

# We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index  
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?  
Contact [book.department@intechopen.com](mailto:book.department@intechopen.com)

Numbers displayed above are based on latest data collected.  
For more information visit [www.intechopen.com](http://www.intechopen.com)



---

# Emulsifying Properties of Hemicelluloses

---

Emmanuel O. Olorunsola, Ekaete I. Akpabio,  
Musiliu O. Adedokun and Dorcas O. Ajibola

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/intechopen.74473>

---

## Abstract

This chapter focuses on the emulsifying properties of hemicelluloses. Hemicelluloses are gummy polysaccharides of complexity between gum and cellulose. Based on the major monosaccharide constituents of their backbone, hemicelluloses can be classified into xylans, mannans, xylogalactans and xyloglucans. Their sources include seeds, husks, straws, leaves and wood. Hemicelluloses bring about emulsification by viscosity modification and by formation of multilayered films around each globule of the dispersed phase. They have strong emulsifying power but are somehow limited by batch-to-batch variation and susceptibility to microbial and chemical degradations. These limitations are overcome by the use of purified and semisynthetic derivatives. Hemicelluloses and derivatives herein considered for their emulsifying properties include those from barley straw, wheat straw, corn fiber, locust bean, guar, soy bean, konjac, prosopis seed and afzelia seed. Hemicelluloses, as plant polysaccharides, are only second to cellulose in terms of abundance. They have superior emulsifying properties compared to the typical gums. They are amenable to many chemical modifications for the enhancement of stability and for the improvement of emulsifying properties. Hemicelluloses were not given adequate attention in the past; but this chapter shows that they are potentially useful emulsifying agents.

**Keywords:** hemicellulose, natural, polysaccharide, emulsifying agent, emulsion

---

## 1. Introduction

Hemicelluloses are cell wall heteropolysaccharides. In terms of complexity, they are intermediate between gums and celluloses, and they have properties similar to these polymers. They are gummy in nature and can be investigated for their emulsifying properties just like gums and celluloses [1].

Emulsification is an important phenomenon because it enables the dispersion of two immiscible or partially miscible liquids such that one is distributed uniformly as fine droplets (the dispersed phase) throughout the other (the dispersion medium) [2]. Emulsions may be formulated for most routes of drug administration, including the oral, rectal, intravenous and topical routes. Besides, some drugs are best administered as emulsions. For instance, vitamins of poor water solubility must be formulated as oil-in-water emulsions in order to achieve optimal delivery [3]. Emulsions have unique advantages of increased bioavailability and reduced side effects. Therefore, they are regarded as important pharmaceutical dosage form.

Emulsions are thermodynamically unstable formulations and tend to separate into the oil and aqueous phases [1]. Hence, there is a need for the incorporation of the third substance called emulsifier or emulsifying agent. The emulsifying agent is to impart kinetic stability to the emulsion system during its shelf-life. Hemicelluloses are mainly used as emulsifying agents in oral drug products.

The suitability of a substance for use as an emulsifying agent (like other pharmaceutical excipients) depends on its ready availability, biodegradability and safety. Hemicelluloses like other polysaccharides are readily available, biodegradable and are nontoxic [4]. Therefore, they can be studied for emulsifying properties.

Hemicelluloses have high potentials as pharmaceutical polymers. However, the physical chemistry and exploration of this group of plant polymers have not been adequately attended to until recently [4]. This chapter focuses on the emulsifying properties of these promising but neglected pharmaceutical polymers.

## 2. Hemicelluloses

### 2.1. Definition

Hemicelluloses are cell wall heteropolysaccharides that are widely distributed in plants. They have a  $\beta$ -(1-4) linked backbone with a symmetrical configuration [5]. They are derived from heterogenous sugars, including xylose, mannose, glucose and galactose in the backbone chain, and arabinose, galactose and 4-O-methyl-d-glucuronic acid in the side chain. Xylose and arabinose are pentose sugars, while mannose, rhamnose, glucose, galactose and corresponding uronic acids are hexose sugars. The different sugar units are present in different proportions and with different substituents. Hence, hemicelluloses can be described as branched polymers of pentose and hexose sugars.

Hemicelluloses are not soluble in water but can be solubilized by aqueous alkali [6]. This character is often used as a distinguishing feature between typical gums and hemicelluloses. Solubility of hemicellulose can be enhanced by chemical modification.

### 2.2. Classes

Hemicelluloses can be classified into four classes based on the sugar composition of the backbone [7, 8]. The classes are as follows: xylans, mannans, xylogalactans and xyloglucans.

### 2.2.1. Xylans

Xylans are heteropolymers having a  $\beta$ -(1,4) linked backbone made of D-xylose. They are the major hemicelluloses in hardwood. They are also predominant in cereals, constituting up to 30% of the cell wall material. They constitute about 30% of lignocellulosic materials. Xylans are obtainable from many plant materials such as sorghum stalk, sugar cane and corn stalks and cobs. They can also be obtained from hulls and husks from starch production as well as from hardwoods and softwoods [9].

There are three subtypes of xylan based on the side chain. The subtypes are homoxylan, glucuronoxylan and arabinoxylan.

In homoxylans, both the backbone and the side chain are predominantly made of xylose. This is a unique hemicellulose because it contains the same pentose sugar as the predominant sugar unit in the backbone and in the side chain. Homoxylan is the predominant hemicellulose in seaweeds [10].

In glucuronoxylans, the backbone is made up of xylose sugar, while the side chain is predominantly made of glucuronic acid [11]. Glucuronoxylan is the most abundant hemicellulose in herbaceous plants.

Arabinoxylan is another unique hemicellulose. The backbone and the side chain are predominantly made of pentose sugars. The major difference between arabinoxylan and homoxylan is that the pentose sugars in the former are of different type. In arabinoxylans, the backbone is composed of  $\beta$ -(1-4) linked D-xylose residue while the short side chain is predominantly of  $\alpha$ -L-arabinose. Arabinoxylans are present in cereals, including wheat, barley, rice, corn and sorghum. They are found in the flour and the bran [12].

### 2.2.2. Mannans

Mannans are heteropolymers of  $\beta$ -(1,4)-D-mannopyranose backbone. They are of three subtypes based on the side chain. These are homomannan, glucomannan and galactomannan.

In homomannans, the backbone is composed of mannose and the side chain is also predominantly made of mannose. Other sugar types could be present in minute quantities. Homomannan is an uncommon hemicellulose.

Glucomannans have mannose-rich backbone with side chain which is rich in glucose. This type of hemicellulose is prevalent in softwood. They are located within the secondary cell wall [12].

Galactomannans have mannose-rich backbone with short side chain which is rich in galactose. They are abundant in cell wall of storage tissues mainly those of leguminous seeds. The plant sources include guar, tara and locust bean [12]. The solubility and viscosity of this type of hemicellulose are influenced by the amount of the galactose residue.

### 2.2.3. Xylogalactans

Xylogalactans have backbone composed of galactose units. The backbone is decorated with  $\alpha$ -D-xylopyranose residues. Xylogalactans are found in leguminous seeds like *Prosopis africana* [13].

#### 2.2.4. *Xyloglucans*

Xyloglucans have a backbone made up of  $\beta$ -(1-4) linked glucose units. This backbone is similar to cellulose. It is decorated with  $\alpha$ -D-xylopyranose residue at position 6 [14]. This type of hemicellulose is strongly bonded to the cellulose microfibrils. Therefore, it is difficult to extract the xyloglucans. Xyloglucan hemicellulose is obtainable from leguminous seeds such as tamarind and afzelia [6].

### 2.3. Sources

Hemicelluloses exist alongside cellulose and lignin in plant cell wall. While hemicellulose exists as a branched polymer of pentose and hexose sugars, cellulose is a polymer of  $\beta$ -(1-4)-D-glucose; and pectin is a polymer of galacturonic acid. Hemicellulose comprises 20–30% of plant cell wall, and it is responsible for the composite structure of the cell wall. Cellulose is embedded in the hemicellulose, and it provides the rigidity while lignin bonds the entire system together. Thus, these three polymers are bound together in the plant cell wall [15].

Hemicellulose is the predominant carbohydrate in the middle lamella of plant [16]. Generally, they are found in abundant quantities in seeds, husks, straws, leaves and wood (hard and soft).

Several methods can be employed for the extraction of hemicellulose depending on the solubility. The most commonly utilized method is alkaline extraction which involves the use of hot sodium hydroxide/hydrogen peroxide solution. This is suitable for the typical hemicelluloses which have poor water solubility. Hot water extraction can also be used for xyloglucan gums. Other methods are microwave treatment, extraction with dimethyl sulphoxide, methanol/water extraction and pressurized ethanol extraction [17].

### 2.4. Mechanism of emulsification

Hemicelluloses act by modifying the viscosity of dispersions [1]. They increase the consistency of dispersion media thereby inhibiting creaming and coalescence. Based on Stokes's law, the rate of separation of the two phases of an emulsion is retarded to an extent which is proportional to the viscosity of the dispersion medium.

Purified and modified hemicelluloses also act by forming multimolecular films around each globule of the dispersed phase. The hydrophilic barrier between the oily phase and the aqueous phase stabilizes the emulsion. Generally, hemicelluloses form oil-in-water emulsions [12, 13].

### 2.5. Limitations

Hemicelluloses show significant batch-to-batch variation in their composition. The variation may be related to the plant species, time of collection or method of extraction. This often results in variation of the emulsifying properties [1].

Susceptibility to microbial contamination is another major limitation of hemicelluloses as emulsifying agents. Microbial contamination leads to reduction in product shelf-life. To reduce susceptibility to microbial attack and the accompanying product instability, purified and semisynthetic derivatives are generally used [1]. Hemicelluloses are also susceptible to degradation by oxidation and hydrolysis.

## 2.6. Modifications

Chemical modification is used to improve the quality of hemicelluloses. It is carried out to enhance their solubility, increase their viscosity or make them thermoplastic. Modified hemicelluloses are more resistant to microbial and chemical degradations, and they possess better emulsifying properties [12]. Hence, chemical modification is an important phenomenon in physical chemistry and pharmaceutical application of hemicelluloses. The different methods of chemical modifications are esterification, etherification, cross-linking and grafting.

### 2.6.1. Esterification

Esterification of hemicellulose can be carried out in both aqueous and nonaqueous conditions [18]. The aqueous condition is characterized by low yield and production of heterogeneous esters. There is a need of specific organic solvent or alkaline condition for production of a homogeneous ester. Esterification of xylan hemicellulose is somehow difficult because of the limited number of hydroxyl groups [9]. Interfacial cross-linking polymerization is rather an easier method of modification for this type of hemicellulose.

There are at least five types of esterification reactions. These include acetylation, succinylation, sulphation, nitritation, and xanthation.

#### 2.6.1.1. Acetylation

This method is essential for the production of carboxylic acid esters. Acetic acid and acetyl anhydride are used for the production of hemicellulose acetate [19]. Propionate and butyrate of hemicellulose are produced using corresponding anhydride/acid as an acetylating agent. Arabinoxylan from corn fiber can be esterified with aliphatic anhydride of 2–4 carbon atoms using methane-sulphonic acid as a catalyst [20]. Aspen wood flake hemicellulose has been acetylated using acetic anhydride vapor as an acetylating agent [21].

#### 2.6.1.2. Succinylation

Succinylation involves introduction of carboxylic functional group to the hemicellulose. It can be achieved by dissolving the hemicellulose in dimethyl formamide/lithium chloride (DMF/LiCl) system and using pyridine or 4-dimethylaminopyridine as the catalyst. The reaction is normally carried out at 40–140°C for 2–12 h. This method has been used to produce succinoylate hemicellulose from wheat straw [22]. Succinylation increases the hydrophilicity of hemicellulose.

#### 2.6.1.3. Sulphation

Sulphation of xylan hemicellulose has been demonstrated using dinitrogen tetroxide-N,N-dimethylformamide (N<sub>2</sub>O<sub>4</sub>-DMF) system as a derivating solvent. The solvent enables the formation of unstable hemicellulose derivative followed by introduction of an acyl group and elimination of the unstable substituent. Nitrosylsulphuric acid (NOSO<sub>4</sub>H) is usually used as the active sulphating agent. Sulphation of xylan has also been demonstrated using sulfur trioxide/pyridine and sulfur trioxide/dimethylformamide in dimethylformamide/lithium chloride solvent [23]. Sulfur trioxide was diluted with the nitrogen-containing compound for use as the sulphating agent.

#### 2.6.1.4. Nitritation

This procedure is normally carried out as a reaction with dinitrogen tetroxide or nitrosyl chloride in a suitable medium. The medium must contain a proton acceptor. Nitric esters have been produced from hemicelluloses of guar and locust bean [24].

#### 2.6.1.5. Xanthation

Xanthation is carried out as a reaction between hemicellulose and xanthic acid in the presence of caustic soda. The hydrogen atom of the acid is replaced by sodium, forming sodium xanthate. Then, carbon disulphide is added to the hemicellulose under alkaline condition to form sodium hemicellulose xanthate. Members of the mannan group of hemicelluloses easily undergo xanthation to form corresponding hemicellulose xanthate [25].

#### 2.6.2. Etherification

Etherification is a very important method of increasing solubility, film forming ability and viscosity of hemicelluloses. By extension, it improves the emulsifying properties of the polymer. Etherification equally serves as a means of reducing the susceptibility of hemicelluloses to microbial degradation. The different etherification methods are as follows: carboxymethylation, methylation, hydroxyalkylation, sulphoalkylation, cyanoethylation and benzylation.

##### 2.6.2.1. Carboxymethylation

Carboxymethylation is normally carried out using chloroacetic acid or its sodium salt in the presence of an alkaline solution [26]. In the work of Kamel *et al.* on carboxymethylation of guar gum [26], sodium hydroxide was first added followed by the addition of monochloroacetic acid. The reaction was allowed to proceed at 80°C for 1.5 h. A non-aqueous carboxymethylation is also feasible using a mixture of ethanol and toluene.

##### 2.6.2.2. Methylation

Dimethyl sulphate can be used as a methylating agent for hemicelluloses. Methylation of hemicellulose has been demonstrated by Kishida and Okimasu using konjac glucomannan [27]. Methylated konjac glucomannan is soluble in water.

##### 2.6.2.3. Hydroxyalkylation

Hydroxyalkylation of hemicellulose can be achieved using alcohol in the presence of sodium hydroxide and alkene oxide. For instance, hydroxyethylated guar gum has been prepared by dispersing the gum in butanol in the presence of sodium hydroxide and ethylene oxide at 0°C. The mixture was heated to 70°C and maintained for a period of 3 h. Hydroxypropylated xylan was prepared using similar method. It was observed that the degree of substitution was directly related to the pH of the reaction. Hydroxyalkylated xylan has also been synthesized to increase the solubility of xylan [28].

#### 2.6.2.4. Sulphoalkylation

This type of etherification is normally achieved by the use of dimethyl sulphoxide for a reaction time of 1–24 h. Sulphoalkylation of xylan has been demonstrated using dimethyl sulphoxide [28].

#### 2.6.2.5. Cyanoethylation

Aqueous sodium hydroxide and acrylonitrile are used as cyanoethylating agents [29]. Cyanoethylated guar gum has been prepared using these agents for the reaction time of 4 h. The degree of cyanoethylation was observed to increase with increasing acrylonitrile concentration and to decrease with increasing sodium hydroxide concentration.

#### 2.6.2.6. Benzylation

Benzyl bromide is the commonly used benzylating agent. For the benzylation of xylan, the hemicellulose was first hydrated in dimethyl sulphoxide. This was followed by the addition of benzylating agent and potassium hydroxide as catalyst. The reaction was allowed to proceed at 70°C for 20 h then at 85–90°C for 3 h.

#### 2.6.3. Cross-linking

Cross-linking is usually carried out to alter the swelling property of hemicellulose. For instance, guar gum grafted with acrylamide was cross-linked with glutaraldehyde forming hydrogel microsphere [30].

#### 2.6.4. Grafting

Grafting is usually carried out by incorporating vinyl monomer into a natural polymer in aqueous slurry. Ceric ammonium nitrate can induce graft copolymerization of acrylonitrile onto hemicellulose. Grafting of hemicellulose has not received much attention.

### 3. Emulsifying properties of specific hemicelluloses and derivatives

Emulsifying properties of polymers are based on their physical and surface properties [31, 32]. The emulsifying properties of specific hemicelluloses and derivatives that have been studied include xylan hemicellulose, barley straw hemicellulose, wheat straw hemicellulose, corn fiber hemicellulose, locust bean (carob) gum, guar gum, soy bean hemicellulose, konjac hemicellulose, prosopis seed hemicellulose and afzelia seed hemicellulose.

#### 3.1. Xylan hemicellulose

Xylans are present in bran of cereals, including wheat, barley, rice, corn and sorghum. They are also present in many plant materials such as sorghum stalk, sugar cane and corn stalks and cobs as well as husks from starch production [9].

Xylans form oil-in-water emulsions with stability which is comparable to tween 20 [12]. Introduction of long alkyl chain and ionic substituents to xylan during etherification confers amphiphilic character. Such etherified xylans are characterized by high surface tension lowering effect. They also possess better emulsifying properties.

### 3.2. Barley straw and hull hemicellulose

Barley hulls and straw contain very useful arabinoxylans, other carbohydrates and non-carbohydrate constituents [33]. To obtain the arabinoxylan, the barley hulls and straws were de-starched and then subjected to alkaline hydrogen peroxide extraction followed by ethanol precipitation as described by Daus *et al.* [33]. The precipitate was subsequently fractionalized. The functional water-soluble non-caloric arabinoxylan was isolated as the B fraction. It was observed that Barley hulls contained more of the Hemicellulose B fraction (20.51%) than the barley straws (7.41 to 12.94%).

Analysis of the hemicellulose B fractions from both the hulls and the straw for sugar composition showed that they are typical arabinoxylans containing galactose, glucose and acidic sugar residues in the side chains. The arabinoxylans from the straws were found to be superior oil-in-water emulsifiers compared to those from the hulls. It was also found that the hemicellulose B fractions contain protein, which could contribute to their emulsion stabilizing property.

### 3.3. Wheat straw hemicellulose

Wheat straw contains about 32.5% hemicellulose on the average with xylose being the predominant sugar. Wheat straw hemicellulose has been found to be very useful as thickener, stabilizer, film former and emulsifier [34]. Succinylation of the hemicellulose was demonstrated by Sun *et al.* [35]. The esterification process was carried out using succinic anhydride in aqueous alkali. The wheat straw hemicellulose succinate produced was found to be of low degree of substitution ranging from 0.017 to 0.21. The emulsifying property of the hemicellulose was enhanced by the succinylation reaction.

### 3.4. Corn fiber hemicellulose

Corn fiber is an abundant by-product of the wet milling of corn kernels. It can also be obtained from the commercial corn dry milling process. Corn fiber contains fractions from the kernel's pericarp and endosperm. The gum, an arabinoxylan, can be obtained from the fiber using alkaline hydrogen peroxide [36].

Corn fiber gum has a highly branched structure made up of a  $\beta$ -(1-4)-xylopyranose backbone decorated with side chains of L-arabinofuranose residues on both primary and secondary hydroxyl groups [37]. The sugar composition of corn fiber gum is as follows: arabinose (33–35%), xylose (48–54%), galactose (7–11%) and glucuronic acid (3–6%).

The emulsifying properties of the gum have been determined by assessing the emulsion stability of the diluted emulsions formulated with the gum using the method as described by Pearce and Kinsella [38]. The gum is known to be characterized by a low solution viscosity.

It is a better stabilizer for oil-in-water emulsion compared to acacia gum. The presence of significant amounts of lipid and protein contributes to the excellent oil-in-water emulsion stabilizing character of the gum.

In the work of Yadav *et al.* [39], two different approaches were employed for the extraction of arabinoxylan from the corn fiber. The two approaches were one-step alkaline treatment and sequential alkaline treatment followed by alkaline hydrogen peroxide bleaching. Corn fiber gum obtained by single-step alkaline treatment was found to possess a higher emulsion stabilizing capacity compared to the fraction isolated by sequential alkaline treatment and alkaline hydrogen peroxide bleaching. The superior emulsifying properties of the extract from one-step alkaline treatment correlate with its higher protein and lipid contents, its higher average molecular weight and a more compact structure.

Corn fiber gum extract from wet-milled pericarp fiber has higher protein content compared to the extract from dry-milled pericarp fiber. It is comparatively a superior emulsifier. The better emulsifying properties can be linked to the presence of phenolic acids, lipids and protein. Corn fiber gum is characterized by high molecular weight and branching which contribute to its excellent emulsifying properties. Its emulsifying character is superior to that of acacia [39].

### **3.5. Locust bean hemicellulose (locust bean gum)**

Locust bean hemicellulose is a galactomannan. It is abundantly present in the endosperm of the seed. The solubility and viscosity of the gum depend on the amount of the galactose residue [12]. Therefore, the functionality of the gum depends on the amount of galactose residue.

### **3.6. Guar gum**

Guar gum is made up of linear  $\beta$ -(1-4) linked d-mannose backbone and side chain predominantly of D-galactose. Therefore, it is a galactomannan. The molecular weight of guar gum is about 220,000 [40]. Just like locust bean hemicellulose, the solubility and viscosity and hence the emulsifying property of this hemicellulose depend on the amount of galactose residue [12].

### **3.7. Soy bean hemicellulose**

While soy bean seed is rich in protein, the hull of the seed is rich in hemicellulose. Hence, a protein-polysaccharide conjugate can potentially combine the outstanding emulsifying properties of the protein with the stabilizing effect of the polysaccharide [41]. Soy hull hemicellulose-soy protein isolate conjugates were prepared by Maillard reaction and assessed for stabilizing of oil-in-water emulsion [41]. The results showed that there was a reaction between amino group and carbonyl group which resulted in the disappearance of some functional groups and the appearance of new groups in the conjugates. Better stabilization of emulsion was obtained by the use of the conjugate as emulsifying agent compared to the individual components (soy hull hemicellulose and soy protein isolate). Hence, a novel emulsifying agent can be produced from soy hull hemicellulose and soy protein isolate suitable for formulation of emulsions with improved physical and chemical stability.

### 3.8. Konjac hemicellulose

Konjac hemicellulose is a glucomannan [12]. The solubility and viscosity modification power of konjac can be enhanced by methylation. Methylated konjac glucomannan is highly water soluble and the viscosity varies with the degree of substitution. The work of Kishida and Okimasu [27] showed that methylated konjac glucomannan with degree of substitution of 0.45 had the greatest degree of solvation and highest viscosity. Invariably, the methylated glucomannan with this degree of substitution showed the best emulsifying property.

### 3.9. Prosopis seed hemicellulose (Prosopis gum)

*Prosopis africana* seed gum is a xylogalactan hemicellulose; the major sugar units being xylose and galactose while fructose and glucose are present in smaller quantities [42]. The physical and surface properties of two hemicelluloses (prosopis and afzelia seed hemicelluloses) have been studied in comparison with sodium carboxymethylcellulose by Olorunsola *et al.* [43]. The work showed that even though the viscosity of 2%w/v prosopis gum is significantly lower than that of sodium carboxymethylcellulose, it is significantly higher than that of acacia gum which was earlier investigated [44]. It can be concluded from the two studies [43, 44] that the surface tension lowering effect of prosopis gum is comparable with those of the two well-studied polymers (acacia gum and sodium carboxymethylcellulose).

Prosopis gum has been evaluated for emulsifying properties [13]. Paraffin oil-in-water emulsions having a fixed oil-to-water ratio were prepared using concentrations of prosopis gum ranging from 2 to 3.5% w/v. Emulsions containing equivalent concentrations of acacia gum were also prepared. All the emulsions prepared were stored at room temperature (25°C) and studied for stability over a period of 8 weeks.

In assessing the emulsifying properties of the prosopis gum, the creaming rate, globule size analysis and rheological properties of the emulsions were evaluated. It was concluded that prosopis gum possesses good emulsifying property and could be used to formulate pharmaceutical preparations requiring this property.

### 3.10. Afzelia seed hemicellulose (Afzelia gum)

*Afzelia africana* seed gum is a xyloglucan hemicellulose. The major sugar units are glucose and xylose while those present in smaller quantities are galactose, mannose, arabinose and uronic acid [14]. Viscosity of 2% w/v afzelia gum is significantly lower than that of sodium carboxymethylcellulose but higher than that of standard acacia gum [43, 44]. The surface tension lowering effect is, however, lower than that of acacia gum.

Emulsifying properties of afzelia seed hemicellulose (afzelia gum) in comparison to acacia gum have been investigated [1]. Liquid paraffin emulsions were prepared using different concentrations (1, 2, 3, 5 and 10% w/v) of the two gums. The viscosities of the preparations were measured. Each of the preparations was also observed for creaming and cracking after 5 days of storage.

The viscosities of the preparations are shown in **Table 1**. Viscosity of liquid paraffin emulsion containing afzelia gum is higher than that containing acacia gum at all gum concentrations

Gum concentration (%w/v)	Viscosity of emulsion (mPa.s)	
	Afzelia gum	Acacia gum
1	47.49	14.64
2	89.87	14.94
3	141.90	15.84
5	222.30	16.08
10	668.90	23.56

Adapted from Olorunsola and Majekodunmi [1].

**Table 1.** Viscosities of liquid paraffin emulsions.

used. In fact, the viscosity of liquid paraffin emulsion containing 1% w/v afzelia gum is higher than that containing 10% w/v acacia gum.

On examining the preparations for creaming and cracking after 5 days, all the preparations containing acacia gum had cracked apart from that containing 10% w/v which showed 28% creaming. For preparations containing afzelia gum, 1% w/v showed cracking; 2, 3 and 5% w/v showed 36, 16 and 4% creaming, respectively while 10% w/v was stable. The stability of liquid paraffin emulsion containing 3% w/v afzelia gum is comparable with that of emulsion containing 10% w/v acacia gum. Therefore, afzelia gum can be used at one-third of concentration of acacia gum to prepare emulsions of similar stability [1]. The gum is superior to the well-studied natural emulsifying agent, acacia gum.

## 4. Conclusion

Hemicelluloses are abundantly available, and only second to celluloses, in all plant polysaccharides. They are of wide variation in terms of composition. They bring about emulsification by viscosity modification and by formation of multimolecular films around each globule of the dispersed phase. Hemicelluloses possess emulsifying properties that are superior to typical gums. They are also amenable to different chemical modifications capable of increasing their stability to microbial and chemical degradations and invariably improving their emulsifying properties. Even though hemicelluloses have been neglected for a long time, they are promising emulsifying agents.

## Author details

Emmanuel O. Olorunsola\*, Ekaete I. Akpabio, Musiliu O. Adedokun and Dorcas O. Ajibola

\*Address all correspondence to: olorunsolaao@yahoo.com

University of Uyo, Uyo, Nigeria

## References

- [1] Olorunsola EO, Majekodunmi SO. Emulsifying properties of afzelia gum in liquid paraffin emulsion. *International Journal of Pharmacy and Pharmaceutical Sciences*. 2016; **8**(11):195-198
- [2] Golkar A, Nasirpour A, Keramat J, Desobry S. Emulsifying properties of Angum gum (*Amygdalus scoparia Spach*) conjugated - Lactoglobulin through Maillard type reaction. *International Journal of Food Properties*. 2015; **18**:2042-2055
- [3] Qiu D, Yang L, Shi YC. Formation of vitamin E emulsion stabilized by octenysuccinic starch: Factors affecting particle size and oil load. *Journal of Food Science*. 2015; **80**(4):680-686
- [4] Liu X, Lin Q, Yan Y, Peng F, Sun R, Ren J. Hemicelluloses from plant biomass in medical and pharmaceutical application: A critical review. *Current Medicinal Chemistry*. 2017. DOI: 10.2174/0929867324666170705113657
- [5] Scheller HV. Hemicelluloses. *Annual Review of Plant Biology*. 2010; **61**(1):263-289
- [6] Ren Y, Picout DR, Ellis PR, Ross-Murphy SB, Reid JS. A novel xyloglucan from seeds of *Afzelia africana* Pers.: Extraction, characterization, and conformational properties. *Carbohydrate Research*. 2005; **340**:997-1005
- [7] Fry SC. Cell wall and fibres. In: *Encyclopedia of Applied Plant Sciences*. Cambridge: Elsevier; 2003. pp. 75-87
- [8] Belgacem MN, Gandini A, editors. *Monomers, Polymers and Composites from Renewable Resources*. Amsterdam: Elsevier; 2008
- [9] Kayserilioglu BS, Bakir U, Yilmaz L, Akkas N. Use of xylan, an agricultural by-product, in wheat gluten based biodegradable films: Mechanical, solubility and water vapour transfer rate properties. *Bio/Technology*. 2003; **87**(3):239-246
- [10] Den-Haan R, Van-Zyl WH. Enhanced xylan degradation and utilisation by *Pichia stipitis* overproducing fungal xylanolytic enzymes. *Enzyme and Microbial Technology*. 2003; **33**(5):620-628
- [11] Habibi Y, Vignon MR. Isolation and characterization of xylans from seed pericarp of *Argania spinosa* fruit. *Carbohydrate Research*. 2005; **340**(7):1431-1436
- [12] Hansen NML, Plackett D. Sustainable films and coatings from hemicelluloses: A review. *Biomacromolecules*. 2008; **9**(6):1493-1505
- [13] Adikwu MU, Udeala OK, Ohiri FC. Emulsifying properties of *Prosopis africana* gum. *STP Pharm Science*. 1994; **4**:298-302
- [14] Builders PF, Chukwu C, Obidike I, Builders MI, Attama AA, Adikwu MU. A novel xyloglucan gum from seeds of *Afzelia africana* se. Pers.: Some functional and physicochemical properties. *International Journal of Green Pharmacy*. 2009; **3**(2):112-118

- [15] Yang H, Yan R, Chen H, Dong HL, Zheng C. Characteristics of hemicelluloses, cellulose and ligning pyrolysis. *Fuel*. 2007;**86**(12-13):1781-1788
- [16] Holtzaple MT. Hemicelluloses. In: *Encyclopedia of Food Science and Nutrition*. 2nd ed. San Diego: Academic Press; 2003. pp. 3060-3071
- [17] Buranov AU, Mazza G. Extraction and characterization of hemicelluloses from flax shives by different methods. *Carbohydrate Polymers*. 2010;**79**(1):17-25
- [18] Monot F, Borzeix F, Bardin M, Vandecasteele J. Enzymatic esterification in organic media: Role of water and organic solvent in kinetics and yield of butyl butyrate synthesis. *Applied Microbiology and Biotechnology*. 1991;**35**(6):759-765
- [19] Carson JF, Maclay WD. Ester of lima bean pod and corn cob. *Journal of American Chemical Society*. 1948;**70**(1):293-295
- [20] Buchanan CM, Buchanan NL, Debenham JS, Gatenholm P, Jacobsson M, Shelton MC, Watterson TL, Wood MD. Preparation and characterization of arabinoxylan esters and arabinoxylan ester/cellulose ester polymer blends. *Carbohydrate Polymers*. 2003;**52**: 345-357
- [21] Rowell RM, Simonson R. Vapour phase acetylation of southern pine, Douglas-fir and aspen wood flakes. *Journal of Wood Chemistry and Technology*. 1986;**6**(2):293-309
- [22] Sun RE, Sun XF, Zhang FY. Succinoylation of wheat straw hemicelluloses in N,N-dimethylformamide/lithium chloride system. *Polymer International*. 2001;**50**(7):803-811
- [23] Daus S, Petzold-Welcke K, Kotteritzsch M, Baumgaertel A, Schubert US, Heinze T. Homogeneous sulphation of xylan from different sources. *Macromolecular Materials and Engineering*. 2011;**296**(6):551-561
- [24] Schweiger RG. Nitrite esters of polyhydroxyl polymers. *Journal of Organic Chemistry*. 1976;**41**:90-93
- [25] Elias HG. Polysaccharides. In: *Macromolecules*. Boston: Springer; 1984. pp. 1053-1090
- [26] Kamel M, El-Thalouth IA, Amer MA, Ragheb A, Nassar SH. Chemical modification of guaran gum part 1: Carboxymethylation in aqueous medium. *Starch/Staerke*. 1992;**44**(11): 433-437
- [27] Kishida N, Okimasu S. Preparation of water-soluble methyl konjac glucomannan. *Agricultural and Biological Chemistry*. 1978;**42**(3):669-670
- [28] Luo Z, Li H. Synthesis and characterization of crosslinking etherification bagasse xylan. *Advanced Materials Research*. 2014;**960&961**:204-207
- [29] Bruson HA. Cyanoethylation. *Organic Reaction*. 2011;**5**(2):79-135
- [30] Suppinath KS, Aminabhavi TM. Water transport and drug release study from cross-linked polyacrimide grafted guar gum hydrogel microspheres for the controlled release application. *European Journal of Pharmaceutics and Biopharmaceutics*. 2002;**53**(1):87-98

- [31] Munoz J, Rincon F, Alfaro MC, Zapata I, Fuente J, Beltran O, dePinto GL. Rheological properties and surface tension of *Acacia tortuosa*. Carbohydrate Polymers. 2007;**70**:198-205
- [32] Cui Z, Chen Y, Kong X, Zhang C, Hua Y. Emulsifying properties and oil/water (O/W) interface adsorption behaviour of heated soy proteins: Effects of heating concentration, homogenizer rotating speed and salt addition level. Journal of Agricultural and Food Chemistry. 2014;**62**(7):1634-1642
- [33] Yadav MP, Hicks KB. Isolation of barley hulls and straw constituents and study of emulsifying properties of their arabinoxylans. Carbohydrate Polymers. 2015;**132**:529-536
- [34] Fang JM, Sun RC, Salisbury D, Fowler P, Tomkinson J. Comparative study of hemicelluloses from wheat straw by alkali and hydrogen peroxide extractions. Polymer Degradation and Stability. 1999;**66**(3):423-432
- [35] Sun R, Sun XF, Bing X. Succinylation of wheat straw hemicellulose with a low degree substitution in aqueous system. Journal of Applied polymer. 2002;**83**(4):757-766
- [36] Yadav MP, Johnston DB, Hotchkiss AT, Hicks KB. Corn fibre gum: A potential gum Arabic replacer for beverage flavour emulsion. Food Hydrocolloids. 2007;**21**:1022-1030
- [37] Saulnier L, Vigouroux J, Thibault JF. Isolation and partial characterization of feruloylated oligosaccharides from maize bran. Carbohydrate Research. 1995;**272**:241-253
- [38] Pearce KN, Kinsella JE. Emulsifying properties of proteins: Evaluation of a turbidometric technique. Journal of Agricultural and Food Chemistry. 1978;**26**:716-723
- [39] Yadav MP, Johnston DB, Hicks KB. Fractionation, characterization and study of emulsifying properties of corn fibre gum. Journal of Agricultural and Food Chemistry. 2008;**56**:4181-4187
- [40] Aspinall GO. Molecular Biology. Vol. 2. New York: Academic Press; 1983 p. 462
- [41] Wang L, Wu M, Liu MM. Emulsifying and physicochemical properties of soy hull hemicellulose – Soy protein isolate conjugates. Carbohydrate Polymers. 2017;**163**:181-190
- [42] Adikwu MU, Yoshikawa Y, Takada KT. Bioadhesive delivery of metformin using prosopis gum with antidiabetic potential. Biological and Pharmaceutical Bulletin. 2003;**26**(5):662-663
- [43] Olorunsola EO, Bhatia PG, Tytler BA, Adikwu MU. Physicosurface properties of afzelia and prosopis hemicellulosic gums: Potential surface active agents. IOSR Journal of Pharmacy and Biological Science 2015;**10**(4) vers 3:1-7
- [44] Olorunsola EO, Bhatia PG, Tytler BA, Adikwu MU. Surface activity and hydrophile-lipophile balance of hydrophilic polymers from exudates of cashew and khaya plants. International Journal of Biological and Pharmaceutical Research. 2014;**5**(5):443-448