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*Original research paper*

# KONJAC GLUCOMANNAN AS A FOAM STABILIZER IN POLYHERBAL DRINK POWDER VIA FOAM MAT DRYING

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**Abstract:** The polyherbal drink contains polyphenol compounds that have many health benefits. The water extract of polyherbal drinks in the liquid phase has a short shelf life. Further powder processing is desirable using simple methods, such as foam mat drying, which depend on the type of foam stabilizer. Konjac glucomannan (KGM) solution has the potential to be a foam stabilizer. This study investigated the effect of konjac glucomannan concentrations (0-1%) as a foam stabilizer on polyherbal drink powder's physicochemical properties and antioxidant activity in foam mat drying. The polyherbal drink foam was prepared by adding lecithin at 10% w/w as a foaming agent and KGM as a foam stabilizer. The foam characteristics, e.g. foam expansion (FE), air fraction (AF), and foam stability (FS), and the powder properties, including total phenolic content (TPC) and total flavonoid content (TFC)), were investigated. Moreover, the powder's antioxidant activity was also analyzed using the DPPH free radical scavenging and ferric reduction antioxidant power (FRAP) methods. The results showed that applying KGM improved the stability of foam at a concentration of 0.5% upwards (FS>92.32%; FE>1.51). However, the physical properties of the powder were unchanged. All powders showed constant TPC (1.16- 1.36 mg GAE/g) and TFC (13.21- 28.92 mg QE/g). In addition, all powders revealed similar antioxidant activity both in DPPH free radical scavenging (231-245 mM TE/g) and FRAP (141-154 mM TE/g). The utilization of KGM as a foam stabilizer in the foam mat drying process demonstrated improved foam stability, particularly when used at a concentration of 0.5%.

**Key words:** *herbal drink, java tea, turmeric, seed-under-leaf, foam mat drying*

## INTRODUCTION

Konjac glucomannan (KGM) is a polysaccharide of natural origin derived from the tubers of plants belonging to the *Amorphophallus* genus, predominantly found in Asian countries like China, Indonesia, Japan, and Thailand (Dav & Mccarthy, 1997; Xu et al., 2014). KGM is a substance extensively utilized in several industries, such as food, pharmaceuticals, chemicals, and biotechnology (Zhang, Xie & Gan, 2005). KGM consists of D-glucose and D-mannose units connected via (1,4)-glycosidic bonds. The molar ratio of glucose to mannose in KGM is 1.0:1.6, and acetyl groups are limited at the C-6 position

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(Ni et al., 2018). KGM is one of the hydrocolloid substances used as a thickening agent. Furthermore, KGM exhibits beneficial characteristics such as proficient film production, which also functions as a stabilizing agent.

Moreover, it shows favorable factors such as high water solubility, suitability for consumption, and the potential to undergo biodegradation Moreover, konjac glucomannan (KGM) demonstrates advantageous physicochemical properties, including efficient film-forming capacity that concurrently serves as a stabilizing mechanism. It further exhibits high water solubility, appropriateness for human consumption, and intrinsic biodegradability, underscoring its suitability for diverse industrial and biomedical applications (Behera & Ray, 2016; Zhang et al., 2005).

In today's era, individuals are increasingly focused on consuming food that is beneficial for their health. One of the advantages of drinking a polyherbal beverage is that it can improve one's overall health (Kharat & McClements, 2019). This beverage contains polyphenol components that contribute to various health benefits, such as antioxidant, anticancer, and immunostimulatory properties (Hartanti & Hamad, 2023a; Jovanovic, Steenken, Tosic, Marjanovic & Simic, 1994). However, the shelf-life of liquid polyherbal drinks is limited due to the presence of water extracts from multiple herbs, as the liquid phase is highly susceptible to microbial proliferation and consequent spoilage (Fang & Bhandari, 2010). To prolong the preservation of these beverages, simple techniques like dehydration could be advantageous (Hamad, Suriyarak, Devahastin & Borompichaichartkul, 2020; Hamad, Suriyarak, Devahastin, Chiewchan & Borompichaichartkul, 2025; Shishir & Chen, 2017).

The foam-mat drying technique incorporates foaming and stabilizing chemicals into liquid or semi-solid food products, creating a foam. This foam is then spread out in a thin layer and subjected to hot air drying under mild temperature conditions (Guazi, Lago-Vanzela & Conti-Silva, 2019; Qadri, Srivastava & Yousuf, 2020). Hence, foam-mat drying offers a practical and suitable method for small-scale drying industries (Kudra & Ratti, 2006).

However, a significant challenge in this thermal process is the degradation of thermolabile bioactive compounds, such as phenolics and flavonoids, due to intense exposure to heat and oxygen, which can diminish the product's antioxidant capacity (Xu et al., 2020). Therefore, effective foam stabilization is critical not only for physical properties but also for protecting these valuable phytochemicals.

Konjac glucomannan (KGM) is a polysaccharide that can serve as an alternative solution for foam stabilization. The effectiveness of KGM in this role depends on its concentration. (Hamad, Kinanti, Pomsang, Naveed & Hartanti, 2025; Hu et al., 2016; Zhou et al., 2021). It is hypothesized that KGM, as a foam stabilizer, can form a protective macromolecular matrix that encapsulates phytochemicals, potentially shielding them from thermal and oxidative degradation. Furthermore, by improving foam structure and stability, KGM can enhance drying efficiency, leading to shorter thermal exposure times and better preservation of bioactivity (Hamad, Putra & Hartanti, 2025; Hardy & Jideani, 2017). Quantitative assessment of bioactive constituents—specifically total phenolic content (TPC), total flavonoid content (TFC), and antioxidant capacity—is indispensable for elucidating the extent of protective effects exerted during processing (İlhan Dincer & Temiz, 2023). Therefore, this study aimed to investigate the effect of different concentrations of konjac glucomannan as a foam stabilizer on the foam characteristics, physicochemical properties, and the retention of bioactive compounds (TPC, TFC) and antioxidant activity using DPPH free radical scavenging and ferric reducing antioxidant power (FRAP) in polyherbal drink powder produced via foam mat drying.

## MATERIALS AND METHODS

### Materials

DPPH (2,2-diphenyl-1-picrylhydrazyl), TPTZ (2,4,6-tri(2-pyridyl)-s-triazine), ethanol, aluminum chloride, ferric chloride, Folin-Ciocalteu reagent, gallic acid, hydrochloric acid, quercetin, sodium hydroxide, sodium acetate, and Trolox were purchased from Sigma-Aldrich (United States). Crude drugs of Turmeric (*Curcuma longa* L.) rhizome, seed-under-leaf (*Phyllanthus niruri* L.) aerial parts, and Java tea (*Orthosiphon aristatus* (Blume) Miq.) leaves were purchased from Wisata Kesehatan Jamu Kalibakung (Tegal, Indonesia). KGM, lecithin and gum arabic, were acquired from Indoplant (Yogyakarta, Indonesia).

**Preparation of polyherbal drinks**

The polyherbal was composed of 20% turmeric, 70% Java tea, and 10% seed-under-leaf. The mixture of crude drugs was extracted in water at a ratio of 1:20 w/v (at a temperature of 100 °C) for 15 minutes in a water bath. As soon as the extracts reached room temperature, they were filtered, and the resultant water extracts were utilized in subsequent experiments (Hamad & Hartanti, 2025; Hartanti & Hamad, 2023a).

**Foam mat drying**

The foam mat drying was prepared by mixing 10% (w/w) gum Arabic as a binder into the polyherbal drink extract. As a foaming agent, lecithin (10%) and foaming stabilizer KGM (0-1% (w/w)) were added to the homogenized mixture (Haris, Hamad, Yulianti, Hartanti & Naveed, 2024). At ambient temperature, the mixture was stirred by Ultra Turrax homogenization IKA T-18 for five minutes at 18,000 rpm to achieve foaming. The foams were poured into 20-centimeter-diameter containers with 5-millimeter-high borders for each test. The sample was desiccated in a cabinet at 60 °C for eight to ten hours. The desiccated substance was scraped from the trays, pulverized with a mortar and pestle, vacuum packaged in polyethylene, and stored for further analysis.

**Evaluation of the physical properties of foam**

Physical properties of foam consist of foam expansion (FE), air fraction (AF), and foam stability (FS). Using equation (1), the FE was calculated as the ratio of the volume increase during whipping to the initial volume. Using equation (2), the air fraction (AF) characterizing the air entrapped in the foam was calculated as the fraction of the foam's volume occupied by air. Using equation (3), the FS (%) was determined by calculating the volume evacuated in 60 min of treatment (Susanti, Sediawan, Fahrurrozi, Hidayat & Putri., 2021).

$$FE = \frac{Volume\ expansion\ (mL)}{Initial\ volume\ (mL)} \quad (1)$$

$$AF = 1 - \frac{Foam\ density\ after\ whipping\ (\frac{g}{mL})}{Initial\ foam\ density\ (\frac{g}{mL})} \quad (2)$$

$$FS = \frac{Volume\ after\ drained\ (mL)}{Initial\ volume\ (mL)}\ x\ 100 \quad (3)$$

**Evaluation of physical properties of polyherbal drinks powder**

The yield of a polyherbal drink powder was determined by calculating the percentage ratio of the total weight of powder resulting from drying to the total weight of solids in the foam. The physical properties of the polyherbal drink powder were determined by its moisture content, hygroscopicity, and solubility. The moisture content of the granules was determined using the oven method. Using the standard AOAC method, the sample was dehydrated in an oven at 105± 2 °C (AOAC, 2016). Powder hygroscopicity was measured using a modified version of method by Cai and Corke (2000).

One gram of polyherbal drinks powder was deposited on a crucible and placed in a hermetic desiccator containing a saturated NaCl solution (75% RH) for one week at 25±5 °C. After a week, the powder was weighed, and the quantity of water absorbed was expressed in grams per 100 grams of dry solids. The weight difference was calculated to determine the hygroscopicity of the granules.

**Evaluation of total phenolic content (TPC) and total flavonoid content (TFC)**

The TPC and TFC were analyzed according to the Tavares's method with a minor modifycation (Tavares et al., 2020). The powder (0.4 g) was extracted in absolute ethanol for one hour at 150 rpm. The supernatant of the resulting extract was further analyzed for TPC and TFC. In the TPC method, 1 ml of extract or standard gallic acid solution was combined with 5 ml of Folin-Ciocalteu reagent containing 7.5% Folin-Ciocalteu reagent. After allowing the mixture to stand for 8 minutes, 4 ml of 1% NaOH was added. After 60 minutes at ambient temperature, the absorbance of the mixture was measured at 730 nm using a UV-Vis spectrophotometer (Shimadzu, Japan). The standard curve equation y= 0.0179 X-0.0307 at y=0.9908 utilized gallic acid solutions ranging from 0-100 ppm, and the TPC was expressed as mg gallic acid equivalent GAE/g dried weight (DW) powder (Hartanti & Hamad, 2023b; Wirantika et al., 2023).

In the TFC method, 0.5 milliliters of extract or standard quercetin solution was combined with 1.5 milliliters of ethanol, 0.1 milliliters of 10% aluminum chloride, 0.1 milliliters of 1M sodium acetate, and 2.8 milliliters of water. After

30 minutes at ambient temperature, the absorbance of the mixture was measured at 425 nm. The standard curve equation y=0.0057 X +0.0258 at $R^2$=0.9930 was derived from 0-250 ppm quercetin solutions, and the TFC was expressed as mg quercetin equivalent QE/g dry weight (DW) extract.

### Evaluation of antioxidant activity using DPPH free radical scavenging and ferric reduction antioxidant power (FRAP) method

The DPPH free radical scavenging and FRAP method of polyherbal drink powder were determined with a slight modification to the standard method (Thaipong, Boonprakob, Crosby, Cisneros-Zevallos & Hawkins Byrne, 2006). A 0.4 g substance was extracted for 1 hour at 150 rpm with absolute ethanol, and the supernatant was filtered through muslin cloth for further analysis. 0.5 milliliter of extract sample or standard Trolox solution was combined with 5 ml of 25g/ml DPPH solution and allowed to stand for 30 minutes at room temperature and in a light-protected environment.

The mixture's absorbance was measured at 517 nm. For the standard curve equation y=0.2438 X-1.759 at $R^2$=0.9910, 0-400 M Trolox was used, and the DPPH scavenging activity was expressed as M Trolox equivalent (TE)/g DW powder (Hartanti & Hamad, 2023a; Purnomo et al., 2023).

The FRAP reagent comprised ten parts of 300 mM sodium acetate buffer, one part of 10 mM TPTZ in hydrochloric acid, and one part of 20 mM ferric chloride with a final pH of 3.6. 0.4 ml of freshly prepared FRAP reagent was combined with 0.21 ml of either an extract sample or a standard Trolox solution. After 30 minutes at ambient temperature, the absorbance of the mixture was measured to be 594 nm. The standard curve y=0.0028 X+0.0362 at $R^2$=0.9927 was generated using Trolox concentrations ranging from 0-225 M, and the FRAP was expressed as M TE/g DW powder.

### Data analysis

The one-way ANOVA and Duncan's post-hoc test were used to evaluate and compare, respectively, the effects concentration of KGM on foam characteristics, physical properties, TPC, TFC, DPPH radical scavenging activity, and FRAP of the polyherbal drink powder using IBM SPSS Statistics version 26.0 (IBM, United States), establishing p <0.05 as the significance level.

## RESULTS AND DISCUSSION

### Foam characteristics

Table 1 provides an overview of the attributes associated with foam, namely "foam expansion" (FO), "air fraction" (AF), and "foam stability" (FS). The study revealed that the concentration of KGM had no statistically significant impact on the foam's characteristics (p>0.05). The inclusion of konjac glucomannan resulted in a decrease in both FE and AF.

The introduction of KGM led to a similar increase in FE until the concentration reached 0.5%. However, a further increase in concentration by 1% resulted in a statistically significant decrease. Likewise, the AF of the foam exhibited a significant decrease with the progression of KGM concentration. The increase in concentration of KGM resulted in a corresponding rise in the viscosity of the liquid in the continuous phase (Dav & Mccarthy, 1997).

This rise in viscosity had the effect of preventing the expansion of volume that ty-pically takes place during the formation of foam. Furthermore, the reduction of expansion led to a decrease in the incorporation of air into the liquid and the formation of bubbles (Guazi et al., 2019).

The observed inhibition of foam volume expansion is attributed to the well-documented rheological property of Konjac glucomannan (KGM) to form highly viscous solutions (Lu, Zheng & Miao, 2018). The increased viscous resistance of the liquid matrix inherently suppresses bubble formation and limits air incorporation during the whipping process, leading to reduced foam expansion.

On the other hand, with an increase in the concentration of KGM, the polyherbal liquid exhibits an associated increase in viscosity. Significant progress was being made in enhancing the stability of the foam (Aveyard, Binks, Clint & Fletcher, 1999). The film forming was enhanced due to the thickening capabilities of the KGM, resulting in the establishment of a protective barrier that effectively prevented foam rupture. Consequently, the foam's stability ex-

**Table 1**.
Physical foam characteristics of polyherbal drinks with different concentrations of konjac glucomannan (KGM)

| KGM concentration (%) | Foam expansion (FE) | Air fraction (AF) | Foam stability (FS) (%) |
|---|---|---|---|
| 0 | 1.46±0.14[a] | 0.56±0.03[a] | 83.44±3.03[c] |
| 0.1 | 1.49±0.09[a] | 0.50±0.02[b] | 86.28±2.98[c] |
| 0.5 | 1.51±0.05[a] | 0.47±0.03[b] | 92.32±1.55[b] |
| 1.0 | 1.17±0.01[b] | 0.30±0.02[c] | 96.77±0.57[a] |

*Mean values ± standard deviations. [a-c] Means with different letters in the same column indicate that values are significantly different ($p < 0.05$)*

hibited an upward trend with the escalating concentration of KGM. Incorporation of konjac glucomannan (KGM) enhanced foam stability by reducing drainage volume and facilitating the formation of stable foam.

This was achieved by increasing the viscosity of the foam film and preventing the fracture of the interfacial wall (Zhang & Rhim, 2022). The beneficial effects observed upon incurporation of konjac glucomannan (KGM) are likely attributable to the synergistic interaction between lecithin, functioning as a foaming agent, and KGM, acting as a stabilizing polymer. The interaction observed is likely driven by the hydrophobic groups and surface charge of konjac glucomannan (KGM), which collectively enhance the hydrocolloid's viscoelastic properties, resulting in increased elasticity and hardness. The synergistic interaction between lecithin and konjac glucomannan (KGM) is key to the observed foam stability, as they do not act independently but rather form a composite interfacial layer. Lecithin, a small molecule surfactant, rapidly adsorbs to the air-water interface to initially stabilize newly formed bubbles (Liu et al., 2025). However, lecithin-stabilized films are often fluid and prone to coalescence. KGM, being a high molecular weight hydrocolloid, contributes through two primary mechanisms. First, it increases the bulk viscosity, retarding drainage and gas diffusion. More critically, KGM's slightly hydrophobic acetyl groups can associate with the non-polar tails of lecithin molecules at the interface (Zhuo, Qi, Liao, Wei & Xiao, 2025). This association, coupled with the entanglement of the long KGM chains in the aqueous phase, results in the formation of a viscoelastic network at the bubble surface (W. Zhang & Rhim, 2022). This composite membrane significantly enhances film rigidity and resistance to mechanical stress, thereby explaining the marked improvement in foam elasticity and hardness compared to either component alone. The incorporation of xanthan gum produced a similar trend to that reported in this study, whereby the stability of foams derived from red sorghum extracts was enhanced. Moreover, foam stability (FS) demonstrated a distinct positive correlation with the concentration of xanthan gum present in the formulation. Importantly, the foam matrix effectively protected the bioactive constituents even following bubble rupture, with this protective effect persisting throughout the entire drying process (Susanti, Sediawan, Fahrurrozi, & Hidayat, 2021).

Foaming agents play a crucial role in the foam mat drying process, since they are essential for facilitating both foam formation and foam stability. An effective foaming agent exhibits the ability to adsorb at the interface between air and liquid, resulting in a reduction of interfacial tension. The material should possess the capability to generate a viscoelastic and cohesive layer at the contact, which is capable of enduring mechanical agitation. The instability of foam bubbles arises from their high interfacial energy and the phenomenon of coalescence, which leads to the merging of smaller bubbles into larger ones, ultimately resulting in collapse (Chaux-Gutiérrez, Santos, Granda-Restrepo & Mauro, 2017; Koç et al., 2022). Foam stabilizers possess the capability to impede the coalescence of foam bubbles through the process of lamella layer solidification, thereby contributing to the enhancement of foam stability. Food additives known as foam stabilizers are utilized to maintain the structural integrity of foam over an extended period of time (Aveyard et al., 1999; Chaux-Gutiérrez et al., 2017). Polymers are commonly employed as stabilizing agents. The addition of certain substances to the liquid results in an increase in its viscosity, thereby leading to a reduction in the rate of drainage.

Polysaccharides are employed as foam stabilizers due to their ability to enhance the viscosity of liquids, serving as thickening or gelling agents. Examples of such polysaccharides are carboxymethyl cellulose (CMC) and methyl cellulose (MC). The KGM exhibits a notable capacity to enhance viscosity at concentrations below 1%, making it more efficient in comparison to other polymers (Hu et al., 2016).

**Physical properties of polyherbal drink powder**

Table 2 describes the physical properties of polyherbal drink powder in terms of process yield, moisture content, and hygroscopicity at various KGM concentrations. The results demonstrate that incorporating KGM as a foam stabilizer significantly enhances the process yield of the polyherbal powder produced via foam mat drying. The marked increase in yield from below 90% in the control sample (0% KGM) to over 90% in samples with 0.1-1% KGM can be attributed to the superior foam-stabilizing properties of KGM. Its high molecular weight and water-binding capacity create a more stable and rigid foam matrix with smaller, more uniform air bubbles, which minimizes bubble coalescence and drainage during the drying process. This stable structure effectively entraps the solid constituents, thereby reducing material loss and maximizing the recovery of dried product. However, polyherbal drink powder using KGM also explains the observed slight increase in moisture content, from 9.03% (0% KGM) to above 10% in KGM-added powders, as the polysaccharide retains more water within the powder matrix.

Crucially, despite this increase, the moisture content for all samples remained well below the 12% threshold for stable powdered products (Kanha, Regentstein & Laokuldilok, 2020). The observed reduction in hygroscopicity, from 6.73 g/100 g in control to values consistently below 4 g/100 g in KGM-added powders (0.1-1%), directly results from the unique functionality of KGM as a foam stabilizer. During foam mat drying, KGM forms a dense, viscoelastic matrix that may encapsulate the soluble sugars and other hygroscopic compounds present in the herbal blend, effectively reducing their direct exposure to atmospheric humidity, as the water-binding sites within the KGM-polysaccharide network are occupied rather than being freely available to absorb moisture from the environment (Zou et al., 2021).

**Chemical properties of polyherbal drink powder (total phenolic content (TPC) and total flavonoid content (TFC)**

Fig. 1 illustrates the chemical characteristics of polyherbal drink powder as measured by TPC and TFC in various concentrations of KGM.

These chemical properties were established by measuring the amount of phenolic and flavonoid compounds present in the powder. Considering the polyherbal drink powder, these characteristics were analysed and rated. The TPC and TFC of polyherbal powder samples that were handled with or without KGM were not statistically different from one another. There was no significant distinction between the two groups. The presence of KGM at concentrations lower than 1% did not result in a change in the total amount of phenolic or flavonoid components that were present upon drying. However, at these concentrations, KGM contributed to increasing the viscosity of the continuous phase, which in turn improved the stability of the foam. The incorporation of konjac glucomannan (KGM) as a foam stabilizer was investigated, although it does not contribute to the preservation of chemical constituents during drying. In this study, a drying temperature of 60 °C was selected.

**Table 2**.
Process yields and physical properties of polyherbal drinks at different concentrations of konjac glucomannan.

| KGM concentration (%) | Yield (%) | Moisture content (%) | Higroscopicity (g/100 g) |
|---|---|---|---|
| 0 | 85.69±2.59$^{b}$ | 9.03±0.80$^{b}$ | 6.73±0.09$^{a}$ |
| 0.1 | 92.07±3.08$^{a}$ | 11.36±1.03$^{a}$ | 3.98±0.11$^{b}$ |
| 0.5 | 90.04±3.97$^{ab}$ | 10.74±1.02$^{ab}$ | 3.15±0.07$^{b}$ |
| 1 | 91.38±2.45$^{ab}$ | 11.83±1.09$^{a}$ | 2.89±0.05$^{b}$ |

*Mean values ± standard deviations. $^{a-c}$ Means with different letters in the same column indicate that values are significantly different ($p < 0.05$)*

Previous findings have demonstrated that phenolic and flavonoid contents remain unaffected by such thermal conditions, even at relatively low temperatures (Santos-Buelga, González-Paramás, Oludemi, Ayuda-Durán, & González-Manzano, 2019). Consequently, these compounds appear to exert no significant influence on the drying process.

## Antioxidant activity of polyherbal drink powder

Fig. 2 presents the antioxidant activity profile of the polyherbal powder formulated with varying concentrations of konjac glucomannan (KGM) as a foam stabilizer. Across all samples, antioxidant activity remained unchanged, as evidenced by both DPPH radical scavenging and FRAP assays, independent of the method employed.

The observed activity is primarily attributable to the contributions of Java tea, turmeric, and seed-under-leaf extracts. It is well established that the botanical origin of herbs, along with the processing techniques applied, directly influences their antioxidant potential (Ivanović, Makoter & Razboršek, 2021).

Since KGM itself lacks intrinsic antioxidant compounds, its incorporation at concentrations below 1% did not exert any measurable effect on the antioxidant activity of the powders.

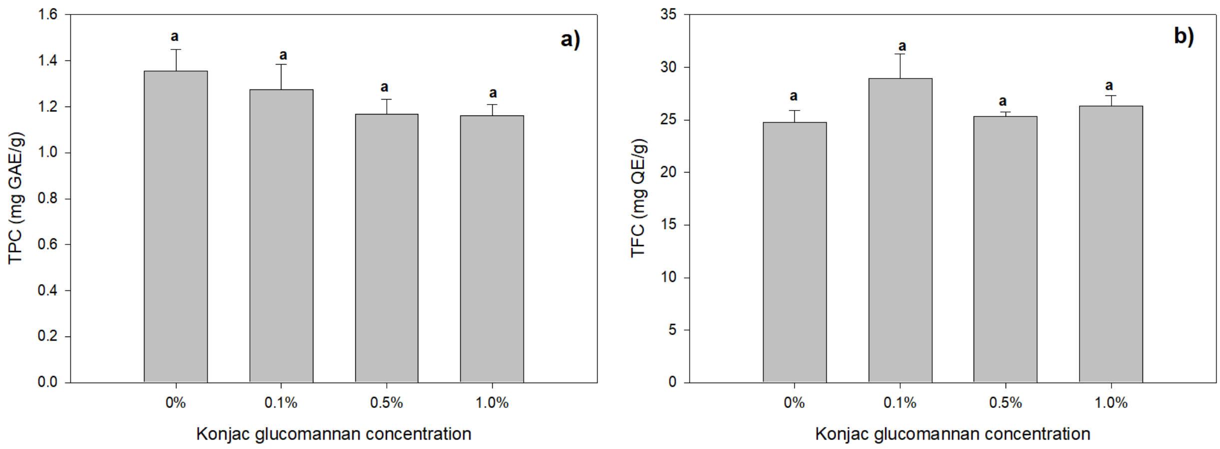


Figure 1. The total phenolic content (TPC) (a), and total flavonoid content (TFC) (b) of the polyherbal powder using different concentration of KGM. Different alphabets on each bars represented statistically different mean values at $p \leq 0.05$

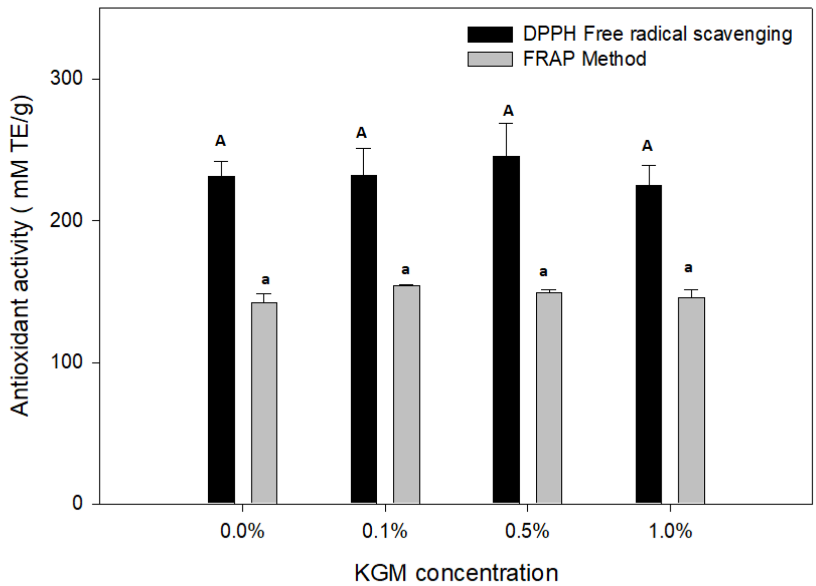


Figure 2. The profile of antioxidant activities of the polyherbal powder using different concentrations of KGM. Different alphabets on bars represented statistically different mean values at $p \leq 0.05$

## CONCLUSIONS

This study demonstrates the innovative potential of konjac glucomannan (KGM) as a natural foam stabilizer in the foam mat drying of a polyherbal drink. The principal finding indicates that a moderate concentration of konjac glucomannan (KGM) at 0.5% optimally stabilizes the foam matrix through viscosity enhancement, which—although not directly quantified—was functionally demonstrated by reduced foam expansion and improved structural stability. This directly translates into powders with superior physical properties, notably reduced hygroscopicity. Most significantly, this stable foam structure proved critical for preserving bioactive compounds. While higher KGM concentrations showed a diminishing return, the KGM-stabilized foams effectively protected the polyherbal extract during drying, as evidenced by the strong retention of TPC, TFC, and antioxidant activity across all treated samples compared to the control. This protective role underscores the primary innovative aspect of using KGM.

This study highlights the need for future investigations to quantitatively characterize rheological properties as a critical objective. Nonetheless, these findings firmly establish KGM as a highly effective and natural agent for producing high-quality, nutrient-rich herbal powders via foam mat drying, offering a practical solution for the functional food industry.

### *AUTHOR CONTRIBUTIONS*

Conceptualization and original draft preparation, A.H., E.S., and D.H.; data curation and data analysis, A.H., and DDP; supervision and modification, ES and DH.

### *DATA AVAILABILITY STATEMENT*

Data contained within the article.

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### *CONFLICT OF INTEREST*

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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# KONJAK GLUKOMANAN KAO STABILIZATOR PENE U PRAŠKASTOM NAPITKU OD MEŠAVINE BILJAKA DOBIJENIM POSTUPKOM SUŠENJA U PENASTOM SLOJU

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**Sažetak:** Napici od mešavine biljaka sadrže polifenolna jedinjenja koja imaju brojne pozitivne zdravstvene efekte. Vodeni ekstrakti ovih napitaka u tečnoj fazi imaju kratak rok trajanja. Stoga je poželjna njihova dalja prerada u prah jednostavnim metodama kao što je sušenje u sloju pene, koja zavisi od vrste stabilizatora pene. Rastvor konjak glukomanana (KGM) ima potencijal da bude stabilizator pene. Ova studija je ispitivala uticaj različith koncentracija KGM (0-1%) kao stabilizatora pene na fizičko-hemijske osobine i antioksidativnu aktivnost napitka od mešavine biljaka u prahu dobijenog tehnologijom sušenja u sloju pene. Pena biljnog napitka pripremljena je dodatkom lecitina u količini od 10% w/w kao sredstva za penjenje i KGM-a kao stabilizatora pene. Ispitivane su karakteristike pene, kao što su ekspanzija (FE), udeo frakcije vazduha (AF) i stabilnost pene (FS), kao i karakteristike praha, uključujući ukupni sadržaj fenola (TPC) i ukupni sadržaj flavonoida (TFC). Pored toga, antioksidativna aktivnost praha takođe je analizirana korišćenjem metode vezivanja DPPH slobodnih radikala i metode redukcije jona gvožđa (FRAP). Rezultati su pokazali da primena KGM-a poboljšava stabilnost pene pri koncentraciji od 0,5% naviše (FS>92,32%; FE>1,51). Međutim, fizičke osobine praha su ostale nepromenjene. Svi prahovi su pokazali konstantan sadržaj ukupnih fenola (1,16-1,36 mg GAE/g) i flavonoida (13,21-28,92 mg QE/g). Pored toga, svi prahovi su pokazali sličnu antioksidativnu aktivnost kako po DPPH testu (231-245 mM TE/g) tako i po FRAP testu (141-154 mM TE/g). Upotreba KGM-a kao stabilizatora pene u procesu sušenja u sloju pene pokazala je poboljšanu stabilnost pene, naročito kada se koristio u koncentraciji od 0,5%.

**Ključne reči:** *biljni napitak, javanski čaj, kurkuma, Phyllanthus urinaria (mešavina, seme-pod-listom), sušenje u penastom sloju*

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