UTILIZATION OF CORN COB HEMICELLULOSE IN SWELLING TABLET FORMULATIONS AS A NOVEL APPROACH OF DIETARY THERAPY

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Abstract

Weight loss through dietary modification and exercise is often difficult to sustain, while anti-obesity medications may be limited by adverse effects. Therefore, a safe and effective alternative is needed. Natural dietary fiber is a promising approach because it can suppress appetite and increase satiety. Hemicellulose derived from agricultural waste, particularly corn cobs, offers a sustainable raw material for developing swelling tablets. The incorporation of crosslinking agents, such as citric acid, polyvinyl alcohol (PVA), and sodium trimetaphosphate (STMP), is expected to improve tablet characteristics, swelling capacity, and water absorption.

This study aims to develop a swelling tablet formulation based on hemicellulose extracted from corn cob waste. Chemical modification of hemicellulose is intended to enhance its ability to form a gastrointestinal-resistant gel and increase water absorption capacity. This approach is expected to support weight management while improving the utilization of agricultural waste. The research also supports the National Medium-Term Development Plan (RPJMN), particularly Asta Cita 4 on strengthening human resources and public health through science-based interventions, and Asta Cita 5 on sustainable development and the green economy through agricultural waste utilization.

An experimental approach was employed to formulate and characterize hemicellulose-based swelling tablets. The research stages included: (1) raw material preparation; (2) hemicellulose extraction; (3) characterization of extracted hemicellulose; (4) swelling tablet formulation;

(5) evaluation of swelling behavior and water absorption capacity; and (6) data analysis to determine the optimum formulation.

Keywords: Innovation, Technology, Research Projects, etc.

1. INTRODUCTION

The prevalence of obesity continues to rese worldwide, including in Indonesia, making it on 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, ofen fail to achieve sustainable long-terms outcome. This is largely due

to difficulties in maintaining adherence to dietary and lifestyle medifications, 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), Polivinyl 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

2.1 Hemicellulosa Preparation Stage 1 Preparation of Corn Cob

The corn cob werw cleaned using 0.1 M hydrochloric acid (HCl) and then drained. The cleaned corn cobs were dred at 60 º C for 2 h. Subsequently, the dried corn cob were ground and sieved trough and 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 fitered 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 ºC 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 ratio of 2:1 and allowing the mixture to stand for 5 h at 4 ºC. The mixture was then centrifuged to separate the precipitated hemicellulose. The resulting precipitated was dried at 50 ºC and subsequently dialyzed for 24 h to remove residual salts and ather low-molecular weight impurities

Stage 5 Hydrolysis and Characterization

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

$$RY = \frac{Wt - Wo}{Wt} \times 100\%$$

Ry = Residual yield (%)
Wt = final weight
Wo = initial weight

2.2 Preparation of Hemicellulose-Based Swelling Tablets Preparation of the Hemicellulosa 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)..

3. RESULTS

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

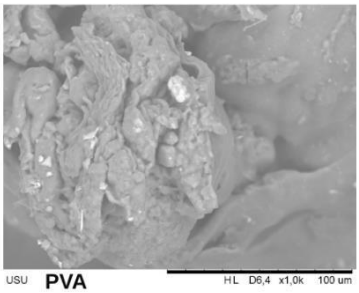
3.1 The results of the FTIR analysis are presented below

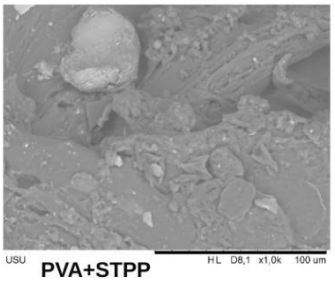
The formation of ester bonds between STPP and PVA was indicated by the presence of a C=C stretching band at approximately 1551 cm^{-1}, Keton 1692, C=0 (420-490)

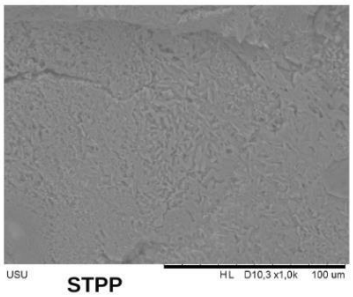
The formation of ionic interactions and cross-linked networks between STPP and

hemicellulose was indicated by the characteristic Aldyhade C=0 and C-0 bands of STPP in the range of 1200-1700 cm^{-1}.

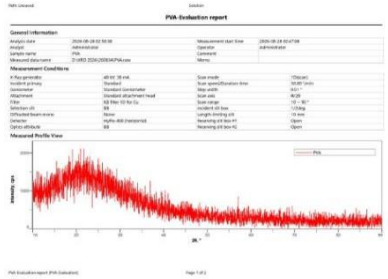
3.2 The results of the scanning electron microscopy (SEM) are presented below



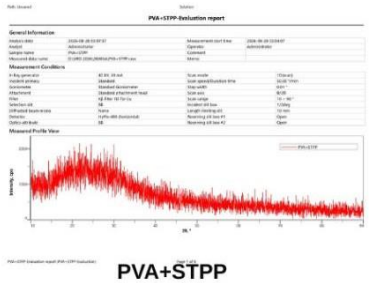




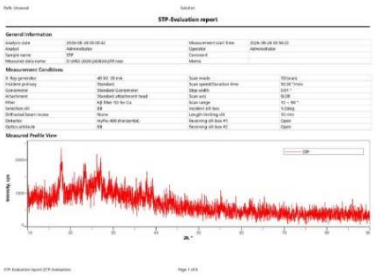
3.3 The results of the X-ray diffraction (XRD) are presented below



PVA



PVA+STPP



STPP

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.

4. CONCLUSIONS

1. 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.
2. Cross-linking of hemicellulose with chitosan–STPP resulted in the formation of a more stable gel matrix.
3. 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.
4. 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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