upon their low molecular mass or moderate molecular mass (Zhao *et al*., 2005). In arabinogalactan protein phenolic amino acid residues are important functional sites. Like other phenolic compounds these phenolic amino acids scavenge free radicals (Sinha *et al.*, 2011a). Antioxidative activity of pectic arabinogalactans containing phenolic compounds directly related to their phenolic content. Upto a certain range the antioxidantive activity of a particular polysaccharide increases with increasing phenolic content (Bandyopadhyay *et al.*, 2012; Chatterjee *et al.*, 2011; Chatterjee *et al.*, 2014). Another class of polysaccharides β-glucan works like a scavenger and has an antioxidant effect (Kayali *et al.*, 2005; Song & Moon, 2006; Lv *et al*., 2014; Liu *et al*., 2014). Taken together, chemical structure dictates the antioxidative property of polysaccharide.

Mechanism of action. Antioxidant enzymes are considered to be a primary defense that prevents biological macromolecules from undergoing oxidative damages (Kang & Saltveit, 2002; Matés *et al.*, 1999; Xu *et al.*, 2007). For example, superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) are important endogenous enzymes related to antioxidant defense mechanisms. The intracellular antioxidant enzyme, SOD protects against oxidative processes initiated by the superoxide anion, while GSH-Px reduces lipid hydroperoxides to their corresponding alcohols and free hydrogen peroxide to water (Johnson, 2002). Now polysaccharides increase the activities of antioxidant enzymes (SOD, CAT and GPX) and this enhanced activity can be effective in scavenging the various types of oxygen free radicals and their byproducts in aging animals (Jin & Ning, 2012; Kodali *et al.*, 2011; Xu *et al.*, 2009; Zhang *et al.*, 2003, 2004).

Furthermore, antioxidant activities studies indicated that the greater capacity of polysaccharides in scavenging free radicals may be related to higher content of uronic acid, which can reduce the generation of hydroxyl radicals by chelating ferrous ion. Thus the changes of uronic acid in polysaccharide affect its hydroxyl radical scavenging ability (Fan et al., 2012) as well as antioxidative potency.

CONCLUSION

During the past decades many significant developments in the utilization of carbohydrate polymers as drug have been put forward. This, however, is not surprising since it is known that many of these biopolymers play an essential role in key biological processes. The series of biolpolymers showed dose dependent free radical scavenging capacity as evidenced by DPPH and Ferric reducing power assay. The pharmacologically active compounds formed a water soluble complex with bovine serum albumin over pH 4.0–7.4. Accordingly, traditional aqueous extraction method provides a molecular entity that induces a pharmacological effect: this could epitomize a smart approach in phytotherapeutic management.

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