ABSTRACT

Agricultural by-products are one of the renewable resources and there is a growing interest in the developing countries for the production of value added products from them. The bioconversion of agricultural by-products into value added functional food components is a key emerging technology for addressing the need for environment friendly and sustainable sources. The milling of cereals (rice/paddy and millet) for the production of food constituents results in a number of low-value by-products/wastes. The major by-products produced by this operation are bran and seed coat, which are currently having low market value.

Agricultural by-products are rich in hemicellulose (20-35%), and xylan being the major component could be used for the production of xylooligosaccharides (XOS). Xylan is a hetero-polysaccharide made up of D-xylose units connected by β, 1-4 glycosidic bonds. Xylan rich sources such as sugarcane baggase, corn cob, corn hull, rice straw, rice husk, Bengal gram husk, wheat bran, finger millet bran etc., have been evaluated by different approaches for the production of functional food ingredient like XOS. Today, there is an increasing expectation for food products that meet consumers demand for a healthy life style. In this context prebiotic XOS play an important role in food industry for its functional and therapeutic effects. This demand has drawn interest in extracting these ingredients from xylan containing agricultural by-products and developing functional foods.

The growing commercial importance of XOS is based on their beneficial health properties, particularly their ability to stimulate the growth and activity of intestinal bacteria such as *Bifidobacterium* and *Lactobacillus* species. XOS are less sweet, acid and heat stable with low recommended
levels of intake (0.7-1.4 g / day) compared to other oligosaccharides. In view of the consumer demand for foods with low sugar, low fat and high fibre contents, they are suitable for incorporation into food products.

In the present research, agricultural by-products rice bran and finger millet CO9 seed coat from the Tamil Nadu region of India were used for the extraction of Water Soluble Xylan (WSX) and production of XOS with potential applications in food product development. This study investigates water soluble containing xylan polysaccharides extracted from rice bran and finger millet CO9 seed coat by four methods namely, water at ambient temperature (25 ± 2º C); water with pressure (25 ± 2º C, 8 bars); water with pressure (25 ± 2º C, 8 bars) after treatment by ball milling and alkali (10% NaOH). The xylan yield (g 100g⁻¹) was three-fold higher with water under pressure (17.02±0.47 and 14.03±0.16) than water alone (5.80±0.03 and 4.84±0.07). Treatment in a ball mill before extraction with pressure enhanced yield about four to five fold (21.20±0.29 and 22.62±0.14) and alkali based extraction gave the maximum yield (27.62±0.61 and 31.83±0.82). Despite giving lower yield, mechanical treatment in a ball mill followed by pressure based water extraction being chemical-free is advantageous when considering production of functional ingredient like XOS for food applications.

Characteristics of extracted WSX were assessed by different methods. Hydrolysis and derivatization of xylan revealed predominance of xylose followed by arabinose and glucose. The molar ratios of Ara/Xyl were found to be 0.55 and 0.68 respectively. Elemental analysis showed similarities in carbon and hydrogen, while nitrogen and sulfur contents showed some variations. Structural identification of β - glycosidic linkages from the IR spectrum, ¹H NMR and ¹³C NMR confirmed the presence of xylan. Properties of the extracted WSX (SEM, particle size, XRD, TGA and DSC) showed similarities in the two sources.
The extracted WSX was treated with xylanase to obtain XOS. The yield of XOS was found to be 68.6% and 71.8% of WSX respectively. The solution containing derived XOS was quantified by HPLC-ELSD with degree of polymerization (DP of 2) and xylobiose was the major sugar present in the both sources. The presence of β- linkages of XOS was identified by FTIR, ESI-MS and NMR studies. XOS mixture of finger millet CO9 seed coat exhibited relatively higher antioxidant activity compared to the rice bran XOS. That xylobiose in the XOS mixture supported a faster growth rate of probiotic microorganisms was evident from fermentation studies. Among the tested species of lactobacilli, the growth of Lactobacillus plantarum in the presence of derived XOS was most notable. The cell-free Lactobacillus plantarum supernatant grown on finger millet derived XOS showed strong antibacterial activities against pathogenic organisms compared to other sources of XOS. Thus, XOS showed good prebiotic and antioxidant effects. Xylobiose the major sugar component could be a potential functional ingredient that can be used to develop new food products with health benefits.

Bread enriched with functional XOS was developed by the partial replacement of sugar with XOS. The incorporation of XOS was studied from 10 to 40% level in bread made from refined wheat flour. The effect of incorporation of XOS on colour, texture, physicochemical properties and sensory characteristics of bread were evaluated. The results revealed that the 30% level was comparable to the control in all aspects. The colour and texture values were found to be stable during a storage period of seven days. These findings have potential to make available a highly nutritious and functional ready-to-eat food product for the common man.

In conclusion, rice bran and finger millet seed coat can be sources of water soluble xylan that could be hydrolyzed to obtain prebiotic XOS. The XOS derived from the two sources can be incorporated in baked food products like bread to enhance their functionality as health promoting foods.