World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(Review Article)

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Characterization and evaluation of okra gum as a tablet binder

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World Journal of Biology Pharmacy and Health Sciences, 2024, 20(01), 063–069

Publication history: Received on 18 August 2024; revised on 28 September 2024; accepted on 01 October 2024

Article DOI: https://doi.org/10.30574/wjbphs.2024.20.1.0698

Abstract

The type and amount of binders decisively influence the characteristics of tablets prepared by wet granulation procedure. Commonly used binders like acacia, gelatin, starch and hydrolyzed starch have natural origin. The aim of this study was to evaluate the effectiveness of a new binder extracted from Hibiscus esculentus (Okra gum) in tableting. Okra gum was extracted from the pods of Okra fruit by maceration in distilled water followed by filtration of viscous solution as well as precipitation of gum extract by using acetone. To evaluate the binder effectiveness, two models, including a placebo formulation (lactose) and a drug formulation (Acetaminophen, Ibuprofen, and/or Calcium acetate) were evaluated. Granules were prepared by different concentrations (0.5-6 %w/w) of Okra gum and tableted using a Kilian single punch press. Cornstarch (12.5 % w/w) and P.V.P (22 %w/w) were employed as the standard binders for comparison. The physical properties of the granulates and those of the tablets including disintegration time and dissolution rate were studied. The properties of granulates (bulk and tapped density, granule strength, flowability) as well as those of tablets (hardness, friability, disintegration time) were generally good. Moreover, the physical properties of Ibuprofen and Calcium acetate tablets containing Okra gum showed sufficient hardness, desirable disintegration time and low friability. The percent of drug released after 45 minutes were 15 %, 44 % and 96 % for Acetaminophen, Ibuprofen and Calcium acetate tablets, respectively. Okra gum produces some tablet formulations with good hardness and friability. However, this binder prolongs the dissolution rate of some slightly soluble drugs and hence may be good candidate for sustained release formulations. (Symecko C., Rhodes C, et.al.,1995)

Keywords: Hibiscus esculentus; Okra; Tablet; Binder; Wet granulation

1. Introduction

1.1. Biological source

Okra, (Abelmoschus esculentus), herbaceous hairy annual plant of the mallow family (Malvaceae).

1.2. Composition and Main Uses of Okra

Okra is a nutrient-rich food and its inclusion in one's diet can bring many benefits. Dietary fibers are the most abundant macronutrients (8.16 g/100 g fresh weight), followed by carbohydrates (4.86 g/100 g fresh weight) and proteins (3.55 g/100 g fresh weight). Despite the low-fat content (0.19 g/100 g) and energy (33 kcal/100 g equivalent to 138 kJ/100 g) of okra fruits, their seeds contain unsaturated fatty acids, such as linoleic acid, that are essential for human nutrition. These seeds are also rich in α-tocopherol and have high levels of minerals, including Ca, K, Cu, Fe, P, Mg, Zn, and Mn.

Binders are a major class of excipients used to hold the active pharmaceutical ingredient (API) and inactive excipients together in a cohesive mass. These are also called granulating agents and promote size enlargement to help build

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granules of desired sizes, thereby enhancing the free flowing qualities of the powder. The presence of a binder also enables intergranular binding and ensures that the tablet remains intact after its compression by improving its crushing strength and reducing friability . The nature and concentration of a binder influences the characteristics of a compressed tablet. There are a wide variety of substances that are used as binders in tablet formulations. Generally, they can be categorized into three groups (i) sugars, such as sucrose, glucose, sorbitol (ii) natural gums and polymers, which include pre-gelatinized starch, starch, gum acacia, gelatin, and sodium alginate; and (iii) synthetic polymers, which include PVP, PEG, and all the semisynthetic derivatives of cellulose (HPMC, HPC, CMC, EC, and polymethacrylates). (Barbosa-Canovas, et.al., 2005)

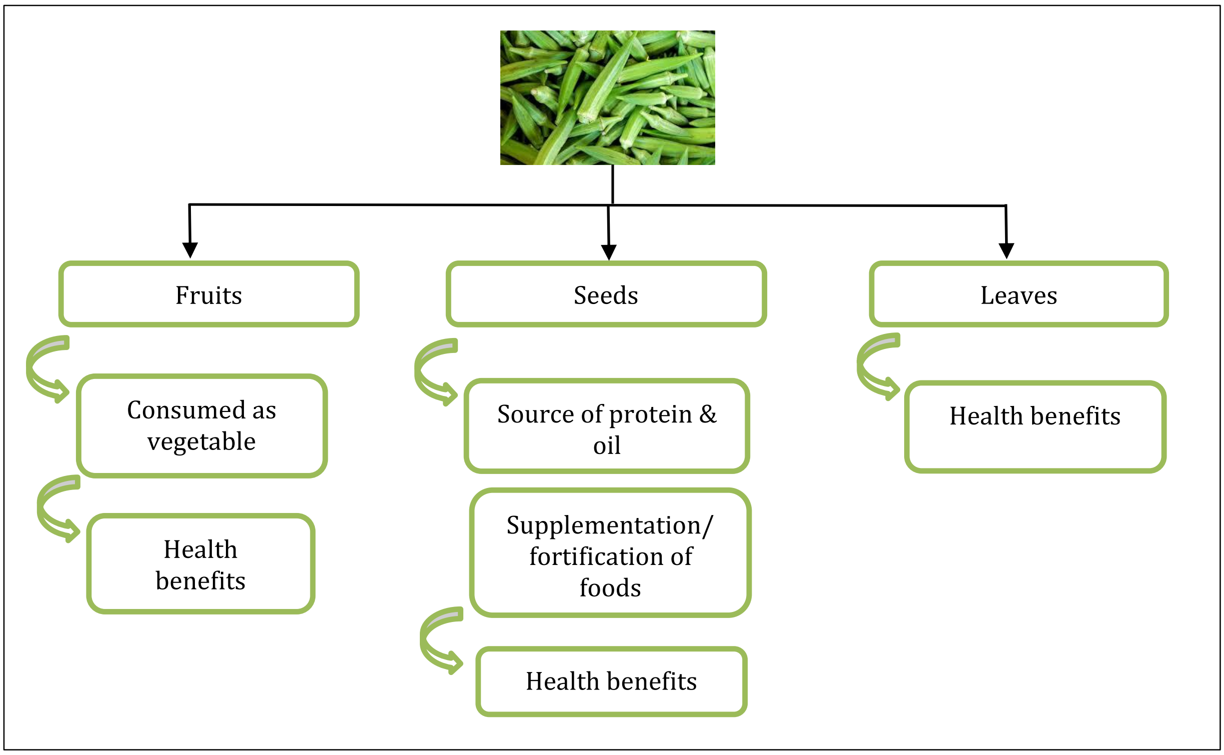

Figure 1 Uses of Okra plant parts

2. Physicochemical Characteristics of Okra Mucilage

The molecular weight of okra polysaccharides can be directly related to their bioactive properties. Low molecular weight polysaccharides are more active than high molecular weight polysaccharides, as they have difficulty crossing cell membranes. Evaluated characteristics of the polysaccharides of different cultivars of okra and isolated two fractions from each cultivar after chromatographic analysis. For the different cultivars, the molecular weights ranged from 2.76 × 103 kDa to 4.20 × 103 kDa for a polysaccharide fraction and 0.11 × 103 kDa to 0.9 × 103 kDa for another fraction. According to the same authors, the different cultivars did not influence the composition of the polysaccharides but did influence their molecular weight. (Nie, et.al., 2019)

2.1. Extraction Methods

Okra mucilage can be extracted using some techniques that are mostly based on the use of distilled water or organic solvents. The application of heat is also present in certain processes. Farooq, Malviya, and Sharma extracted the mucilage while keeping the okra stirred in distilled water under continuous agitation at 60°C for approximately 4 hrs. Sequentially, the mucilage was isolated with the aid of acetone. (Farooq, et.al., 2013)

Okra mucilage is easily extracted in an aqueous medium due to the high solubility of its polysaccharides, and the good yield of extraction is one of the advantages of this method. Cahyana and Kam evaluated the influence of some factors such as time, temperature, and the ratio between water and okra fruits on the extraction yield and on antioxidant and anti-α-glucosidase activities. The different treatments used in the extraction did not significantly influence the yield; however, the extract was obtained by soaking the fruit for 12 hrs at 4–5°C. The ratio of 1:6 (fruit:water) showed the best antioxidant activity. (Oliveira, et.al., 2020)

2.2. Preparation of the Aqueous Extract of Okra

Okra gum was extracted from the fresh pods of the Abelmoschus esculentus, by adopting the extraction method as already described in the literature. For this purpose, okra pods (~0.25 kg) were washed, dried at room temperature (~25 °C), and sliced horizontally into small ~1 inch pieces after the calyces were removed. These slices (weighing 0.10 kg) were taken in a pan, ~1.5 L of distilled water was added, and they were then heated at ~60 °C for 4 h with intermittent stirring. The mixture was filtered through a muslin cloth, and the aqueous extract was cooled at 4–6 degree Celsius. (Farooq, et.al., 2013)

2.3. Preparation of Tablets

The tablets of naproxen sodium containing either okra gum or pre-gelatinized starch as a binder in the similar concentrations (1%, 3%, and 5%) were prepared by wet granulation. A set of twelve formulations was prepared; six were made using okra gum as a binder. The first three formulations (F1–F3) were without any disintegrant and the next three (F3–F6) had 7% starch as disintegrant. The other six formulations were prepared using pre-gelatinized starch as a binder; of these, three formulations F7–F9 were prepared without any disintegrant, while the remaining three formulations F10–F12 had starch as a disintegrant.(Table 1)

Table 1 Formulation of tablets prepared with okra gum and starch paste as a binder in different concentration

Formulation name	Naproxen Sodium (mg)	Okra gum (%w/w)	Starch Slurry (%w/w)	Disintegrant Starch (%w/w)	Magnesium Sodium (%w/w)	Talc (%w/w)	Lactose (%w/w)	Total Weight of tablet(mg)
F1	275	1	-	-	1	0.5	168	450
F2	275	3	-	-	1	0.5	163	450
F3	275	5	-	-	1	0.5	157	450
F4	275	1	-	7	1	0.5	149	450
F5	275	3	-	7	1	0.5	143	450
F6	275	5	-	7	1	0.5	138	450
F7	275	-	1	-	1	0.5	168	450
F8	275	-	3	-	1	0.5	163	450
F9	275	-	5	-	1	0.5	157	450
F10	275	-	1	7	1	0.5	149	450
F11	275	-	3	7	1	0.5	143	450
F12	275	-	5	7	1	0.5	138	450

2.4. Applications of Okra Mucilage

Mucilage extracted from plant sources have rheological characteristics with potential for use as thickeners and food stabilizers and are well accepted by consumers because they are natural substances. In the pharmaceutical industry, some mucilage can be used as raw materials to produce natural coatings due to constituents such as pectin, galactan, and glucuronic acid. (Cornelia, et.al. 2019)

Studies that characterized okra mucilage have reported its physicochemical and rheological properties for pharmaceutical applications and its use as a natural additive in food products and nutraceutical supplements. The main potential applications of okra polysaccharides in different industries are described below. (Hussain, et.al., 2017)

2.5. In Vivo Studies on the Health Benefits of Okra and Its Components

As stated earlier in this review, okra and its bioactive components are reported to have potential beneficial health effects. A significant reduction in the blood glucose level, along with an increase in body weight, was reported by Dubey and Mishra (2017) and Sabitha et al. (2011) in streptozotocin-induced diabetic rats when fed the peel and seed powder of okra. Also reported a significant increased level of hemoglobin and the total protein level and a decrease in HbA1c. They also reported that okra peel and seed powder at a dose of 200 mg/kg showed a significant reduction in blood glucose compared to a 100 mg/kg dose. Additionally, the treatment of both the doses of okra seed powders significantly produced a greater blood glucose reduction when compared to okra peel powder at a 100 or 200-mg/kg dose. Meanwhile, there several studies suggested multiple mechanisms of antidiabetic plants to exert their blood glucose-lowering effects, such as the inhibition of carbohydrate metabolizing enzymes, enhancement of insulin sensitivity, regeneration of damaged pancreatic islet β-cells, and enhancement of insulin secretion and release. (Panneerselvam K, et.al., 2011)

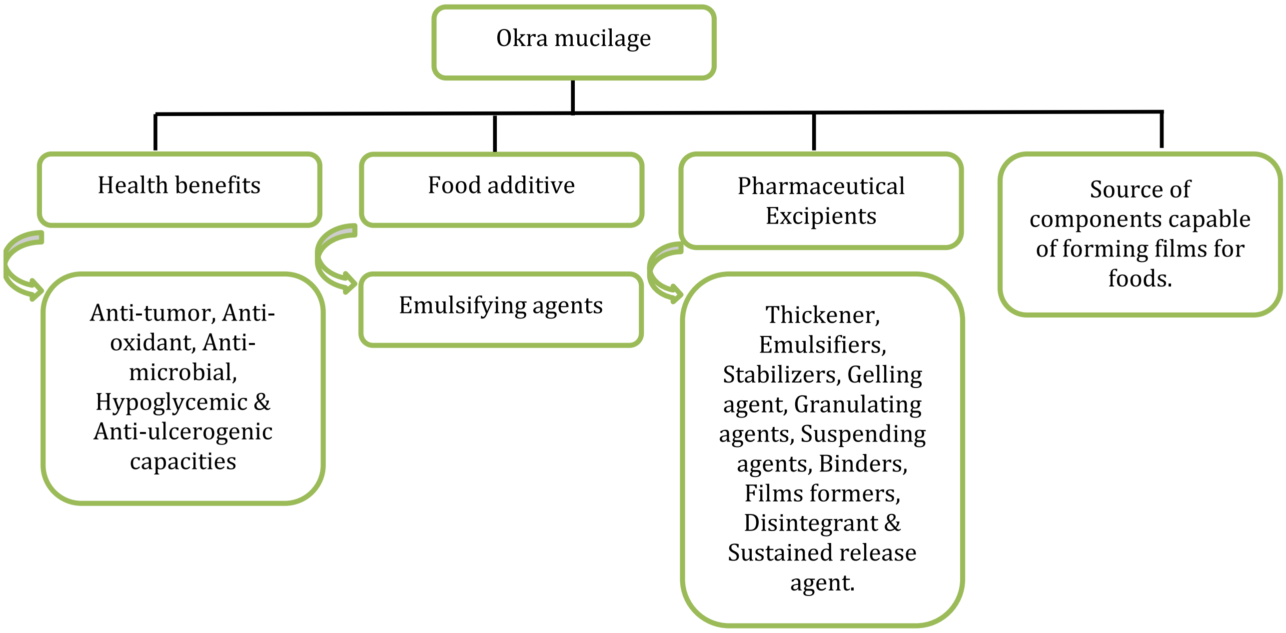

Figure 2 Benefits of Okra & its component

2.6. Food technology

Emulsifiers are one of the main classes of additives used in the food industry, and they play an important role in the formation and stability of emulsions, including milks, creams, seasonings, desserts, sauces, and beverages. (Mcclements, et.al., 2017)

Okra mucilage has been studied as a potential emulsifying agent for food; in addition, its fruit extract is used empirically in traditional cooking to thicken stews and soups. Researcher observed this property in the mucilage extracted from okra fruits of different maturation stages from its inclusion in a coconut milk oil–water emulsion system. The results confirmed the possibility of using okra as an emulsifier in the food industry. According to the authors, mucilage can improve the quality of food in terms of stability, texture, and appearance, also acting as gelling agents or texture modifiers. (Noorlaila, et.al., 2015)

2.7. Pharmaceutical Technology

Okra is a great resource for obtaining a safe option of mucilage. According to researcher processing okra with a polymer that has the property of forming films, such as chitosan, could increase its use in the production of medicines. (Ghori, et.al., 2014)

Many polysaccharides are being used as carriers for the delivery of drugs, as they are able to control the rate and release of these substances. As the polysaccharides present in okra mucilage are naturally occurring molecules, they can be an alternative for reducing the side effects of synthetic polymers commonly used by the pharmaceutical industry. (Pushpamalar, et.al., 2016)

2.8. Therapeutic Prospects of Okra as Dietary Medicine/Nutraceuticals

Around two-thirds of the world population (7.8 billion) is dependent on plant-based materials for their medicinal and healing properties, mainly because of their easy availability, accessibility, affordability, and safety, as well as the traditional beliefs of the consumers. A very old quote by Hippocrates stated, “Let food be thy medicine and medicine be thy food”, which described the significance of food and its nutritional, as well as therapeutic, values for the prevention, treatment, and management of diseases. Thereafter, DeFelice coined the term nutraceutical by merging “nutrition” and “pharmaceutical” and defined it as food or part of a food that not only imparts health benefits but, also, contributes to the prevention or treatment of various diseases. Importantly, nutraceuticals have been formulated in such a way that they could benefit or facilitate the management of human health without instigating any harm due to their natural occurrence. Nutraceuticals derived from plants, animals, or live microorganisms possess great potential for use by scientific communities, food researchers, and food-processing industries to produce unique foods or food components for the forthcoming needs of human beings to stay healthy without any side effects. Currently, the rapid rise in demand for nutraceutical products has been largely observed because of their therapeutic value in various diseases, such as diabetes, hypertension, arthritis, inflammatory bowel disease, the common cold, dyslipidemia, heart disease, and cancer. Nutraceutical products may also increase the lifespan by delaying aging, promoting the integrity of the body, and sustaining smooth normal functioning. Moreover, based upon various pharmacological potentials of okra-derived molecules, okra has been seen as one of the potential sources of nutraceuticals. (Adnan M, et.al., 2020)

3. Formulation and Development of Okra-Based Nutraceuticals

Nutraceuticals are broadly described as food or parts of food that provide incremental health benefits. Okra-based nutraceuticals represent popular health foods, owing to its intrinsic nutritional and other bioactive components, which show health-associated beneficial properties. Several efforts are being made to improve the well-known hypoglycemic outcomes of okra fruit by formulating different proportions of seeds and peels of Ex-maradi Okra fruit in the ratio of (10:90, 20:80, 30:70, 40:60, 50:50%, and so on), which is subsequently followed by investigating the antidiabetic and antioxidant efficacy of these formulations in vitro. (Kumar S, et.al., 2014)

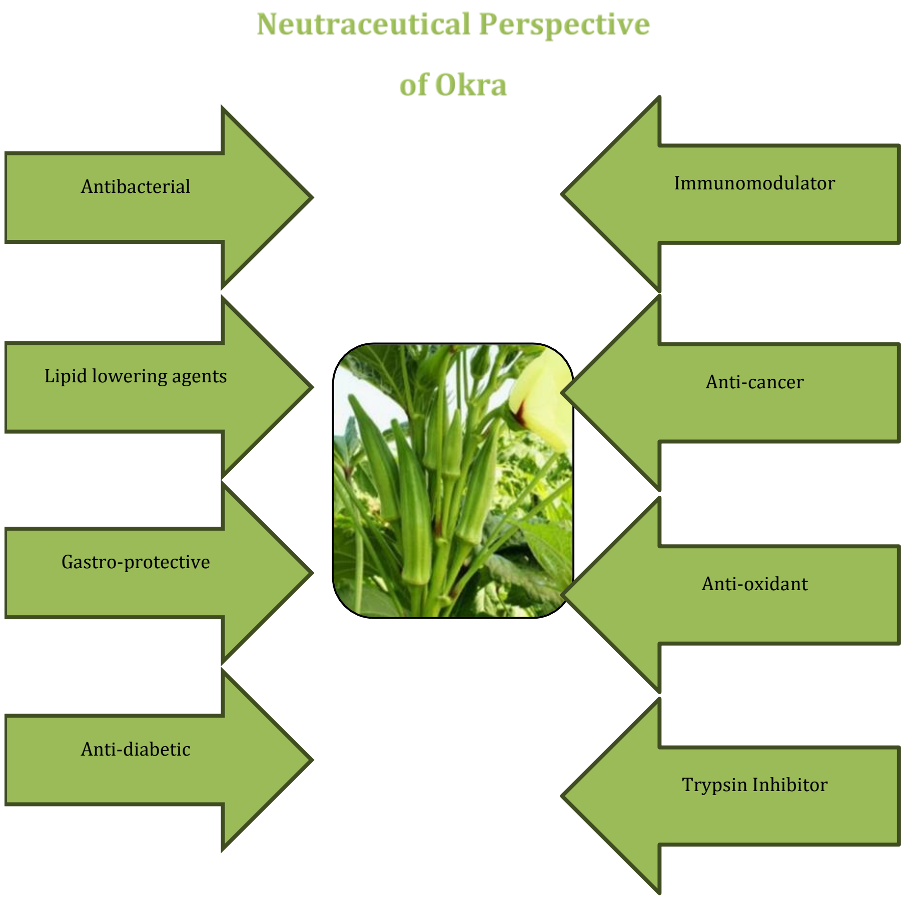

Figure 3 Medicinal benefits of Okra

4. Conclusions

Okra showed to be a promising low-cost functional food for inclusion in the diet or to be used as a raw material for ingredient production due to the important nutrients and bioactive compounds in its composition; the use of its mucilage is of particular interest for human health. Plant-extracted mucilages are important, low-cost, and biocompatible natural resources. Okra is a rich source of mucilage.

Compliance with ethical standards

Acknowledgments

The authors are thankful to Samarth Institute of Pharmacy, Belhe, Junnar, Pune 412410 for all the guidance and support.

Disclosure of conflict of interest.

All authors declare that no conflict of interest.

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