Magnetically responsive cereal byproducts: Preparation and application

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Introduction

Cereals represent the most important group of crops employed for both the human food and livestock feed production. They provide essential nutrients, including carbohydrates, proteins, fiber, and various vitamins and minerals. Cereal grains are the major source of energy and carbohydrates (including dietary fiber) and one of the major plant protein sources in the human diet. Grains are most often milled prior to food use to remove the outer parts of the grain, which are used for feed or other non-food use. Refined products are primarily based on the starchy endosperm and mainly contribute energy, with only small amounts of vitamins, minerals, fiber, and bioactive phytochemicals, which are mainly found in the germ and bran parts.

Cereals processing leads to the production of several types of byproducts, which can be employed for variety of applications. Magnetic modification of cereal byproducts enables their simple magnetic separation.

Major cereals

- **wheat (Triticum aestivum)**
- **rice (Oryza sativa)**
- **maize (corn) (Zea mays)**
- **barley (Hordeum vulgare)**
- **oats (Avena sativa)**
- **sorghum (Sorghum bicolor)**
- **millet (Panicum miliaceum)**
- **rye (Secale cereale)**
- **triticale (Triticum x Secale)**

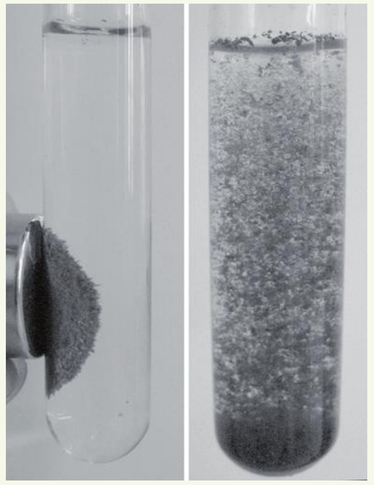
Cereal byproducts

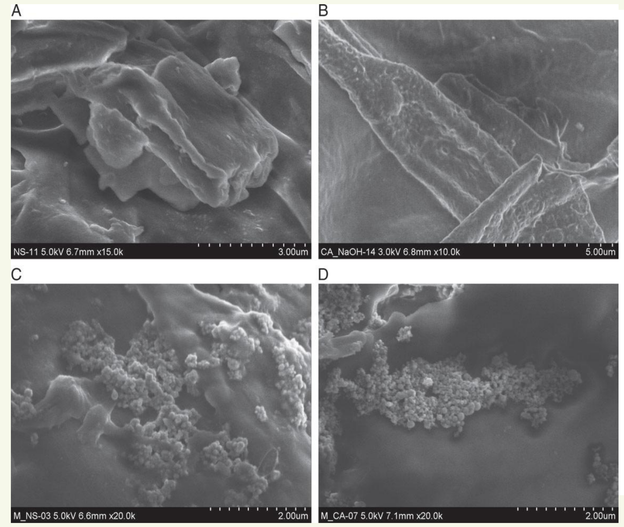
- **straw**
- **husk**
- **bran**
- **germ**
- **brewers' spent grain**
- **distillers' grains**

Magnetic modification

Attachment of iron oxide nano- and microparticles on the surface and into the pores of cereal byproducts using:

- **ferrofluid treatment**
- **microwave synthesis**
- **Fe(II) + Fe(III) precipitation**





Removal of organic dyes

Many organic dyes are nonbiodegradable and carcinogenic and pose a major threat to health and the environment. Technologies employing various types of adsorbents are often employed for their removal. Magnetic cereal byproducts serve as efficient low-cost biosorbents for their removal by biosorption. Especially straw and spent grain have been employed.

Removal of heavy metal ions and radionuclides

Heavy metal ions and radionuclides are significant environmental pollutants because they are toxic, non-biodegradable, and tend to accumulate in living organisms, posing serious risks to ecosystems and human health. Adsorption is a widely used and effective method for their removal. Magnetic cereal byproducts serve as efficient biosorbents for their elimination by biosorption.

Other applications

- **Magnetic spent grain employed as a biocompatible carrier for immobilization of enzymes**
- **Magnetic spent grain can efficiently adsorb bacterial signal molecules leading to decrease of biofilm formation**
- **Magnetic iron oxide particles exhibit peroxidase-like activity**