Int. j. adv. multidisc. res. stud. 2025; 5(3):1736-1744

Received: 07-05-2025
Accepted: 17-06-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Opportunities for the Development of Food Stabilizers in Zimbabwe from Indigenous Plant Sources: A Review

[1] Dinga Njini Moyo, [2] Augustine Mpofu, [3] Kudakwashe Chitindingu

[1] Department of Food Processing Technology, School of Industrial Sciences and Technology, Harare Institute of Technology, Harare, Zimbabwe

[2] Department of Food Science and Technology, Chinhoyi University of Technology, P. Bag 7724, Chinhoyi, Zimbabwe

[3] School of Health Sciences and Technology, Chinhoyi University of Technology, P. Bag 7724, Chinhoyi, Zimbabwe

DOI: https://doi.org/10.62225/2583049X.2025.5.3.4521

Corresponding Author: **Dinga Njini Moyo**

Abstract

The burgeoning global demand for natural and sustainable food ingredients has intensified the interest in indigenous plant resources, particularly in regions rich in biodiversity, such as Zimbabwe. Despite housing over 5,000 plant species, approximately 10% of which possess documented food and medicinal applications, the potential of indigenous plants as food stabilizers remains largely untapped. This review investigates the functional properties of these plants, particularly their polysaccharides, which are crucial for emulsification and stabilization in the food industry. It examines the formation and storage of polysaccharides such as mucilage, cellulose, and hemicellulose within various plant tissues to elucidate their roles in food systems. Furthermore, the review defines food stabilizers as macromolecular polymers that impart essential functionalities, such as thickening, gelling, and emulsifying, thereby enhancing product stability and texture. Specific indigenous stabilizers, including cellulose derivatives, pectin, gums, and alginates, offer promising avenues for commercial application. This review ultimately calls for a concerted effort to integrate traditional knowledge with modern scientific exploration, aiming to harness these indigenous plant resources for the development of innovative, nutritionally, and economically valuable food products.

Keywords: Indigenous Plants, Food Stabilizer, Polysaccharides, Emulsification, Sustainable Food Systems

Introduction

Current consumers emphasize the cost, nutritional value, and satiety properties of food products. The choice of various functional ingredients is as important as the product to be produced. While many ingredients are used for the production of desired products, the focus has now shifted to those derived from natural resources. There are a wide range of plants in Zimbabwe and Africa, which have attracted many applications in food, pharmaceuticals, and medicine. Despite the lack of scientific knowledge on most of these vegetation types, traditional methods have been used to benefit societies for decades. This review details how indigenous plants found in Zimbabwe may be used as food stabilizers in the food industry.

Status on the utilization of Indigenous plants in Africa

According to Interreg Central Europe (I-CON, 2017), traditional and regional food can play an important role in feeding around 925 million people who suffer from hunger and malnutrition worldwide, even though the food has been undervalued or judged as forgotten. This means that traditional foods are an integral part of the daily diet of most people, particularly in the developing world. Despite being a source of energy, traditional foods also provide necessary macro- and micronutrients. However, in terms of cultivation and value addition of traditional plants, little is being done; rather, the focus has shifted to cash crops. It is evident that the diversity and resistance of traditional plants to drought and diseases can be of greater importance in stabilizing food security. In 2013, Zimbabwe was known to have more than 5000 plant species, and more than 10% of these plants have known food and medicinal applications (Gelfand *et al*., 1985 and Maroyi, 2013) [22, 36]. Traditionally, leaves, roots, tubers, corms, rhizomes, bulbs, seeds, buds, shoots, stems, pods, and flows form a part of the main diet. Of all African vegetables, those

that have been the continent's greatest are cowpea, yam, and okra (National Research Council, 2016). Many studies have revealed the medicinal properties of the traditional plants found in Zimbabwe (Maroyi, 2013 [36]; Gelfand *et al*., 1985 [22]; Mukamuri, 1998 [43]; Chitemerere & Mukanganyama, 2011 [9]; Ngarivhume *et al*., 2015 [46]; Ngarivhume *et al*., 2014). However, little research has been conducted on other functionalities, such as emulsification and stabilization.

The introduction of traditional plants into the commercial food industry has been deterred by many factors. The National Research Council (2016) illustrated that the African continent has many food sources that have no scientific support, official promotion, or inclusion in development schemes. Shava (2005) [52] indicated that current research places more emphasis on the documentation of knowledge about indigenous plants, while lacking knowledge on their applications. The integration of existing knowledge and possible viable applications cannot only preserve our scarce indigenous plants but also lead to the production of valuable industrial products of nutritional, medicinal, and economic value. Africa's own edibles have yet to receive due attention, let alone a chance to develop their potential under the power and promise inherent in modern capabilities. It is time to open minds to the power and promise of indigenous edible wealth (National Research Council, 2016).

To ensure the total application of indigenous plants as food, Gomez (1988) [25] indicated that they are needed for the development of valuable food resources through improved production practices, storage, preservation, and utilization technologies that are directed towards exploiting their potential. Genetic engineering and breeding of indigenous plants to increase productivity and optimize plant functionality. Shava (2005) [52] specified 206 wild food plants that were further categorized as edible roots (roots, tubers, rhizomes, and corms), edible bulbs, edible leaves (leaves, stems, stalks, and inflorescences), edible fruits (berries, drupes, aggregates, and pods), edible grains (grasses), edible seeds, and edible gums.

Formation and storage of polymers in higher plants

The anatomy of the growing plants showed that they have a flexible primary plant cell wall. The primary cell wall may later reign to a thick secondary cell wall, which is used in the manufacturing of many products, including biofuels, thickeners, textiles, and lumber (Voiniciuc *et al*., 2015) [60]. According to Clifford *et al*. (2002) [12], a large number of mucilage-containing cells are usually found in the upper epidermis and in extracellular mucilage-containing cavities in the leaf veins and stem cortex. The main sugar constituents of the water-soluble mucilage extract are rhamnose, glucose, and galactose. Mucilage can be found in the rhizomes, roots, seed endosperms, and leaves. Mucilage has a higher concentration of hydroxyl groups, and hence, a high water-binding capacity. Despite their low abundance, xylans and heteromannans appear to control mucilage properties. Information on the development of specific plant cells and mucilaginous material was also referenced in Voiniciuc *et al*. (2015) [60], Sechet *et al*. (2018) [51], Buckeridge (2010) [7], Naqvi *et al*. (2011) [44], North *et al*. (2014) [47], Clifford *et al*. (2002) [12], and He *et al*. (2017) [27].

Formation of Seed Coat Epidermal (SCE) Cells

The cell walls of seeds are reached by mannans and galactomannans. SCE cells synthesize one primary wall and two distinct secondary walls (Beeckman *et al*, 2000) [4]. Four days post-anthesis (DPA), SCE cells fully expand and accumulate in the amyloplast, which partially displaces the central vacuole (**V**) from to 5-8 DPA, and synthesize mucilaginous polysaccharides and secrete them in a polar manner (Western *et al*., 2000 and Young 2008) [61, 63]. The deposition of a thick ring of mucilage resulted in the formation of a volcano-shaped cytoplasmic column as shown in Fig 1. From 9-13 DPA, the cytoplasmic column is gradually displaced by the deposition of a secondary wall called the columella; by 18 DPA, the SCE cells reach maturity and are fully desiccated (Western *et al*., 2000; Naqvi *et al*, 2011; North *et al*., 2014) [61, 44, 47].

The mucilage is stored in SCE until the mature seed is hydrated, and the mature seeds quickly release copious amounts of mucilage from SCE cells (Voiniciuc *et al*, 2015 and Sechet *et al*, 2018) [60, 51].

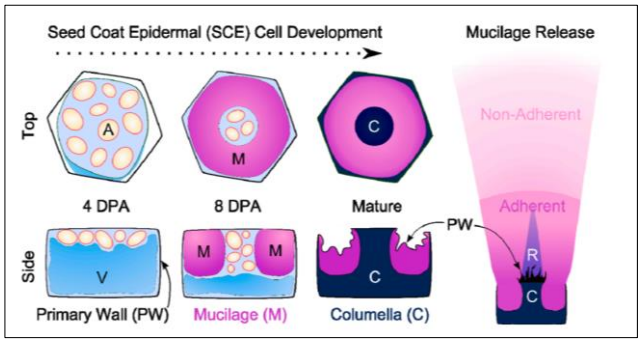


Fig 1: Structural model of the seed coat epidermal (SCE) development and extruded mucilage structure. (A)- young cells containing amyloplast and vacuole (V). C -is a mucilage ring produces by each SCE followed by a columella. Hydration of the dry seed makes the mucilage to burst out, rupturing the primary cell wall and forming two-layered capsule and a ray-like structure

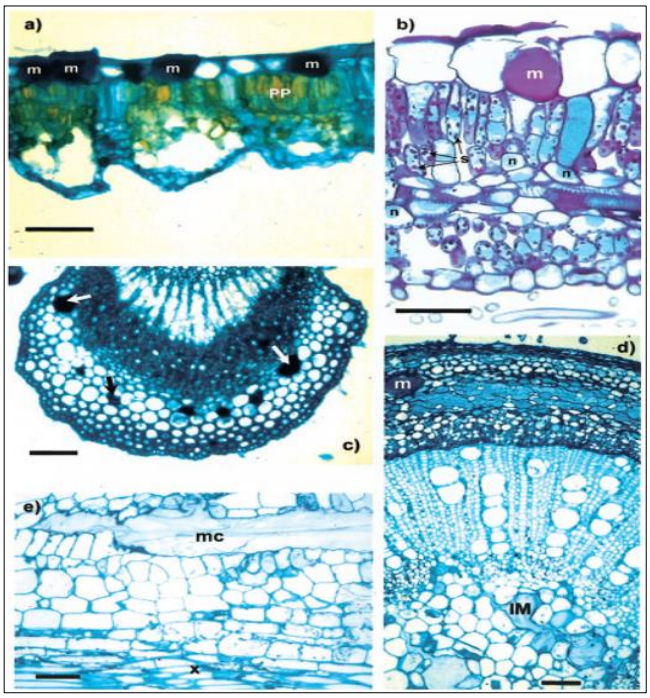
According to Voiniciuc *et al*. (2015) [60] and Buckeridge (2010) [7], extruded mucilage can be classified into adherent and non-adherent capsules. The nonadherent capsule represents approximately 65% of the total mucilage and is easily extracted from the seed. Unlike the adherent layer, which is approximately 35%, it is difficult to remove from the seed even with harsh chemical treatments (Voiniciuc *et al*., 2015; Western *et al*., 2000 and Yu *et al*., 2014) [60, 61, 64]. The inner layer of the seed was associated with a ray-like structure that radiated outwards from the cell wall fragments at each columella-Fig. 1 (Western *et al*., 2000 and Voiniciuc *et al*., 2015) [61, 60]. Factors that affect mucilage properties include mutants that affect the biosynthesis of cellulose, hemicellulose, or arabinoxylans (North *et al*., 2014) [47]. The structure and properties of mucilage may also be affected by the presence of biotic and abiotic stresses, earlier development in plant development, manner of seed harvesting, and extraction processes (Buckeridge, 2010; Western *et al*, 2000 and North *et al*., 2014) [7, 61, 47].

Leaf anatomy and localization of mucilage

Clifford *et al*. (2002) [12] demonstrated the storage of polymeric materials using *Ziziphus* species as an example. The transverse section from fresh leaf lamina material showed that both *Ziziphus* species have characteristic C_3 anatomy, with an abundance of mucilaginous material exclusively localized in the adaxial epidermal cells, which stained intensely with the mucopolysaccharide stain alcian

blue (Clifford *et al*, 2002) [12], as shown in Fig 2. The mucilage stained positively with periodic acid-Schiff reagent (PAS). Staining with the PAS/toluidine blue-O combination for light microscopy showed no discernible nuclei, vacuoles, or cellular organelles in the epidermal mucilage cells, but numerous starch grains and nuclei were clearly visible in the mesophyll parenchyma (Mariani *et al*, 1988) [35]. Mucilage produced in the Golgi accumulates initially in the plasmalemma and cell wall, and after prolonged mucilage deposition, the cytoplasm becomes compressed against the outer periclinal cell wall and degenerates (Bakker and Gerritsen, 1992) [2].

Ziziphus spp. have been documented to secrete intracellular mucilage, while high polysaccharide subspecies of *Hemizonia luzifolia* exhibit substantial amounts of extracellular mucilage within the spongy mesophyll layer (Morse, 1990) [41]. Additionally, significant mucilage accumulation has been observed in the cortical and peripheral parenchyma of leaf veins in *Ziziphus spp.* In the stem, intercellular spaces in both the central cortex and the peripheral cortex surrounding the phloem are filled with mucilage. When examined in longitudinal sections, this mucilage forms intercellular channels, similar to findings in Hibiscus schizopetalus (Bakker and Gerritsen, 1992) [2].



Source: Clifford *et al*., 2002) [12]

Fig 2: (a) Fresh transverse section of the leaf lamina of Z. mauritiana, displaying abundant mucilage (m) stained blue, with chlorophyll appearing green in the palisade parenchyma (PP). (b) This section also highlights mucilage (m) and abundant starch grains (s) found throughout both palisade and spongy parenchyma, with distinctly stained nuclei (n). (c) Fresh transverse section of a main leaf vein in Z. mauritiana, showing intensely stained tracts of intercellular mucilage (arrows) in the peripheral cortex. (d) Transverse section of the resin-embedded stem of Z. mauritiana stained with azure/methylene blue, revealing large mucilage-filled intercellular spaces (IM) in the cortex, along with additional extracellular mucilage (m) in the peripheral cortex. (e) Longitudinal section of the resin-embedded stem of Z. mauritiana stained with azure/methylene blue, illustrating an intercellular mucilage channel (mc) traversing the inner cortex adjacent to the xylem (x)

Storage in stems

He *et al*. (2017) [27] and Choct (1997) [10] found that polysaccharides in plant stem and seed endosperm biomass include starch and non-starch polysaccharides. Non-starch can be classified into three groups: Cellulose, non-cellulose (mannan polysaccharides), and pectic polysaccharides (Choct, 1997) [10]. The mannan family can be divided into linear mannan, glucomannan, galactomannan (GM), and galactoglucomannan (GMM) (Choct, 1997; Moreira, 2008) [10, 40]. Using histochemical analysis of polysaccharides using periodic acid-Schiff (PAS) staining and ultramicroscopic observation, the polysaccharide profile in the stems was observed using *D. officinale* plant species as an example (He *et al*., 2017) [27]. The anatomy of the transverse sections from the fresh stem of *D. officinale* showed that several vascular bundles were dispersed throughout the stem, similar to other monocots (Fig 3A). The ground tissue was compromised by a mass of parenchyma cells, among which vascular bundles were embedded (Fig 3A and 3B) (He *et al*., 2017) [27]. The ground tissue was stained with pass as strongly labelled as compared to the parenchyma and cortical cell walls, which were weakly labelled (Fig 3B). Polysaccharides from granules in parenchyma cells stained intensely purple with polysaccharide stains (Fig B & C). A complicated membrane system in which polysaccharide granules were embedded was present in the parenchyma cells. Polysaccharide granules had various forms of unequal sizes and were localized in the plastids. Mannan polysaccharides in the stems of *D. officinale* serve as storage materials rather than structural polysaccharides. Starch is the principal reserve polysaccharide and is considered the only polysaccharide that is formed in the plastids of higher plants (Meier and Reid, 1982) [38]. The non-starch polysaccharides in *D. officinale* stems form granules localized in plastids, similar to starch grains (He *et al*., 2017) [27].

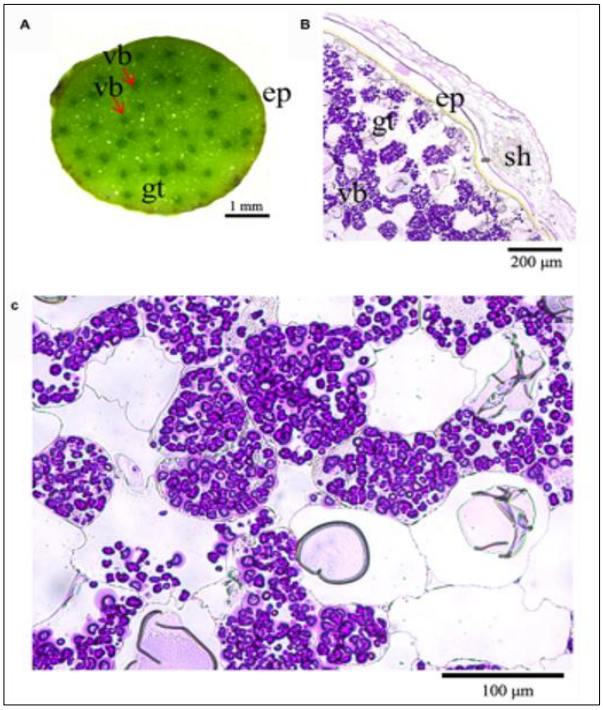


Fig 3: Histochemical analysis of the localization of polysaccharides in D. officinale stems. (A) Cross section of D. officinale. (B) Determination of polysaccharides by PAS method. Enlarged view of B: ep-epidermis; gt-groud tissue; vb-vascular bundles; sh-sheath

Food Stabilizers-Generic Definition

Food stabilizers are defined as groups of substances or materials used in food systems, such as holders, colloids/hydrocolloids, binders, improvers, and fillers (Goff & Sahagian, 1996 and Sommer, 1932) [24, 53]. These materials are macromolecules in nature (polymers) and are capable of interacting with different types of solvents (Bahramparvar & Tehrani, 2011) [1]. In particular, they are water-soluble; hence, they are referred to as hydrocolloids (Garti and Reichman, 1993) [21]. The polymeric nature of the stabilizers suggests that they are composed of various monomeric units. Clarke (2004) [11] indicated that stabilizers consist of monomeric units amounting to ~10^3 and have molecular weights of ~10^5-10^6 (Bahramparvar & Tehrani, 2011) [1]. The low hydrophobicity, limited flexibility (i.e., rotational restriction of the functional groups), and interfacial density packing limitation of polysaccharides are believed to be caused by the limited number of monomeric units, as stated by Garti and Reichman (1993) [21]. In contrast, proteins contain both hydrophilic and hydrophobic moieties that display a high degree of flexibility and hydrophobicity. According to Stainsby (1988) [54], gums/polysaccharides adsorb onto solid or liquid surfaces weakly and slowly with a limited surface load.

Stabilizers are sometimes confused with emulsifiers. Dickinson and Stainsby (1988) [18] specified that an emulsifier is a single chemical or a mixture of components that promotes emulsion formation and short-term stabilization by interfacial activation. A stabilizer is a single chemical component or a mixture of components that offers long-term stability on the emulsion, possibly by a mechanism involving adsorption, but not necessarily so. Thus, emulsification is usually achieved by a steric mechanism (chemical interactions), as opposed to stabilization, which is attained through mechanical mechanisms (physical interactions) (Garti and Reichman, 1993) [21].

The mode of action of polymers involves adsorption and non-adsorption. Food particles can be prevented from coalescing if the polymer covers the particle surfaces with a thick protective layer. Thus, the coated particles strongly repel one another at close range through a combination of polymeric elastic and osmotic effects, which are said to be sterically stabilized (Garti and Reichman, 1993) [21]. This type of stabilization is achieved using copolymers with a combination of anchoring groups and dangling chains. The anchoring groups should have a strong affinity to the particle surface and a low affinity to the continuous phase, and the dangling chains should act in opposite directions. The adsorbed copolymer should be sufficient to effectively cover the surface of the particles, and the thickness of the polymer should be sufficient for two particles to achieve pair separation. Garti & Reichman (1993) [21] explained that a high molecular mass favors thick film formation and hence good steric stabilization, as opposed to thin layers, as observed in homopolymers (composed of many identical adsorbing segments).

In the case of incomplete coverage, a single polymer chain becomes attached to more than one particle, that is polymer bridging. Milani and Maleki (2012) [39] showed that proteins have significant hydrophobicity and flexibility; hence, they can readily adsorb onto particles or oil, and there are considered emulsifiers with short-term stability action on dispersed particles (steric stabilization mechanism). In contrast, polysaccharides and hydrocolloids are considered stabilizers with limited adsorption ability and long-term stability (depletion stabilization mechanism) (Garti and Reichman, 1993) [21]. However, some hydrocolloids such as Gum Arabic adsorb strongly and effectively on oil droplets through their proteinaceous moieties, whereas other biopolymers such as guar gum and locust bean gum adsorb weakly and precipitate at the oil surface, with its hydrophobic mannose backbone facing the oil (Milani & Maleki, 2012) [39]. Therefore, they act as proteins.

Tasneem *et al*. (2014) [56] and Bahramparvar and Tehrani (2011) [1] stated that a good stabilizer is nontoxic, easily dispersed in other ingredients, does not affect excessive viscosity or separation or foam in the mix, passes easily through strainers and filters, economical (amount of stabilizer to be used), and impacts flavor and stability to processing temperatures (HTST). Stabilizers should also be compatible with other ingredients, such as proteins. The incorporation of stabilizers into any particular product results in various forms of interactions. The use of a particular stabilizer is also extended to its intended use, availability, and legal aspects.

Basic Properties and Functionality

Polysaccharides from plant sources (hydrocolloids or gums) are a diverse group of long-chain polymers characterized by their ability to form dispersions and/or gels when dispersed in water (Milani & Maleki, 2012) [39]. The ability of these polymers to dissolve and interact with water gives them the main functional properties, including thickening, gelling, emulsifying, surface activity, stabilization, fat replacers, and coating (Milani & Maleki, 2012; Burey *et al*, 2008; Cui, 2005) [39, 8, 13].

Stabilizers can prevent the separation of oil-in-water emulsions through steric and mechanical stabilization mechanisms (Milani & Maleki, 2012) [39]. According to Tasneem *et al*. (2014) [56], stabilizers can smoothen the texture of two or more heterogeneous or immiscible food materials. Dickinson (1988) [18] stated that the beneficial effects of stabilizers are related to the retardation of dispersed solid particles, decreased creaming rates of oil droplets and foams, prevention of the aggregation of dispersed particles, prevention of syneresis of gelled systems containing oils, and retardation of the coalescence of oil droplets.

It is necessary to know that a single or a group of stabilizers can be used for diverse products, such as beverages, dairy products, confectionaries, margarine, shortenings, and bakery (Maroziene & de Kruif, 2000) [37]. Stabilizers improve thickening, mouthfeel, product structure stability, water binding capacity, creamy consistency, and viscosity (Harrison, 1990 and Tasneem *et al*., 2014 [56]). The use of stabilizers enables the production of healthy low-calorie products by reducing high-energy foods, such as eggs and fat-fat replacers (Keogh & O'Kennedy, 1998) [32]. The water-binding properties are also helpful in extending and stabilizing the shelf quality of food products. Common foods that contain stabilizers include soups, gravies, salad dressings, sauces, toppings, ice creams, jams, jellies, gelled desserts, cakes, and candies (Milani & Maleki, 2012) [39].

In ice creams, stabilizers have been used to increase the viscosity of ice cream mix, improve aeration, cryoprotect and control meltdown, stabilize proteins to prevent wheying off, suspend flavoring particles, slow down moisture migration, create a stable form with easy cut-off and stiffness, and prevent volume shrinkage during storage (Bahramparvar & Tehrani, 2011; Tasneem *et al*., 2014) [1, 56]. These

functionalities were achieved at relatively low concentrations. Thus, the end ice cream product, made from an appropriate stabilizer, will have the desired properties such as body and texture smoothness, reduced crystal growth of ice and lactose during storage, and shape retention during melting (Tasneem *et al*., 2014) [56].

Some recent studies have indicated food-grade stabilizers that extend the shelf life of food products to prevent microbial attack. For instance, alginic acid $(C_6H_8O_6)_n$ a food stabilizer derived from brown algae, is widely used in ice cream, syrups, and desserts toppings (Tasneem *et al*., 2014) [56]. Hsieh *et al*. (2008) [28] showed that mannan polysaccharides have benefits such as increased cytokine expression and antioxidant and anticancer activities. Most stabilizers can chemically interact with food mixtures using the hydrogen and carboxyl radicals present in their structure (Tamime & Robinson, 1999) [55]. Apart from providing the basic stabilization of food physicochemical behavior and mechanical properties such as texture and kinetic stability in food emulsions, they also behave like nanostructures to control, retain, and intensify the existing color and flavor of food (Fiszman & Salvador, 1999; El Sayed *et al*., 2002; Bahramparvar & Tehrani, 2011) [20, 19, 1].

Common Food Stabilizers from Plants

Milani and Maleki (2015) and Cui (2005) [13] indicated that the main sources of hydrocolloids, natural polysaccharides, and gums are trees and bushes, extracts from plants or seaweeds, flours from seeds or grains, gummy slimes from fermentation processes, and many other natural products. Several hydrocolloids that can function as food stabilizers are listed in this review. These include cellulose and its derivatives, hemicellulose, pectin, gum, mucilage, fructans, alginates, and carrageenan.

Cellulose and Derivatives

Cellulose is one of the most abundant polysaccharides found in green algae, rye, barley, oat straw, wheat, sugar cane, corn stalks, and fungal membranes. Milani and Maleki (2015) listed the relative abundance of cellulose in some common plants, including cotton bolls (100%), flax (80%), jute (60-70%), and wood (40-50%). According to William *et al*. (2000) and Milani and Maleki (2015), cellulose has a dense molecular weight, containing (1→4)-linked β-D-glucopyranose residues. Cellulose can be purified to form purified microcrystalline cellulose (MCC), which is produced by converting fibrous cellulose to a dispersible gel or an aggregate of crystalline cellulose using hydrolysis (Milani & Maleki, 2015; Cui, 2005 [13]). These colloidal dispersions affect a wide range of desirable characteristics, such as suspension of solids, heat stability, ice crystal control, emulsion stabilization, texture modification, and fat replacement (Imeson, 2010) [29]. Carboxymethylcellulose (CMC) is a cellulose polymer derivative, which is an anionic, water-soluble polymer used to improve the viscosity of food systems (Bahramparvar & Tehrani, 2011; Glicksman, 1986) [1, 23]. Cellulose can also transform into methylcellulose (MC), which has thickening, surface activity, and film-forming properties (Milani & Maleki, 2015). According to Cui (2005) [13], MC derivatives, such as hydroxypropyl methylcellulose (HPMC), have also been widely used.

Hemicellulose

Hemicellulose is a heterogeneous group of polysaccharides that constitutes the cell walls of higher plants. Polysaccharides are physically entangled, covalently or non-covalently bonded to cellulose and lignin. The structure of hemicellulose depends on its origin; however, the four main groups include D-xylans/aribinoxylans (1→4-linked β-D-xylose), D-mannans (1→4-linked β-D mannose), D-xyloglucans (D-xyropyranose residues attached to the cellulose chain), and D-galactans (1→3-linked β-D-galactose). D-xylans, D-mannans, and D-xyloglucans are similar to cellulose, which has a main-chain backbone linked via (1→4) diequatorial linkages capable of adopting extended ribbon conformations (Cui, 2005 [13]; Bahramparvar & Tehrani, 2011 [1]; Milani & Maleki, 2015). The degree of substitution in galactomannans, which profoundly affects their solution properties, differs for galactomannans extracted from various plants, such as LBG and guar gum (Cui, 2005; Kilara & Chandan, 2008; Tanseem *et al*., 2014) [13, 33, 56]. β-D-Glucans (high molecular weight and viscous) are present in grass species, cereals (main sources: Kernels of oats, barley, wheat, and rye), and lichens. β-D-Glucans have known cholesterol-and blood glucose-lowering properties. One of the common D-galactans is Arabinogalactan from soft wood, such as pine, larch, cedar, and spruce. Arabinogalactan is a highly branched polymer with an arabinose ratio of 1:6 (Milani & Maleki, 2015).

Pectin

Most cell walls of fruits and vegetables are composed of pectin. Commercial pectin is typically made from apple pulp, citrus peel, and sugar beet pulp. Pectin contains sections of homopolymers made from galacturonans and rhamnogalacturonans. Galacturonans have (1→4)-linked α-d-galactosyluronic acid residues in their backbones (Cui, 2005) [13]. The carboxylic acid groups in galacturonans may have been methyl-esterified. The degree of esterification (DE) has a significant effect on the conformation and solution properties of pectin. There are low methyl (LM) pectin with DE < 50% and high methyl pectin (HM) with DE > 50%. Depending on the pectin, 20-80% of rhamnose residues may be branched at O-4 with side chains that vary in length and composition. Pectin type I arabinogalactans have been found in potatoes, soybeans, onions, kiwi, tomatoes, and cabbage. Although pectin is present in most plant tissues, its use is limited. This is due to the fact that the gelling properties of pectin depends on the molecular size and degree of esterification (DE), (Joel *et al*., 2018) [30]. Valdes *et al*. (2015) [58] reported that pectin $(C_6H_{10}O_7)$ obtained from citrus fruits and apples has also been used as a stabilizer in yogurt (Tromp *et al*., 2004) [57]. Pectin is widely used in fruit jellies and beverages (Tasneem *et al*., 2014) [56].

Gums

Some plants produce polysaccharides as a result of stress, physical injury, and/or fungal attacks. Common gums used in various foods include Gum Arabic, gum tragacanthin, gum karaya, and gum ghatti. Structurally, gums are related to arabinogalactans, galacturonans, and glucuronomannans, all of which contain a high proportion of glucuronic or galacturonic acid residues (up to 40%). Gum Arabic is obtained from acacia trees and has been used in food as an additive and ingredient in the pharmaceutical industry and for technical purposes (Immerson, 2010) [29].

Mucilage gums

Mucilage gums are highly viscous polysaccharides that are usually extracted from the seeds, stems, and leaves of plants (Benhura and Marume, 1993). Common examples are psyllium (*Plantago* sp.), yellow mustard (*Sinapis alba*), and flax mucilage (*Linum usitatissium*). Mucilage is an acidic polysaccharide and its structure is closely related to that of gums (Milani & Maleki, 2015). They are commonly used for viscosity enhancement, gelation, and water binding in food applications. They can also play a bioactive role in the prevention and/or treatment of certain diseases, as noted by Cui (2005) [13]. The polymeric chains of mucilage usually consist of highly branched arabinoxylan with some D-glucuronic acid residues (Pysllium gum), a mixture of neutral polymer chains of glucose (1→4-linked β-D-glucose) and acidic polysaccharide containing galacturonic and glucuronic acids, galactose, and rhamnose residues (yellow mustard mucilage), and flaxseed mucilage contains a neutral polysaccharide composed of xylose, arabinose, and galactose and an acidic polysaccharide containing galactose, rhamnose, and galacturonic acid residues (Milani & Maleki, 2015). Flaxseeds can be used as thickeners, stabilizers, and water-binding agents; yellow mustard mucilage in processed meat formulations, stabilizers in salad dressing, and as a bulking agent; psyllium gum is used as a laxative and dietary fiber supplement in the pharmaceutical and food industries.

Fructans

They are reserve polysaccharides in certain plants that either replace or complement starch. The main type of fructan is inulin, which is found in the roots or tubers of plants, for instance, Compositae family- dandelions, chicory, lettuce, Jerusalem artichoke, and *Liliace* family- lily bulbs, tulips, and hyacinth (Milani & Maleki, 2015). Inulin is a low-molecular-weight polysaccharide containing (2→1)-linked β-D-Fru*p* residues.

Alginates

They constitute the primary structural polysaccharides of brown seaweed (*Phaeophyceae*). These are unbranched copolymers of (1→4)-linked β-D-mannuronic acid (M) and α-L-guluronic acid (G) residues (Milani & Maleki, 2015). If the ironic acid groups are in the acidic form (-COOH), the polysaccharide (alginic acid) is water soluble. Sodium salts (-COONa) and sodium alginate are water-soluble. They form heat-stable gels that can be set at room temperature.

Carrageenan

They are found in red seaweed. According to Milani and Malek (2015), carrageenan from red seaweed has no nutritional value but provides many unique functional properties that can be used for gel, thickening, and stabilization of food products and systems. κ-carrageenans, ι-carrageenan, and furcellarans are linear polysaccharides with a backbone structure based on a repeating disaccharide sequence of sulfate esters of (1→3)-linked β-D-galactose and (1→4) linked 3,6-anhydro-α-D-galactose (Bahramparvar & Tehrani, 2011) [1]. They differ from one another in terms of the number and position of sulfate groups. κ-carrageenans and ι-carrageenan can aggregate and form a thermally reversible gel that ranges from firm and brittle to soft and elastic. The functional properties of carrageenan, such as rigidity, turbidity, and tendency to syneresis, generally increase with increasing degrees of sulfation in these polymers. However, λ-carrageenans are very different red seaweed polysaccharides that contain β-D-galactopyranosyl residues sulfated at C-2 instead of C-4, as in κ-carrageenans and ι-carrageenan, and contain 6-di-O-sulfato-α-D-galactopyranosyl units. λ-carrageenans are used as cold-soluble thickeners in syrups, fruit drinks, pizza sauces, and salad dressings (Milani & Maleki, 2015; Tanseem *et al*., 2014 [56]). Different stabilizers have also been used to achieve the desired properties. Starch and carrageenan have been used in a wide range of ready-to-eat milk-based desserts (Tanseem *et al*., 2014) [56]. Starch affects the structure of carrageenan through omission effects, helping other gelling agents in solution (Verbeken *et al*., 2004) [59]. It also breaks up the consistency of the carrageenan gel and hence enhances the mouthfeel (de Wijk *et al*., 2003) [14]. The use of a reduced amount of starch is also important to reduce the caloric values of most desserts.

Potential Food Stabilizers from Some Common Plants in Zimbabwe

They are potential plants in Zimbabwe for extracting food stabilizers. However, in this review, we shortlisted some plants/fruits that can be used in the manufacturing of various stabilizers

Table 1. We examined how these various plants are being used locally, and which parts of the plants are being utilized as food. Backed by other studies, there is evidence that most of these plants contain a polymer or a mixture of polysaccharides that can be used in the food processing industry. Nevertheless, we cannot easily determine whether the polysaccharides could be used as stabilizers in these studies. The main purpose of this research is to determine food stabilizers from various indigenous plants and develop extraction methods from their respective loci. Furthermore, the functionality of the respective stabilizers was tested practically through product development.

Table 1: Potential food stabilisers found in Zimbabwe

Names	Parts used	Period Availability	Food application	Reference
Baobab /Muuyu/mkhomo (*Adansonia digitata*)	Pulp/shell: Pectin Leaves: Mucilage	April-June	Drink, porridge, expience in medicine and pharmaceuticals Fruit smoothies Yogurt, ice cream & dairy products Juice/beverages Jams and jellies	Shava (2005) [52] Gomez (1988) [25] Woolfe *et al*., 1977 [62] Kitano & Zenko (2017) [34] Deshmukh *et al* (2013) [15] Baobest Kamatou *et al* (2011)
Snot apple /matohwe /uxhakuxhaku (*Azanza garckeana*)	Fruit: Mucilage, Pectin (galactose, glucose, arabinose and rhamnose units)	Feb-Sept.	Food and phamarceutical Gelling agent and stavilizer (pectin) Drug delivering system/expience	Shava (2005) [52] Joel *et al* (2018) [30] Benhura *et al* (1999)
Musawu /umsawu /(*Ziziphus mauntania*)	Leaves: Mucilage, starch Fruit: Mucilage, Starch	Nov-Feb	Jams, sweet strips	Shava (2005) [52] Clifford *et al* (2002) [12]
Mbola plum \Shakata \umkhuna *(Parinari curatellifolia)*	Fruit: pectin, starch (galactose, xylose, glucose)		Syrup, porridge, alcoholic beverages jam	Ogungbenle and Atere (2014) [48]
Stud plant /Seso, ruredzo /nduku /(*Dicerocaryum zanguebarium*)	Leaves: Mucilage,	Jan-Dec	Emulsifier, viscosity enhancement	Benhura & Maurume (1993a,b) [5, 6] Rambawasvika *et al* 2017
Bush Okra /derere /(*Corchorus olitorius*)	Leaves: Mucilage	Jan-Dec	Viscosity enhancement	Gomez (1988) [25]
Banana *(Musa spp.)*	Pulp(green): starch Peels: pectin, cellulose, hemicelluloses	Jan-Dec	Edible films, jams,	Poli *et al* 2011 [49] Valdes *et al* 2015 [58]

Future Directions

Future research should focus on detailed chemical and functional characterization of indigenous plant polysaccharides to establish a deeper understanding of their properties and mechanisms of action as food stabilizers. Conducting practical application trials in food systems will provide insights into the effectiveness of these stabilizers in real-world scenarios, allowing for the optimization of formulations and processing methods. Additionally, investigating the environmental impact and sustainability of harvesting and utilizing indigenous plants will ensure that their commercial use does not compromise biodiversity or local ecosystems.

It is also essential to collaborate with local communities to integrate traditional knowledge with scientific research, thereby enhancing the relevance and applicability of findings while fostering community involvement and support. Addressing the regulatory aspects of indigenous plant stabilizers in food production will help ensure safety, efficacy, and consumer acceptance. Furthermore, evaluating the nutritional benefits of food products formulated with indigenous stabilizers will contribute to understanding their role in promoting health and well-being.

Finally, increasing awareness and education regarding the potential of indigenous plants among food scientists, industry stakeholders, and consumers will promote the use of these natural resources in food production. By pursuing these recommendations, future research can significantly advance the utilization of indigenous plants as food stabilizers, ultimately leading to innovative and sustainable food solutions.

Conclusion

The exploration of indigenous plant resources in Zimbabwe presents a significant opportunity for the development of natural food stabilizers, addressing the growing global demand for sustainable and health-oriented food products. This review highlights the functional properties of various indigenous plants, particularly their polysaccharides, which play crucial roles in emulsification and stabilization processes within the food industry. The potential of these plants remains largely untapped, despite the rich biodiversity and traditional knowledge available in the region. The identification and characterization of specific stabilizers, such as cellulose derivatives, pectin, gums, and alginates, indicates promising avenues for their application in commercial food products. Integrating traditional knowledge with modern scientific methodologies can enhance the understanding and utilization of indigenous resources. This approach not only preserves cultural heritage but also contributes to the development of nutritionally and economically valuable food products that can improve food security and support local economies.

Acknowledgments

None.

Conflict of Interest Declaration

The authors agree to the publication of the final manuscript and declare no conflicts of interest.

Data Availability Statement

The authors confirm that all the data related to this manuscript will be provided upon request.

All requests should be addressed to: Dinga Njini Moyo; dmoyo@hit.ac.zw

Funding

No funding or sponsorship.

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