Food Research International 56 (2014) 166–173

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

# Soluble polysaccharides from flaxseed kernel as a new source of dietary fibres: Extraction and physicochemical characterization

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ARTICLE INFO

*Article history:*
Received 8 October 2013
Accepted 7 December 2013

*Keywords:*
Flaxseed
Dietary fibre
Monosaccharide composition
Surface activity
Rheological property

ABSTRACT

Flaxseed (*Linum usitatissimum* L.) is rich in soluble and insoluble dietary fibres. Recent study in our research group discovered that the kernel of flaxseed contained about 20% (w/w) of dietary fibres, which has not been reported before. Scanning electron microscope (SEM) images revealed that flaxseed kernel dietary fibres (FKDF) are mostly in the supporting structure of the cell walls. To study the structure and physicochemical properties of FKDF, a modified sequential extraction and fractionation procedure was utilised, and five separate FKDF fractions were obtained as flaxseed kernel (FK) water-extracted polysaccharides (FK-WP), FK EDTA-extracted polysaccharides (FK-EP), FK $Na_2CO_3$-extracted polysaccharides (FK-NP), FK 1 M KOH-extracted polysaccharides (FK-KPI), and FK 4 M KOH-extracted polysaccharides (FK-KPII). FKDF fractions were all water-soluble. The average molecular weight of FK-WP was 486 kDa, FK-EP 593 kDa, FK-NP 704 kDa, FK-KPI 770 kDa, and FK-KPII 1660 kDa. Monosaccharide compositions were different among FKDF fractions; alkaline solution extracted FKDF fractions had relatively higher percentage of arabinose, but relatively lower content of glucose compared with FK-WP and FK-EP. All FKDF fractions had the ability to lower the surface tension of water, among which FK-KPI exhibited the best surface activity. Rheological properties showed that FKDF fractions had low viscosity and 2% (w/v) FKDF water solution exhibited viscoelastic behaviour at 25 °C. Those findings could benefit the related food industries for providing healthier and more value-added flaxseed products.



## 1. Introduction

Flaxseed (*Linum usitatissimum* L.), one of the most economically important oilseed crops, is largely produced in Canada. The flaxseed production of Canada accounts for 17.4% of world production in 2012, covering 46.4% of the global flaxseed trade (Statistics Canada, 2012). The generally recognised as safe (GRAS) status of flaxseed has been confirmed (FDA, 2009), and it is the richest source of plant-based alpha-linolenic acid in the North American diet (Morris, 2001, 2007).

Flaxseed is also rich in soluble and insoluble dietary fibres. Compared with the other cereals and oilseeds like wheat, barley, oat, soybean, etc. (Dhingra, Michael, Rajput & Patil, 2012), flaxseed has extremely higher content of total dietary fibres (27%–28%, w/w), lignan (0.6%–1.3%, w/w) and minerals (3%–4%, w/w) (Cui & Mazza, 1996; Johnsson, Kamal-Eldin, Lundgren, & Aman, 2000; Morris, 2007; Mueller, Eisner, Yoshie-Stark, Nakada, & Kirchhoff, 2010; Singh, Mridula, Rehal, & Barnwal, 2011), but very low content of starch (<1.6%, w/w) (USDA, 2011).

The health benefits of dietary fibres include (but are not limited to) protecting against several chronic diseases (e.g. diabetes, obesity, colon cancer), reducing blood cholesterol levels, and improving insulin sensitivity, etc. (Elleuch et al., 2011; Health Canada, 2012). Due to the high nutritional potential and relatively low glycemic index value, flaxseed and its products have been used for preparing value–added food products, such as muffin, salad dressing (Stewart & Mazza, 2000), spaghetti (Lee, Manthey, & Hall, 2003) and dairy products (Hall, Tulbek, & Xu, 2006). Compared with insoluble dietary fibres, soluble dietary fibres are easier to incorporate into beverages, dairy products, and processed foods as thickeners, emulsifiers, stabilisers, and fat replacers (Cui, Wu, & Ding, 2013).

Previous research on flaxseed dietary fibres mainly focused on soluble flaxseed gum from the mucilaginous part of whole seed or flaxseed hull (Cui, Kenaschuk, & Mazza, 1996; Cui & Mazza, 1996; Cui, Mazza, & Biliaderis, 1994; Fedeniuk & Biliaderis, 1994; Mazza & Biliaderis, 1989; Muralikrishna, Salimath, & Tharanathan, 1987; Naran, Chen, & Carpita,

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0963-9969/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.foodres.2013.12.005

2008; Oomah, Kenaschuk, Cui, & Mazza, 1995; Qian, Cui, Wu, & Goff, 2012), as well as aqueous extracted and/or chelator and alkali extracted dietary fibres from whole flaxseed meal (Goh, Pinder, Hall, & Hemar, 2006; Ray et al., 2013). The mucilage accounts for around 8% (w/w) of the flaxseed (Mazza & Biliaderis, 1989), and it exists in two states, one which can be easily separated and the other which tightly adheres to the cell walls (Naran et al., 2008). Recent study by our research group discovered that the kernel of flaxseed contained about 20% (w/w) of dietary fibres (Ding et al., 2012), which has not been reported before. Flaxseed kernel is composed of two cotyledons and embryo in which the major portion of oil is located (Vaughan, 1970). As more than 70% (w/w) of flaxseed oil is polyunsaturated fatty acids, milled or ground flaxseed can be easily oxidised (Morris, 2007; Singh et al., 2011), while relatively high content of flaxseed kernel cell wall materials (dietary fibres) provide a natural but tight encasement to protect the oil inside (Cui, 2012).

To promote further utilisation of flaxseed, investigation on structure and physicochemical characteristics of flaxseed kernel dietary fibres (FKDF) is an important step to explore their potential, thus producing more value-added flaxseed products in food, nutrition, and drug industries. In this paper, five separate FKDF fractions were obtained using a modified sequential extraction and fractionation method, and their chemical composition, molecular weight distribution, monosaccharide ratio, as well as physicochemical characteristics (rheological properties and surface activities) were investigated.

## 2. Materials and methods

### 2.1. Materials

Flaxseed kernels (~70% purity) were obtained by a patented dehulling technique (Cui & Han, 2006) from Natunola Health Inc. (Ontario, Canada); then, pure flaxseed kernels (>99.9% purity) were collected through further sieving and cleaning. The cultivar of flaxseed was CDC Sorrel. All chemicals were of reagent grade.

### 2.2. Extraction and fractionation procedure

The extraction and fractionation procedures for FKDF fractions followed that of Dusterhoft, Voragen, and Engels (1991), Cui, Mazza, Oomah, and Biliaderis (1994), and Selvendran and Stevens (1985) with modification as shown in Fig. 1.

### 2.3. Determination of sugar, uronic acid, dietary fibre, starch, protein, ash, and moisture contents

Sugar content was determined by phenol–$H_2SO_4$ method (Dubois, Gilles, Hamilton, Rebers, & Smith, 1956) with glucose solutions as standards. Total uronic acid content was determined by m-hydroxyphenyl colorimetric method (Blumenkrantz & Asboe-Hansen, 1973) with glucuronic acid and galacturonic acid (1:1) solution as standards. Dietary

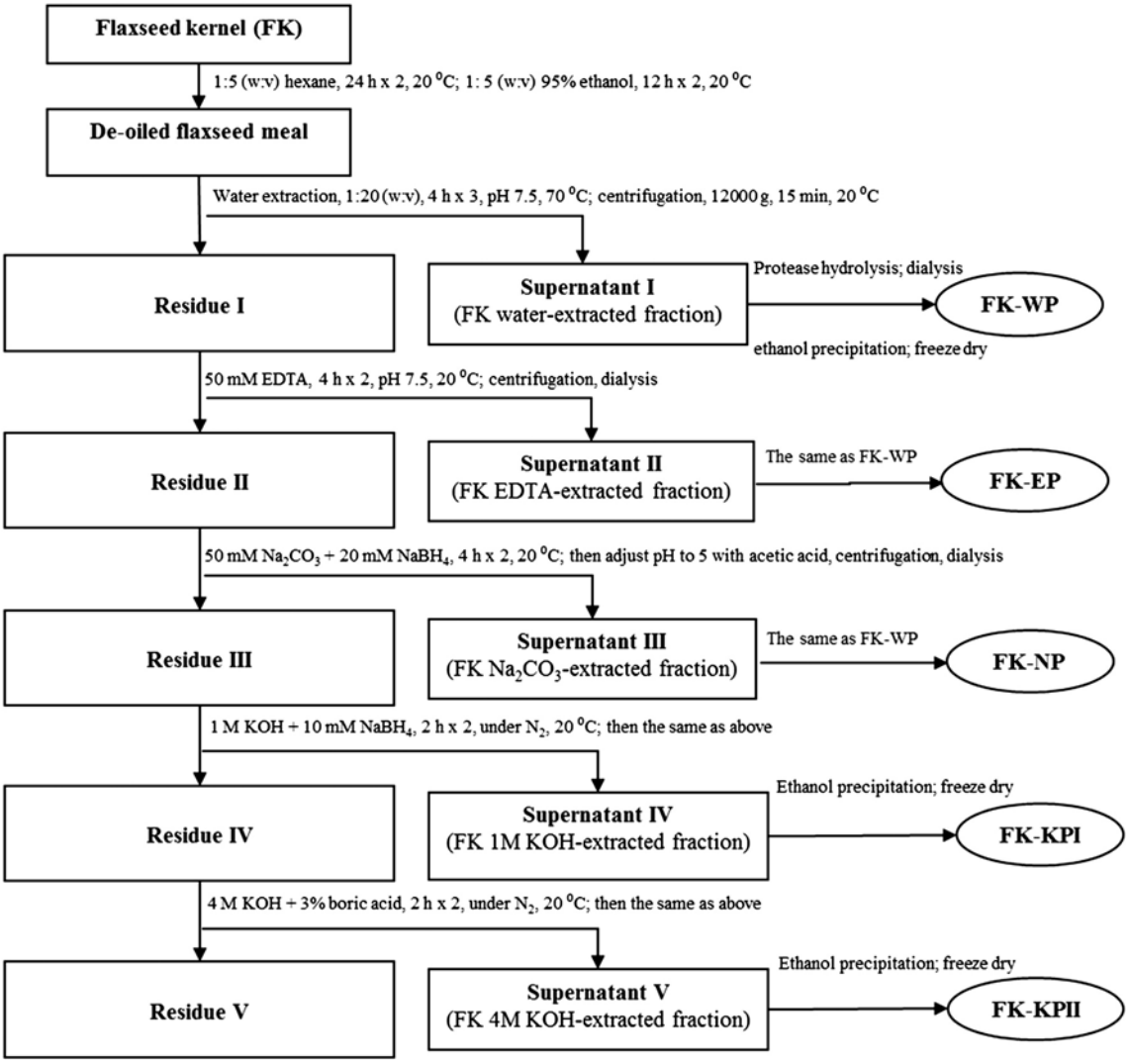


**Fig. 1.** Extraction and fractionation procedure of flaxseed kernel dietary fibres (FKDF).