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RESEARCH ARTICLE

Assessing The Role of Psyllium Husk for Sensory Impact on Taste, Aroma and Texture of Rice Crispy Cereal Bar Snack

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A B S T R A C T

The cereal bars market has experienced significant growth due to the rise of "*snackification*", a trend where snacks replace meals. Time constraints during meal occasions have led consumers to seek satisfying snacks like cereal bars, offering tailored nutrition solutions. Ingredients do not only affect the nutritional value of cereal bars, but they also contribute to their sensory attributes, such as taste, aroma, and texture. One of the important ingredients in cereal bars is xanthan gum, which serves as a binding agent. Psyllium husk is a potential substitute for xanthan gum, enhancing cereal bar texture and acting as a dietary fiber to enhance feelings of fullness and facilitate healthy digestion. The objective of this study is to formulate cereal bars with functional properties, utilizing psyllium husk as an essential ingredient and understanding its impact on sensorial properties in comparison to xanthan gum. Four types of samples (two formulations using xanthan gum and two formulations using psyllium husk) were examined using 9-scale hedonic tests among 50 panelists to evaluate the degree of acceptance of the sensory attributes of cereal bars. Formulation with *Butter-psyllium* showed the highest acceptance in terms of aroma (7.52), hardness (6.22), and taste (7.54), followed by the formulation of *Margarine-Psyllium*. This study showed that formulations with psyllium husk surpassed those with xanthan gum in terms of aroma, taste, hardness, and chewiness, making the psyllium husk a preferred binding agent for cereal bars.

K E Y W O R D S

Binding agent, Cereal bar, Functional benefit, Psyllium husk, Sensory attributes

H I G H L I G H T S

- ❖ Cereal bars have gained popularity as a convenient and tasty snacking option that combines both health benefits and palatability.
- ❖ With growing interest in functional foods, cereal bars are often fortified with additional nutrients or functional ingredients.
- ❖ Psyllium husk could be an innovative approach to improve both the texture and nutritional properties of cereal bars.

INTRODUCTION

The demand for cereal bars is increasing as ready-to-eat products with lower calorie contents that are suitable for consumption at any time and under any circumstances increase (Kosicka-Gębska et al., 2022). According to the industry report of cereal bars from Mordor Intelligence, the cereal bar market size is anticipated to reach a CAGR (compounded annual growth rate) of 8% during the forecast period 2023-2031 (Mordor, 2023). The rising rate is due to the increased consumption of cereal bars consumed for many

purposes, such as for snacking, as meal replacement, and as on-the-go breakfast cereals. In other words, it acts as a quick source of energy and can become a meal substitute. Currently, snacks like bars are consumed not just between or outside meals, but also on the go: This trend is known as “snackification” (Mellentin, 2023). According to Boukid et al. (2022) the “snackification” trend has been increasing, as in 2018, 70% of adults in the US consumed snacks two or more times per day and 17% consumed snacks four or more times per day. Due to time playing a crucial role in meal occasions and hectic lifestyles, the demand for nutritious snacks, such as cereal bars, has been increasing (Sharma et al., 2014). As a ready-to-eat product, cereal bars must be made using ingredients that can give satiety and fulfill the nutritional needs of the consumer. The ingredients used will not only affect the nutritional composition, but they also affect the sensory characteristics of the product (Covino et al., 2015; Ojha et al., 2022). Based on a previous study done by Tramujas et al. (2021), which studied the effect of different binding agents, it was found that psyllium husk on salty cereal bar production results in a higher acceptance score for sensorial evaluation. In addition, the utilization of psyllium husk in the salty cereal bar also resulted in it having the most similar properties to the traditional cereal bar. Therefore, in this experiment, the cereal bar was produced by reformulating and analyzing the acceptance of psyllium husk utilization in cereal bars with different types of fats.

Components of cereal bars usually consist of a solid phase and a binding phase. Commonly, the solid phase includes cereals, while the binding phase is used to bind dry ingredients. The binding phase or binding agent is usually mixed with water prior to being used to gain the binding dispersion. The most common substance used as a binding agent is sugar syrups and/or polysaccharides. One of the examples of polysaccharides is xanthan gum, which is used to increase viscosity (Boukid et al., 2022). Following consumer trends, both the research and the food industry are focused on the development of healthy food products with clean labels to fulfill consumer expectations and needs for more natural foods made from ingredients that are recognized, sustainable, locally produced, and authentic (Angus & Westbrook, 2019; Asioli et al., 2017). In this context, replacing synthetic (e.g., hydroxypropyl methylcellulose, HPMC) and natural hydrocolloids (e.g., xanthan gum) with alternative sources of biopolymers (flaxseed, chia, and psyllium husk) could be a valid technological approach to improve both texture and nutritional properties of food. Natural hydrocolloids (xanthan gum) could be replaced with alternative sources to improve both the texture and nutritional properties of cereal bars. Psyllium husk is recognized as a natural source of fiber with a high water-absorbing capacity. On the other hand, xanthan gum is usually used as a binding agent in baked goods, such as cereal bars. The increasing favor for psyllium husk can be attributed to its natural composition and abundance in dietary fiber, establishing it as a more preferable option when compared to xanthan gum. According to Tramujas et al. (2021), using psyllium husk as the binding agent is shown to have the most similar characteristics to the commercial cereal bars that use xanthan gum as its binding agent. Psyllium husk is a polysaccharide that can be obtained from the extraction of Plantago ovata seeds, which contain a lot of soluble dietary fibers (Tramujas et al., 2017). The benefit of dietary fiber is the reduced risk of chronic diseases andconstipation (Lairon et al., 2005). In addition, psyllium can also be used to provide several health benefits, such as lower cholesterol, reduced obesity, and many more (Khan et al., 2021). Moreover, psyllium can be applied to improve consumer acceptance (Beikzadeh et al., 2016). The aim of this paper is to study the role of psyllium husk as a substitute for xanthan gum in cereal bars towards consumer preference on taste, aroma, and texture of cereal bars. This experiment is a continuation of a research by Angrainy et al. (2023), where two different fats, butter, and margarine were previously assessed for sensory comparison. In this research, four types of samples were examined: (f1) butter-psyllium, (f2) margarine-psyllium, (f3) margarine-xanthan gum, and (f4) butter-xanthan gum. A nine-point hedonic scale was carried out to describe the attributes and to evaluate the degree of acceptance for the texture, aroma, and taste.

MATERIALS AND METHODS

The object of this experimental study was a cereal bar (CB) base with four different formulas using the combinations of the following ingredients: (f1) sucrose butter-psyllium, (f2) sucrose margarine-psyllium, (f3) sucrose margarine-xanthan gum, and (f4) sucrose butter-xanthan gum. This study focuses on assessing the respondents' perceptions of texture, aroma, and taste. Prior to the sensory evaluation, preliminary sessions were carried out to validate the procedure and ingredients, as well as ensure replicability. Participants were recruited from the Institute Bio Scientia International Indonesia and were chosen according to their willingness, availability, health condition, and absence of resistance or allergic towards the ingredients. Figure 1 illustrates the experimental design of the study.

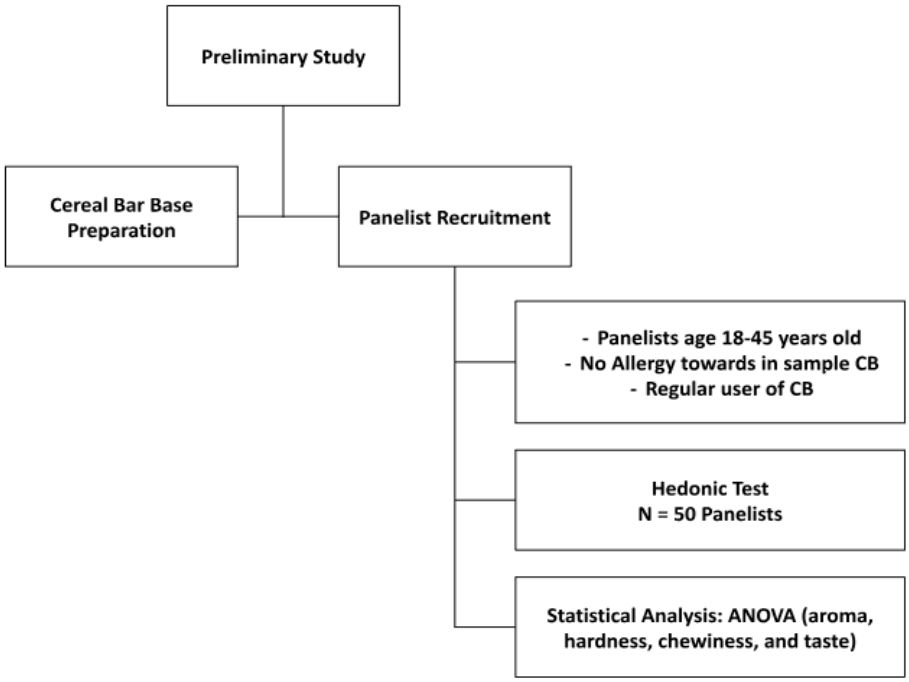

Figure 1. Experimental design

Material

Oval-shaped cereal puffs were sourced from Queenature (Bekasi, Indonesia). Fine Psyllium Husk was purchased from Ourbrand (North Jakarta, Indonesia). Sugar was obtained from Moro Seneng Jakarta (North Jakarta, Indonesia). *Unsalted Anchor Butter* was obtained from Goela Goela Baking Supplies (North Jakarta, Indonesia). *Margarine Blueband Cake & Cookie* was bought from a local mini market (East Jakarta, Indonesia).

Equipment

GEA Freezer by Royal-Kincool uses 690 watts of electrical power and operates at a frequency of 50 Hz (PT.Royal Sutan Agung, Indonesia). *GEA Chiller* requires 480 watts of electrical power and runs at a frequency of 50 Hz (PT.Royal Sutan Agung, Indonesia). *S/S Gas Baking Oven 2 Deck+Proofer* uses 1000 watts of electrical power and operates at a frequency of 50 Hz (PT.Royal Sutan Agung, Indonesia).

Methodology

The cereal bar was created by precisely measuring all the ingredients: 52.24% of puffed cereal, 10.45% of fat (butter or margarine), 22.39% of binding agent (xanthan gum or psyllium husk), and 14.92% of sucrose.

For the xanthan gum, the process involved diluting 1% of xanthan gum powder in 147.76% of room temperature water, creating a 1% xanthan gum solution. The powder was carefully spread over the water and left at room temperature for 10 minutes. Afterward, the mixture was stirred and heated on a stove to 60°C with continuous stirring. Once the temperature reached 60°C, the xanthan gum solution was removed from the stove and allowed to cool for 5 minutes, all the while being stirred. This prepared the 1% xanthan gum solution for use.

Similarly, to prepare the psyllium husk, 8.95% of psyllium powder was gradually added to 447.76% of water while being stirred until fully dissolved. The psyllium husk preparation was done by following the instructions from the packaging of the psyllium husk. This resulted in a ready-to-use psyllium husk solution.

After the xanthan gum and psyllium husk were ready, the binding agent was mixed with fat and sucrose. Then, the cereal puff was added into the slurry to produce a wet cereal bar base. Wet cereal bar bases were molded into 3 x 3 x 1.5 cm bars and stored in the freezer for 15 minutes. The baking pan was smeared with fat (butter or margarine) while waiting. After 15 minutes, the cereal bars were moved from the mold into the baking tray to be baked at 150^{o}C for 35 minutes. The oven is preheated to 150^{o}C prior to being used. Baked cereal bars were placed in tissue to remove the excess fat. Finally, the cereal bars were ready to be consumed. The process of preparing the cereal bar base sample is illustrated in Figure 2.

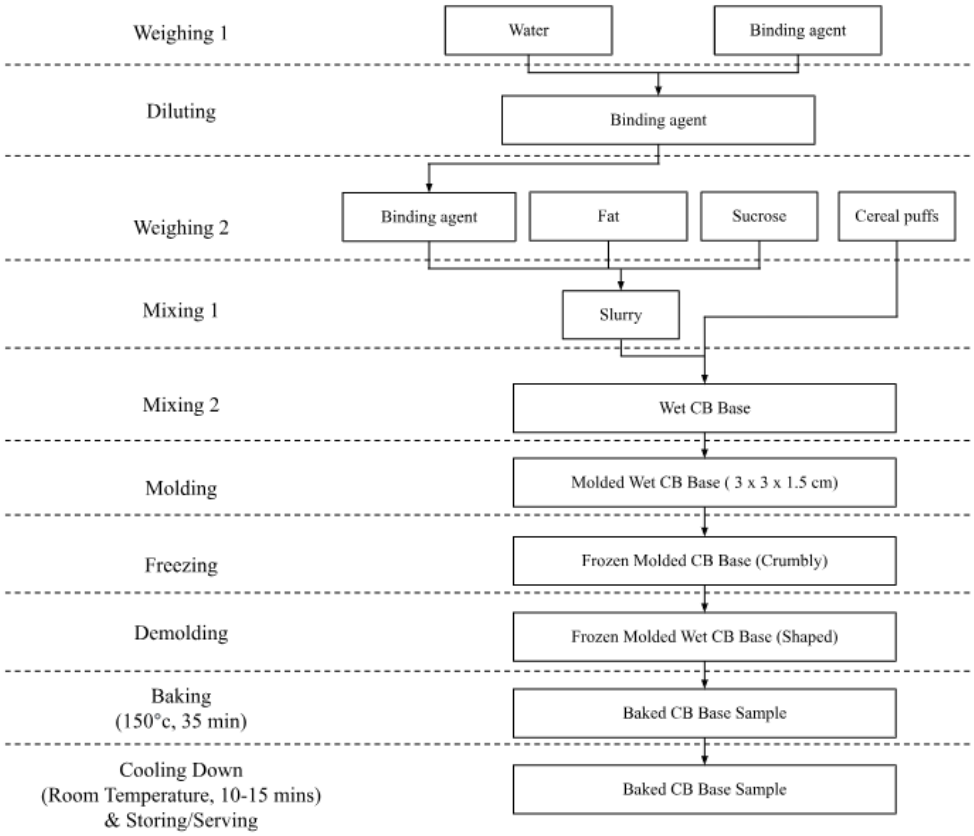

Figure 2. Cereal bar sample preparation

Sensory Evaluation

Sensory evaluation was carried out by recruiting Indonesian panelists from the Indonesia Institute for Life Sciences in Jakarta who were students, lecturers, and staff members using Google Forms. Fulfillment of the requirements to contribute as a panelist is based on their availability, health condition, absence of allergies to the sample ingredients, and consumer/regular users of cereal bars. The sensory test was done

using a nine-point hedonic test taken from each panelist to collect their responses. Nine-point hedonic test is appropriate for measuring panelists' preferences in accepting cereal bar samples. It consists of nine points in the form of verbal categories, with a scale of 1 being "dislike extremely" 5 being "neither like nor dislike", and 9 being "like extremely". A total of 50 panelists were involved in evaluating the sensorial attributes (aroma, hardness, chewiness, and taste) of each sample. Panelists at the end of the assessment for each sample were asked to provide scale ratings regarding overall liking.

Statistical Analysis

Data obtained from sensory tests were analyzed using IBM SPSS (Statistical Package for Social Sciences) statistical software version 26 (University of Chicago, Chicago, Illinois, United States) to calculate the mean ± SD (standard deviation) for each sample. A one-way analysis of variance (ANOVA) was performed to test for significant differences in attributes (aroma, hardness, chewiness, and taste) among samples that included various fat substitutes, including (f1) butter-psyllium, (f2) margarine-psyllium, (f3) margarine-xanthan gum, and (f4) butter-xanthan gum.

RESULTS AND DISCUSSION

The study examined the sensory preferences of four different cereal bar formulas. Figure 3 provides a visual representation of the liking rates for each formula (For more detailed information, please refer to Table 1). Notably, Formula 4 (F4) consistently received the lowest scores across all sensory attributes, and these differences were statistically significant ($p<0.05$).

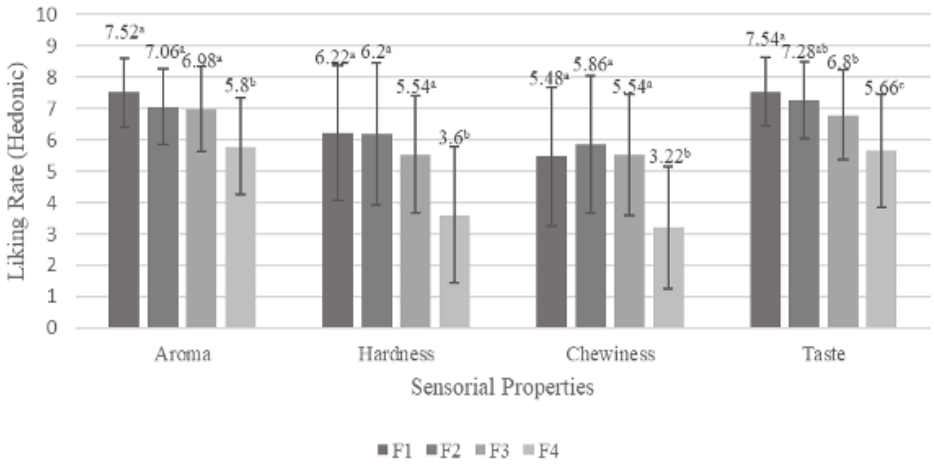

Figure. 3. Liking rate of cereal bar samples with different binding agent and fat source combination using 9-point hedonic scale. Note: Same superscript annotation on each value per sensorial attribute shows no significant difference ($p>0.05$); F1 (Butter-Psyllium), F2 (Margarine-Psyllium), F3 (Margarine-Xanthan Gum), F4 (Butter-Xanthan Gum)

A previous study by Angrainy et al. (2023) also found that the combination of sucrose, butter, and xanthan gum led to low acceptance with the same reasoning by participants as in this study. The samples proved difficult to bite into and had a low level of chewiness. According to the previous study by Lu and Cen as well as a study from Chen and Rosenthal, food texture acts as the main driver of food rejection, acceptability, and purchasability (Chen & Rosenthal, 2015; Lu & Cen, 2013). Exhibiting the texture characteristics, unfortunately, does not comply with the description of desirable cereal bars stated by Tramujas et al. (2021), which possess a firm texture without requiring excessive effort to chew.

On the contrary, Formula 1 (F1) received the highest preference scores, particularly in the aspects of aroma, hardness, and taste. This outcome implied that the combination of psyllium husk and butter produced the most favorable sensory experience for the panelists. The distinct butter aroma in F1 was notable, making it more appealing to the participants compared to the other samples. Moreover, the texture of F1 was considered superior in comparison to the other variants.

Nevertheless, substituting butter with margarine was still acceptable, as there were no significant differences in sensory preference rates ($p>0.05$). Formula 2 (F2), which utilized margarine and psyllium, exhibited the highest chewiness texture among the cereal bars, followed by the variant with margarine and xanthan gum. This highlights the role of margarine in creating the chewy texture of the cereal bars. Furthermore, an investigation published by Angrainy et al. in 2023 showed that the substitution of butter with margarine in sorbitol CB base led to a significant difference ($p<0.05$) in their preference for chewiness.

Hence, the results of this experiment showed that formulations containing psyllium husk (F1 and F2) garnered greater acceptance compared to those incorporating xanthan gum (F3 and F4). Interestingly, when assessing different fat source alternatives, xanthan gum showed better acceptance when paired with margarine, whereas psyllium husk received higher liking rates when combined with butter in the context of sucrose-based cereal bars. A related study conducted by Tramujas et al. in 2021 explored the development of savory cereal bars utilizing different binding agents, including psyllium husk and xanthan gum, which presented similar findings. In this study, the psyllium husk showed that the acceptance using butter and psyllium husk were more preferred than other formulations.

This result is also supported by a previous study from Dikeman and Fahey (2006), where it was found that the addition of psyllium in the formulation of baked goods could increase water absorption, as psyllium husk has a high water-binding capacity. If psyllium increases water absorption during the mixing of the cereal bar, it can lead to several effects. Firstly, the texture of the cereal bar might change, becoming denser or stickier due to the additional moisture content. This could affect the overall mouthfeel and chewiness of the bar. Secondly, the increased water absorption might impact the binding properties of the ingredients. Psyllium husk acts as a binding agent, so if it absorbs more water, it could potentially enhance the cohesion of the ingredients, making the bar hold together better. Lastly, the flavor could be influenced. If the psyllium husk absorbs more water, it might dilute the taste of other ingredients, affecting the overall flavor profile of the cereal bar. Besides that, the interaction between the psyllium husk and butter, which is a solid fat, would help to bind the ingredients together, resulting in a higher texture acceptance.

Figure. 4. Sample of cereal bar formula with different binding agents and fat sources

CONCLUSION

The aim of this study was to create a functional cereal bar using psyllium husk and to evaluate its influence on consumer preferences regarding taste, aroma, and texture, in comparison to xanthan gum. Results found significant differences ($p<0.05$) in the formula of butter xanthan gum (F4), where the scores

consistently received the lowest value across all sensory attributes, including aroma, hardness, chewiness, and taste. In contrast to F4, a combination of butter psyllium husk (F1) was the most favored, primarily due to their aroma profile and acceptable firm texture. Psyllium husk is a natural polysaccharide that is rich in fiber and can lower cholesterol. It also has an effect on the cereal bar aroma and firm texture. This study endeavors to craft a cereal bar using psyllium that combines nutritional advantages with better sensory qualities in comparison to Xanthan Gum. In future research endeavors, it is suggested to investigate diverse attributes and profiles of psyllium husk in other product applications, not only as binding agent alternatives but also in terms of its functional benefits. This should encompass factors like its unique properties as well as varying chemical reactions with other ingredients. This comprehensive approach will result in a more extensive dataset for analysis in future studies.

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