

Pemanfaatan Hemiselulosa Tongkol Jagung dalam Formulasi Tablet Mengembang sebagai Pendekatan Baru Terapi Diet

Utilization of Corn Cob Hemicellulose in Swelling Tablet Formulations as a Novel Approach of Dietary Therapy

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Abstrak

Latar Belakang: Obesitas merupakan tantangan kesehatan masyarakat yang memerlukan pendekatan pendukung pengelolaan berat badan secara aman dan berkelanjutan. Hemiselulosa tongkol jagung berpotensi dikembangkan sebagai bahan tablet mengembang berbasis polimer. **Tujuan:** Mengembangkan dan mengkarakterisasi tablet mengembang berbasis hemiselulosa tongkol jagung menggunakan kombinasi kitosan, polivinil alkohol (PVA), dan bahan pengikat silang. **Metode:** Penelitian eksperimental meliputi preparasi bahan, delignifikasi, ekstraksi hemiselulosa, formulasi tablet, serta karakterisasi menggunakan *Fourier-transform infrared spectroscopy* (FTIR), *scanning electron microscopy* (SEM), dan *X-ray diffraction* (XRD). Hasil: Hemiselulosa diperoleh dalam bentuk serbuk putih dengan rendemen kurang dari 20%. Karakterisasi menunjukkan pembentukan matriks polimer, struktur berpori berdasarkan SEM, dan pola difraksi berdasarkan XRD. Formulasi kitosan-PVA dan kitosan-PVA-STPP menghasilkan tablet utuh yang mampu mengembang tanpa mengalami disintegrasi selama 2–4 jam. **Kesimpulan:** Hemiselulosa tongkol jagung berpotensi dikembangkan sebagai bahan tablet mengembang berbasis matriks polimer kitosan-PVA, dengan atau tanpa STPP. Namun, diperlukan pengujian kuantitatif kemampuan mengembang, stabilitas, dan keamanan untuk memastikan kelayakan sediaan sebagai pendukung pengelolaan berat badan.

Kata kunci: Hemiselulosa; Tongkol jagung; Tablet mengembang; Kitosan; Hidrogel

Abstract

Background: Obesity is a growing global public health concern that requires safe, effective, and sustainable approaches to support weight management. Natural polysaccharides, particularly hemicellulose derived from agricultural waste, offer promising potential for developing swelling tablets due to their hydrophilic properties and ability to form polymeric matrices. **Objective:** This study aimed to formulate and characterize corn cob hemicellulose-based swelling tablets using chitosan, polyvinyl alcohol (PVA), and crosslinking components. **Methods:** This experimental study involved corn cob preparation, delignification, hemicellulose extraction, tablet formulation, and physicochemical characterization using *Fourier-transform infrared spectroscopy* (FTIR), *scanning electron microscopy* (SEM), and *X-ray diffraction* (XRD). **Results:** The isolated hemicellulose was obtained as a white powder with a yield below 20%. Characterization indicated polymer-network formation, porous morphology, and distinct XRD diffraction features. Chitosan-PVA and chitosan PVA STPP formulations produced visually intact tablets that exhibited swelling while maintaining structural integrity for 2–4 hours. **Conclusion:** Corn cob hemicellulose demonstrates potential as a renewable polymeric material for developing swelling tablets. However, further quantitative evaluation of swelling capacity, mechanical properties, and safety is required to establish its suitability for weight management applications.

Keywords: Hemicellulose; Corn cob; Swelling tablet; Chitosan; Hydrogel

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1. INTRODUCTION

The prevalence of obesity continues to rise worldwide, including in Indonesia, making it one of the most serious public health challenges of the 21st century. Obesity is associated with an increased risk of various chronic diseases, including diabetes mellitus, cardiovascular diseases, stroke and other metabolic disorders. Conventional approach to obesity management, which primarily rely on reducing nutritional intake and increasing physical activity, often fail to achieve sustainable long-term outcome. This is largely due to difficulties in maintaining adherence to dietary and lifestyle modifications, as well as fluctuations in body weight and the tendency to regain weight after initial loss. Therefore, there is growing need for safe, effective and sustainable alternative strategies for long term weight management.

Pharmacological therapies for obesity may be associated with adverse effects and high treatment costs, which can limit their accessibility and long-term use for some individual. Therefore, there is need to develop alternative approach that are safe, effective, affordable and widely acceptable to the community. Dietary fiber promotes faster and prolonged satiety through several mechanisms, including increasing chewing time, increasing gastric volume, and enhancing the viscosity of the gastric and intestinal contents. These effects induce gastric distension, thereby delaying hunger signals (4,5). Viscous and highly swelling fibers are considered effective in suppressing appetite. Several studies have demonstrated that the consumption of viscous dietary fiber can significantly reduce body weight, body mass index (BMI), and waist circumference, even without strict caloric restriction. Furthermore, a high-fiber diet may reduce the risk of cardiovascular disease, diabetes, and certain types of cancer (6,7).

However, not all types of dietary fiber exert the same effects on weight reduction. Viscous soluble fibers tend to be more effective in suppressing appetite than insoluble fibers, such as bran and wheat fiber (3). One of the most promising materials as a source of hemicellulose is corn cob. Corn cobs are abundant agricultural waste in Indonesia and remain underutilized, which may contribute to environmental pollution. Corn cobs are rich in dietary fiber, accounting for approximately 80–90% of their dry weight. The fiber fraction of corn cobs is predominantly composed of cellulose and hemicellulose (8).



Figure 1 Corn cob

Corn cob contain approximately 35% xylan. Making them one of the most promising sources of non-starch dietary fiber for further development (9). Hemicellulose is a branched-chain polysaccharide, predominantly composed of arabinoxylan, with an amorphous structure and high water-absorption capacity. Therefore, modification of hemicellulose is required to enhance its swelling capacity and structural integrity, allowing it to swell fully without disintegrating upon water absorption (10). The incorporation of Citric Acid (CA), Polyvinyl Alcohol (PVA), Tripolyphosphate (STTP) promotes the formation of a cross-linked gel network.

Study (2) reported that a late-stage clinical trial demonstrated the safety and efficacy of Plenity. Obese patients who consumed this hydrogel for 24 weeks experienced an average body weight reduction of 6.4% from baseline. In addition, natural dietary fibers have the advantage of low fermentability, resulting in minimal bloating and gastrointestinal discomfort. A study investigating hemicellulose as a dietary supplement at a dose of 1–2 g/day reported that hemicellulose acts as a prebiotic by increasing Bifidobacteria in the gut and potentially reducing

intestinal inflammation (9). Study (15) reported that hemicellulose is an abundant source of biopolymer that remains underutilized commercially.

Study (16) further demonstrated that the combination of hydrophilic polymers, particularly chitosan and polyvinyl alcohol (PVA), can form hydrogels with good swelling capacity. The type and ratio of polymers play an important role in determining the degree of swelling, matrix strength, and release rate. Study (17) reported that a crosslinking time of 10 minutes resulted in improved release and penetration profiles, possibly because the polymer network became less densely crosslinked and more porous. Therefore, the degree of intermolecular crosslinking should be optimized to enhance the swelling index.

2. METHODOLOGY

This study was conducted from March to September 2026 at the Laboratorium Terpadu Universitas Islam Negeri Sumatera Utara, Medan, Indonesia. The research was conducted in several stages using a laboratory-based experimental method, with corn cobs serving as the source of hemicellulose. The research procedures were carried out according to the following

Hemicellulosa Preparation

Stage 1 Preparation of Corn Cob

The corn cob was cleaned using 0.1 M hydrochloric acid (HCl) and then drained. The cleaned corn cobs were dried at 60 °C for 2 h. Subsequently, the dried corn cobs were ground and sieved through an 80 Mesh sieve. The resulting corn cob powder was then subjected to extraction using 80% ethanol.

Stage 2 Delignification

The corn cob powder was subjected to a delignification process using 2% potassium hydroxide (KOH) solution. Following delignification, the material was filtered and washed to remove residual alkali and other soluble components.

Stage 3 Hemicellulose extraction

Hemicellulose was extracted by preparing a suspension of the delignified pulp in 10% sodium hydroxide (NaOH) solution at a solid-to-liquid ratio of 1:10. The suspension was maintained at 50 °C for 2 h. The resulting alkaline filtrate was subsequently neutralized to pH 5-6.

Stage 4 Hemicellulose Precipitation and Purification

Hemicellulose was precipitated by adding 95% ethanol at a ratio of 2:1 and allowing the mixture to stand for 5 h at 4 °C. The mixture was then centrifuged to separate the precipitated hemicellulose. The resulting precipitate was dried at 50 °C and subsequently dialyzed for 24 h to remove residual salts and other low-molecular weight impurities.

Stage 5 Hydrolysis and Characterization

The extracted hemicellulose was subjected to hydrolysis using HCl 1% and heated at 100 °C. Following hydrolysis, the solution was neutralized using sodium hydroxide (NaOH) and then filtered. The hemicellulose sample obtained from corn cob extraction was subsequently subjected to a yield determination using the following equation:

Preparation of Hemicellulose-Based Swelling Tablets

Preparation of the Hemicellulose Solution

Hemicellulose (5 g) was dispersed in distilled water at a ratio of 1:20 (w/v) and stirred at 400 rpm until a homogeneous dispersion was obtained. The dispersion was then divided into three portions for the cross-linking reaction.

Crosslinking Chitosan/PVA

A 5% (w/v) PVA solution was prepared by dissolving PVA in distilled water at 80 °C. A 1% (w/v) chitosan solution was prepared in acetic acid solution. The PVA solution was then added to the chitosan solution, followed by the addition of the hemicellulose dispersion. The mixture (60:25:15 % b/b) was stirred until a homogeneous formulation was obtained.

Crosslinking Chitosan/STPP

Citric acid (2% w/w) was then added to the Chitosan solution (1% in Acetic Acid), followed by the addition of the hemicellulose mixture as a cross-linking agent.

Crosslinking Chitosan/PVA/STPP

A 5% (w/v) PVA solution was prepared by dissolving PVA in distilled water at 80 °C. A 1% (w/v) chitosan solution was prepared in acetic acid solution. The PVA solution was then added to the chitosan solution, followed by the addition of TPP 2%, the hemicellulose dispersion. The mixture was stirred until a homogeneous formulation was obtained.

The resulting mixture was added Citric Acid 2% and then dried at 50 °C. The dried material was subsequently passed through a 50-mesh sieve and compressed into tablets using a compression force of 5 kN.

The resulting hemicellulose was characterized based on its extraction yield and physicochemical properties using Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and X-ray diffraction (XRD).

Rendemen ekstraksi dihitung berdasarkan persamaan pada naskah asli: $RY = [(Wt - Wo)/Wt] \times 100\%$, dengan Wt sebagai bobot akhir dan Wo sebagai bobot awal. Definisi dan bentuk persamaan perlu dikonfirmasi kembali sebelum publikasi.

3. RESULT

The isolated hemicellulose was obtained as a white powder. Lignin and hemicellulose were not effectively separated, resulting in a yield of less than 20%.

The results of the FTIR analysis are presented below

The formation of ester bonds between STPP and PVA was indicated by the presence of a C=C stretching band at approximately 1551 cm^{-1} , Keton 1692 cm^{-1} , C=O ($420\text{--}490\text{ cm}^{-1}$)

The formation of ionic interactions and cross-linked networks between STPP and hemicellulose was indicated by the characteristic Aldehyde C=O and C-O bands of STPP in the range of $1200\text{--}1700\text{ cm}^{-1}$.

Morfologi SEM

Hasil pengamatan morfologi pada variasi formulasi disajikan pada Gambar 2.

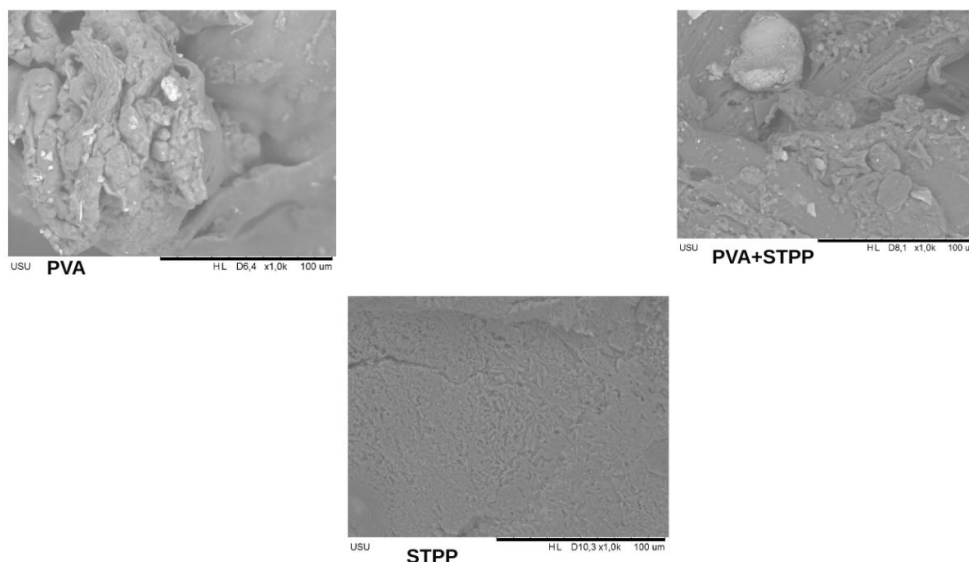


Figure 2. SEM images of PVA, PVA+STPP, and STPP formulations (as labeled in the source image)

The results of the X-ray diffraction (XRD) are presented below

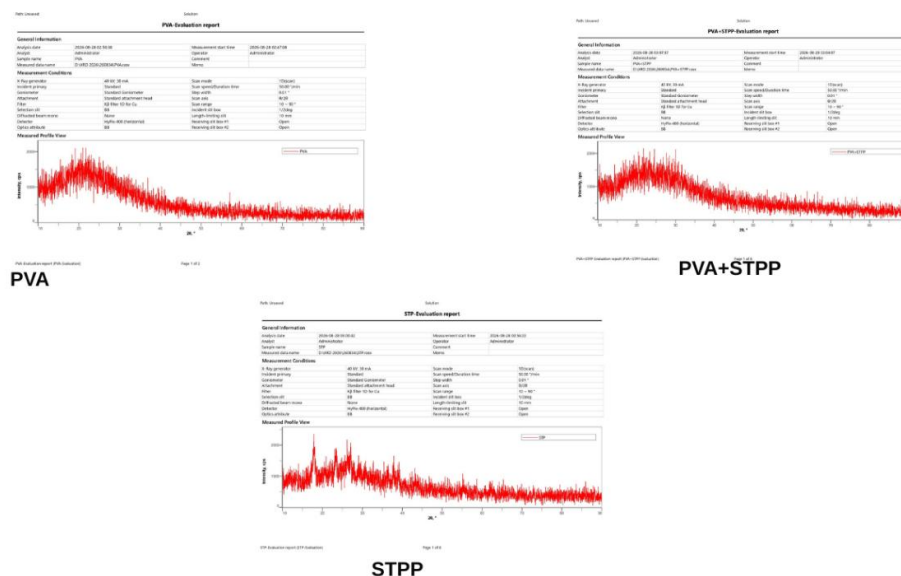


Figure 3. X-ray Diffraction (XRD) Patterns of PVA, PVA + STPP, and STPP Formulations.

4. DISCUSSION

It exhibits a good degree of crystallinity based on XRD analysis, high porosity based on SEM analysis, as well as good thermal stability. The tablets possess moderate hardness and can swell gradually in the stomach, preventing them from easily disintegrating.

Conceptually, cross-linking can affect the density of the polymer network and the swelling capacity of the hydrogel [10–14]. Previous studies have also reported the role of chitosan and PVA in the properties of polymer matrices [16–18]. However, the source manuscript has not presented values for the swelling index, tablet hardness, porosity parameters, or crystallinity quantification. Therefore, comparisons of performance between formulas and determination of the optimal formula cannot yet be determined quantitatively [21,22].

5. CONCLUSION

The combination of hemicellulose with chitosan-PVA and hemicellulose with chitosan-PVA-STPP formed cross-linked polymer networks, resulting in hydrogels with good swelling capacity, appropriate porosity, and an optimal degree of interchain cross-linking. Cross-linking of hemicellulose with chitosan-STPP resulted in the formation of a more stable gel matrix. The combination of hemicellulose with chitosan-PVA and hemicellulose with chitosan-PVA-STPP produced intact tablets without visible cracks, as confirmed by visual inspection. The tablets also exhibited relatively uniform weights across individual units.

The combination of hemicellulose with chitosan-PVA and hemicellulose with chitosan-PVA-STPP produced tablets with good swelling capacity, enabling them to expand while maintaining structural integrity without disintegration for 2–4 h.

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