



Campaign education and communication to the potential consumers of brewers' spent grain (BSG)-added food products as sustainable foods

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ARTICLE INFO

Keywords:

Valorisation
Agroindustrial byproduct
Consumer behaviour
Consumer expectations
Food commercialization

ABSTRACT

Byproduct of the brewery industry, brewers' spent grain (BSG), has been reported for enhancing the nutritional value of food products thus potentially as a future sustainable food ingredient. As it is a byproduct, society as potential consumers tend to consider BSG as waste. Consequently, commercialization of BSG-added food products would be responded negatively by potential consumers. Campaign education seems to be important in order to familiarize such products to the society thus change the consumers perspective and finally increase the consumers acceptability. This study, which was conducted by an online survey platform (surveymonkey.com), aims to educate the society about the positive value of BSG for human health and its valorisation to the environment which generates sustainable food and to observe their opinion and expectation regarding such products. Majority of participants (57.38%) never knew BSG before. After BSG was introduced, most of the provided information about BSG is new for the majority of participants and they are convinced that consuming BSG-added food products would be beneficial for their health and help a sustainable environment. Furthermore, if such products are claimed as healthy foods, 81.97% of the participants are willing to buy. Besides the mindset of consumers, several issues might need to be considered in commercializing BSG-added food products including food regulation and safety as well as specific health conditions. Further study is still needed in order to educate society in a wider and to be specific in certain groups of community.

1. Introduction

Brewery industry generates a byproduct which is called brewers' spent grain (BSG). Annually, a number of 0.76 billion hectolitres of BSG is generated worldwide [1]. The potential of BSG as a healthy ingredient has been studied continuously for its obsession with several biological activities such as antioxidant, antimicrobial, anti-inflammation, and several important roles in noncommunicable

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<https://doi.org/10.1016/j.heliyon.2023.e19169>

Received 4 January 2023; Received in revised form 11 August 2023; Accepted 15 August 2023

Available online 18 August 2023

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diseases [2,3]. These properties are related to the abundance of polyphenolic compounds, dietary fiber, amino acids, fatty acids and minerals in BSG [3]. Therefore, the addition of BSG into food products has been studied including bread, cookies, pasta, composite flour, ice cream, yogurt, and dough [4–10].

Beside the fact that the addition of BSG in food products modifies the mechanical and technological processing properties during food processing, BSG enhances the nutritional value of the foods while at a certain amount, it decreases the acceptability of food products [3]. The amount of BSG addition inversely affects the food acceptability due to its direct impact in color and texture of BSG-added foods. A maximum 15% of BSG addition has been reported in enhancing the acceptability of bread products compared to control [9,11]. In contrast, 15% of BSG addition in bread products is reported to have a lower acceptability than that in commercial bread [12]. According to Heredia-Sandoval et al. [13], BSG generated a bitter taste and brittle texture in cookies product thus it is reported that taste and texture of BSG-added cookies play an important role in the general test acceptability of such food product [4]. A 20% addition of BSG in cookies products is categorized as acceptable [13] while in pasta 10% of maximum addition of BSG was observed [14]. Moreover, BSG influence the aroma of food products for having certain volatile compounds such as 2-butyl-1-octanol, 3-methyl-butanol, 2-heptane, butanol, benzene and 2,3-butanedione [4].

BSG-added food products potentially to be developed as functional foods which have been studied for their health benefits. However, consumer acceptance has to be taken into consideration in order to commercialize such food products [15]. According to a previous study, experiencing with BSG-added food products is one of the most concerns discussed by participants after health concept and sensory [16]. It is reported that most of the participants, 37 of college students, were willing to try BSG-added food provided. Furthermore, participants who are familiar with grain sensory will be more receptive to BSG-added food products. Educating the society as a potential customer is discovered to be necessary in order to enhance the acceptability of such products [16]. Therefore, education and spreading the information about BSG as a food ingredient has to be conducted continuously [15].

To the best of our knowledge, this is the first research related to educating society the utilisation of BSG as a food ingredient by online platform. This study aims to educate the society as potential consumers of BSG-added food products and to obtain their opinion regarding the expectation and willingness to purchase such kinds of food products. Therefore, this study will be useful for related scientists and the food industry in order to develop, provide and commercialize BSG-added food products.

2. Materials and methods

2.1. Experimental design and survey methodology

The study was conducted in an online platform survey ([surveymonkey.com](https://www.surveymonkey.com)) which was conducted in English with the typical

Table 1
List of questions in online survey questionnaire.

Number	Question	Answer option
Section 1. Personal information		
*1	What is your nationality?	Empty space was provided
*2	What is your age	Age range group were given
*3	Which of the following best describes your current occupation?	Several group of occupation were given
Section 2. General knowledge about brewers spent grain		
*4	Have you ever known about brewers spent grain (BSG) before?	Yes/No
*5	Where did you know about brewers spent grain?	Several options were provided
*6	Please watch the short video provided	done
*7	Please identify which are new information for you about BSG after watching the video.	Several options were listed
Section 3. Eating behaviour and preferences regarding listed food products, future expectation and opinion regarding BSG as a food ingredient		
*8	how often do you eat the listed products (Note: always, if you eat the product every day; Sometimes, if you eat at least 4 times a week; Rare, if you eat NOT more than 2 times/week; Never, if you never eat this product; Willing to eat, if you never eat, but you will eat in the future).	Food products were listed including the quantity category
*9	What do you consider the most when deciding to buy food products?	Options were listed to be ranked
*10	If there are any kind of food products which use BSG as one of the ingredients, would you buy them? And why? (minimum 7 characters)	Empty space was provided
*11	Look at the pictures on the link provided. Please choose maximum 3 which you prefer the most if those products are available in the market.	5 BSG-added food products were listed as shown in the figure provided
*12	If you have to choose from those type BSG-added food. Products, which product do you like the most? (Only 1 answer is allowed)	5 BSG-added food products were listed as shown in the figure provided
*13	As it was mentioned previously, BSG has enhanced the health value of the food products. If the physical appearance of the products is not change, would you buy them, if they are claimed to be healthy food?	Yes/No/Not sure
14	If not sure, Why?	Empty space was provided
*15	What do you think the impact of the transformation “from by-product to food” trends? Considering, by-product harmful to the environment, cheap materials, and converted become a healthy food ingredient.	5 options were listed
*16	Do you expect the BSG-added food products available in the market soon?	Yes/No
*17	Do you think there will be any issue concerning the utilisation of BSG as a food ingredient?	Yes/No
18	If your answer is yes, what could be the issue(s)?	Empty space was provided

Note: *required answer.

questions shown in [Table 1](#) and the questionnaire is presented in Supplementary Material. The link for the survey was spread through colleagues in several continents for a month period. The survey was designed in three different sections. First, personal profile including nationality, age and current occupation of participants. Second section is general information of BSG which is aimed to evaluate how much knowledge the participants have about BSG. In the middle of this section, a short video was provided to identify their knowledge in BSG. The last section is eating behaviour and preferences of selected food products as well as BSG-added food products. A figure containing 5 BSG-added food products was provided: bread, cookies, pasta, yogurt and ice cream. Finally, general opinion of and future expectation of participants were expected.

122 participants completed the survey out of 192 participants. The incomplete survey is excluded. The average time to complete the survey is approximately 10 min. The participants were from 31 different nationalities with variability in ages and occupations. There are some participants who have more than 1 occupation. In addition, the minimum age required for this survey is 18 years old. The profile composition of participants who completed the survey is shown in [Table 2](#).

Table 2
Profile of participants: nationality, occupations and age ranges of participants.

	Category	Number of participants
Nationality	Polish	24
	Croatian	16
	Spanish	11
	American	11
	Indonesian	10
	Albanian	5
	Dutch	5
	German	5
	Brazilian	4
	French	3
	Irish	3
	Macedonian	3
	Algerian	2
	Indian	2
	Sri Lankan	2
	Angolan	1
	Bangladeshi	1
	Belgian	1
	British	1
	Cameroon	1
	China	1
	Iranian	1
	Malaysian	1
	Mauritian	1
	Mexican	1
	New Zealand	1
	Nigerian	1
	Norwegian	1
	Portuguese	1
	Salvadorian	1
	Serbian	1
Occupation*	Education, training, student, and library	46
	Life, physical, and social science	16
	Business and financial operations	12
	Food preparation and serving related	12
	Healthcare practitioners and technical	11
	Architecture and engineering	10
	Arts, design, entertainment, sports, and media	8
	Office and administrative support	7
	Sales and related	4
	Legal	2
	Farming, fishing, and forestry	1
Age range	Other (flight attendant, retired, freelancer)	3
	18 to 24	28
	25 to 34	52
	35 to 44	17
	45 to 54	16
	55 to 64	8
	65 to 74	1

Note: there are some participants who have more than 1 occupations.

2.2. Data analysis

Data was provided by the online survey service in a simple excel and it is presented in simple calculations based on the number of participants and the percentage.

3. Results and discussion

3.1. General knowledge of participants about brewers spent grain

The level of the knowledge of participants in BSG is evaluated based on the questions Section 2 of the survey (Table 1) and the result is depicted in Table 3. The majority of participants (57.38%) have never known about BSG before this survey while about 42.62% of participants have known BSG before. There are three major sources of information about BSG which are mentioned by participants including magazine, news and internet followed by scientific paper, conference/lecture and working place. Those groups seem related to the occupation category in Table 2 which shows the highest category is in education, training, student and library employment.

Facts about BSG are delivered to the participants by a short video presentation which covers the information about source, general annual production, positive and negative value, current utilisation and the trend in the food science field about valorisation of BSG. As is shown in Table 3 question 3, the majority of participants (more than 50%) answered that the majority of information provided is new. A number of 21 from the total 52 participants who have known the BSG before are from the field of education, training, student and librarian occupations. The answer of participants in question 3 (Table 3) shows that the knowledge of society about BSG can be categorized as low because almost all the provided information is new for the majority of participants. By this, the purpose of this study, educating and campaigning the potential consumers of BSG-added food products, are achieved. However, such study is currently still needed in order to familiarize society about the potential of BSG as a food ingredient. Since the major source of information about BSG (question 2, Table 3) related to the current occupation of participants (Table 2), this result shows that certain groups of society are more familiar than others with BSG which could lead to low acceptability of BSG-added food products in future. Thus, certain community groups such as regions, occupation and other social group categories can be used as a target in the future campaign. Introducing such a positive value of BSG is expected to increase the acceptability of such products thus the sustainable food [15,16]. Furthermore, educating society is a way to enhance the consumers behaviour towards sustainable food [17]. All stakeholders such as the government, scientists and customers are responsible for reaching sustainable food.

3.2. Food preferences and willingness in purchasing BSG-added food products

3.2.1. General food preferences in selected food products

Eating habits and food preferences of participants on selected food products were evaluated regarding the answer of the questionnaire in section 3 (Table 1) question 8–9. Food products which are used as an example in this study are bread, cookies, pasta, yoghurt and ice cream. The selection of food products as the examples in this study is based on the current study in which BSG has been added and studied for improving nutritional value (bread, cookies, and pasta) and potential utilisation of BSG in dairy food products in future (yoghurt and ice cream). The tendency of participants to consume selected food is described as “always”, “sometimes”, “rare”, “never”, and “willing to eat” as is shown in Fig. 1a. Between those selected food examples, bread, pasta and cookies are the most

Table 3
General knowledge of participants about brewers spent grain.

Questions	Participants response	Amount	
		Number of participants	Percentage
1. Have you ever known about brewers spent grain (BSG) before?	Yes	52	42.62%
	No	70	57.38%
2. Where did you know about brewers spent grain?	Magazine, news, internet	21	30.43%
	Scientific paper, conference/lecture	18	26.09%
	Working place	15	21.74%
	Workshop/social event	6	8.70%
	Around the residence	3	4.35%
	Common knowledge	3	4.35%
	Personal interests	1	1.45%
	Friend	1	1.45%
3. Please identify which are new information for you about BSG after watching the video.	Faculty	1	1.45%
	General information about BSG as a by-product of brewery industry	78	63.93%
	BSG has a negative impact on the environment	95	77.87%
	BSG is a cheap material as it is a byproduct	78	63.93%
	BSG has been used as an animal feed and fertiliser	85	69.67%
	BSG contains nutritive value	86	70.49%
	Potentially to be used as a food ingredient	96	78.69%
BSG increases the nutrition value of food products	93	76.23%	

consumed by the participants in daily life. A small number of participants had never eaten such food products, however some of them are willing to eat in the future. These results show a potential of several types of food to which BSG can be added and potentially to be continuously consumed in the future. It is important to produce healthy and sustainable food which are familiar to consumers in order to increase the acceptability [18]. Based on the study, such selected food products seem to be familiar food for the participants.

Fig. 1b shows the decision in purchasing food products which is highly influenced by taste and ingredients, followed by health impact, price and appearance. This result is aligned with previous study conducted by Combest & Warren [16] in BSG-added bread which highlighted that health and sensory are the most important in making the decision to purchase food products. Interestingly, ingredients are observed to be the most important in the purchase decision in this study. By this, the addition of BSG into food products has to be taken into account from the perspective of consumers. The nutritional value of BSG can be used as a strong image of BSG in order to convince consumers to purchase BSG-added food products.

3.2.2. Willingness to buy BSG-added food products in the future

Willingness to buy such BSG-added food products are evaluated based on the answers of the questionnaire in section 3 question 10–14 in Table 1 and the result is shown in Table 4. The study indicates that the majority of respondents (76.23%) are willing to buy such products for different reasons. The main reasons are that they are convinced that BSG-added food products are healthy (32 participants) in addition to reducing waste and sustainable environment (18 participants). Interestingly, 15 participants are able to recommend certain products which seem suitable regarding the addition of BSG. The mentioned products are bakery products, ice cream, yoghurt, pasta and cereal-type foods. The minor reasons are based on curiosity, taste and seems interesting. This shows that the information provided in the video during the survey is able to convince the participants and thus commercial BSG-added food products would be highly accepted. However, even though the utilisation of BSG in food products is a sustainable approach, highly accepted by potential consumers, it is mentioned that BSG-added food product must be consumer friendly, which consider taste, price and appearance have to be in order to gain consumers' willingness [15].

A small number of respondents (8) do not want to buy BSG-added products concerning BSG as a waste. Another group of respondents is categorized as "not sure" due to the fact that the answers were "not sure" (4 participants), "do not know" (8 participants) and "maybe" (9 participants) concerning lack of confidence in health impact, taste and price. According to Naibaho & Korzeniowska [3] the health impact of BSG-added food products has been confirmed in several studies. By this, future challenges are convincing society about the health impact. This can be done by several institutions including the government, food industry and researchers. According to Spurling et al. [17] industry plays an important role in advertising in order to influence the consumers choices. Changing of consumers behaviour can be also done by re-skilling the consumers through research and communication. Moreover, taste which is

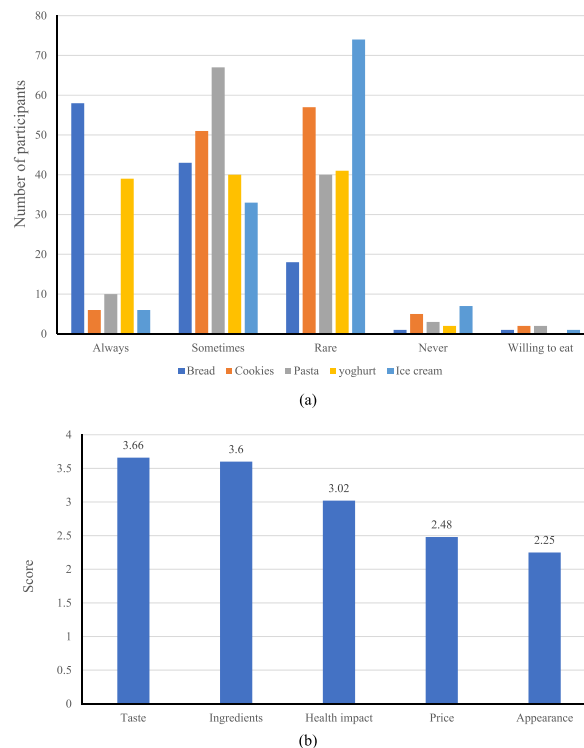


Fig. 1. Preferences of participants in selected food products (a) and the rank factors on purchasing decision (b). Note: always, if you eat the product every day; Sometimes, if you eat at least 4 times a week; Rare, if you eat NOT more than 2 times/week; Never, if you never eat this product; Willing to eat, if you never eat, but you will eat in the future.

Table 4
Willingness to buy selected BSG-added food products.

Answer	Number of participants	Reason
No	8	Healthy Harmful as waste Liking
Not sure	4	–
Do not know	8	–
Maybe (If)	9	good taste Price Healthy proved Need to be convinced by more information
Yes	93	Healthier products (32) Reducing waste is helpful for the environment (18) Suitable for specific products (15) Curiosity (9) No reason (9) Taste (5) Others (5)

the highest priority of participants in purchasing decisions (Fig. 1b) as well as price and appearance can be justified in food formulation and processing by industry. Even though price and appearance are not in the top priority in the previous section (Fig. 1), this issue must be considered as an important factor in order to attract the potential consumers. Industry as a producer needs to meet the consumers expectation thus decreasing the negative perception of consumers regarding the new products [19].

The next question shows several images of BSG-added food products, bread, pasta and cookies which were collected from previous publications [8,20,21] while yogurt and ice cream were from our current experiments. This stage aims to introduce the participants to the visual appearance and to strengthen their knowledge in selected BSG-added food products which they might discover in the market in the near future. As is shown in Fig. 2a, based on visual liking evaluation, BSG-added bread, pasta and cookies are three the most preferred by participants. Furthermore, Fig. 2b shows the highest level of liking is obtained in bread (43%) followed by pasta (20%), cookies (19%) ice cream (11%) and yoghurt (7%). This result describes the potential of BSG in food products from the perspective of appearance. This might be affected by food preference which is shown previously that yoghurt and ice cream are consumed quantitatively lower than bread, pasta and cookies. The potential of BSG-added bread, cookies and pasta seems to be promising regarding the habit (Fig. 1a) and preferences (Fig. 2). However, BSG additions in dairy products such as ice cream and yoghurt are still expected.

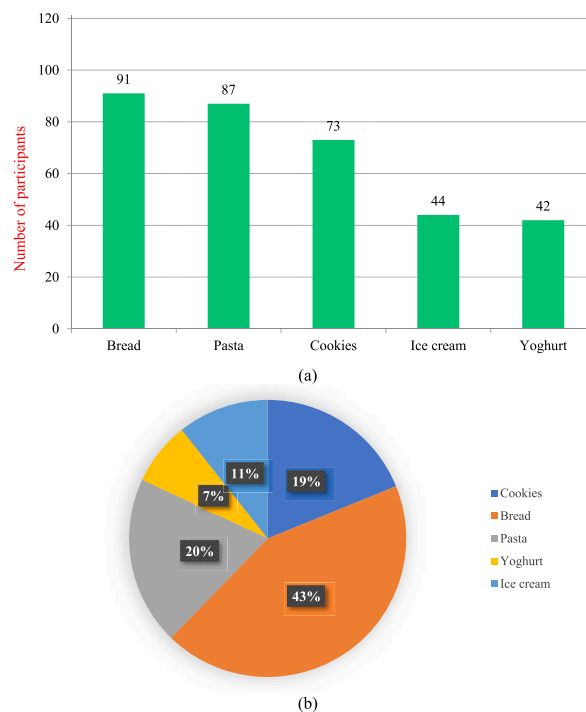


Fig. 2. Preferences of participants on BSG-added food products according to image visual appearance of selected food products: (a) the most three preferred; (b) the most desired BSG-added food products.

Since the addition of BSG in food products enhances the nutritional value in addition to its biological activity [8,9,13,14], BSG-added food products are potentially to be classified as functional foods. Therefore, this issue is addressed to the participants with the expectation how much the participants were convinced through this study. Furthermore, the participants who were not convinced enough were asked for their reasons. Fig. 3 shows a number of 100 (81.97%) participants were convinced they would buy such food products. Meanwhile, 15 participants (13.93%) were not sure with major reasons for hesitation in healthy-claim and taste of such products. As mentioned previously, these would be the challenges for the food industry in producing BSG-added food products which meets the consumers expectations.

Generally, new functional food products are facing the same response from potential consumers. For instance, organic food trends [22] and insect-based food [23]. This study shows the same pattern that some potential customers might not easily accept such BSG-added food products. Campaign education, communication and re-orientation of consumers' perspectives have been suggested as an important step to increase the positive response from society as is mentioned previously. Concerning BSG as a sustainable food ingredient, behavioural strategies towards the consumption of sustainable food are important [24]. In addition, campaign education by personal characteristics and lifestyle approach seems to be a strategy [24]. Personal behaviour issues are aligned with reported studies which discovered that the awareness of consumers in food sustainability is low [25,26]. Therefore, educating potential consumers for BSG-added food products is still expected in the near future in a broad and specific group of communities.

3.3. General opinion and future expectation of participants in the valorisation of BSG as a food ingredient

The general opinion of participants is shown in Table 5 which were collected from the answer of question 15–18 in Table 1. The results show that participants agree regarding the idea of valorisation of BSG as a healthy food ingredient. Majority of the participants (85) participants agree with the necessity and urgency of this trend. This result is related to their reasons for willingness to consume BSG-added products which is believed to be healthy and helpful to the environment in Table 4. Meanwhile 34% of participants agree to this trend however they disagree regarding the urgency and necessity. This might be because information about food sources availability and hunger around the world were not included in this study. In fact, the population of undernourished people around the world is high; more than 820 million people are in hunger in the world [27] and it was predicted about 43.6 million in European countries [28]. This phenomenon leads to the urgency and the necessity of food sources availability. Therefore, valorisation of by-products, BSG specifically, as a food ingredient is currently needed due to the fact that it is cheap and healthy materials.

Most of the participants (67.21%) also are expecting such products to be commercially available soon. This result depicts the positive response of society to this new trend. By this, the purpose of this research which is educating society is to succeed. Further study with the same purpose is still needed to reach as many participants as possible. Taking into consideration, there is about 32.79% of participants who do not expect such food products soon in the future might be concerned in the lack of confidence regarding the nutritional value and others beneficial of this trend. This phenomenon can be minimized by further education programs both by scientists and the food industry.

As is shown in Table 5, 40 participants believe that there might be several issues in commercialization of BSG-added food products and all the suggested issues are listed in Table 6. The main suggested issue is from the perspective of consumers (20 participants) such as lacking acceptance due to taste and appearance, mindset of society as BSG can be considered as a waste thus considered to be harmful and unhealthy. In fact, those issues appeared also during this study which has been mentioned in the previous section. By this, as the purpose of this study, educating society is needed in order to hinder those mentioned issues and to convince the society. Interestingly, there would be a possibility when this trend becomes a new style which leads to generating expensive food products as participants mentioned. Nowadays, consumers tend to search for natural based products [29]. Therefore, the BSG-added food products can be a new trend in the future which could lead to a high demand and price. Other possible issues which are predicted by participants are from the perspective of policy makers such as region and global regulation, health issues such as allergy and specific health conditions as well as toxicological perspective. Those issues might be because of mistrust of customers in policy maker and industry [22]. Labelling is expected to give clear information about health impact [30–32].

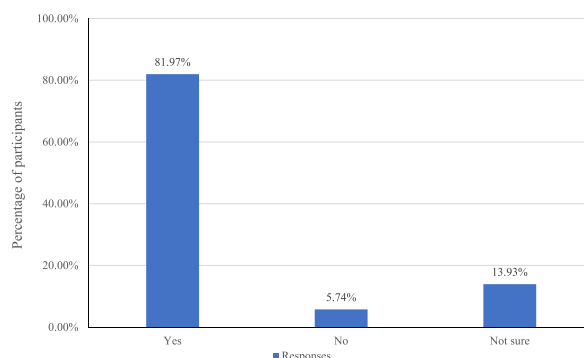


Fig. 3. Willingness to buy BSG-added food products with a claim to be healthy food products.

Table 5
General opinion and the expectation of participants in the addition of BSG in food products.

Questions	Participants response	Amount	
		Percentage	Number of participants
What do you think the impact of transformation “from by-product to food” trends? Considering, by-product harmful to the environment, cheap materials, and converted become a healthy food ingredient	This is good idea and necessarily needed	43.44%	53
	This is good idea and urgently needed	26.23%	32
	This is good idea but not urgently needed	15.57%	19
	This is good idea, but not necessarily needed	12.30%	15
	Nothing special with that	4.92%	6
Do you expect the BSG-added food products available in the market soon?	Yes	67.21%	82
	No	32.79%	40
Do you think there will be any issue concerning the utilisation of BSG as a food ingredient?	Yes	32.79%	40
	No	67.21%	82

Table 6
Potential issues in the utilisation of BSG as a food ingredient.

Potential Issues	Number of participants
Consumer perspective	20
Taste	
appearance/attractiveness	
New ingredients	
Mindset: waste	
Queries in healthy	
Scepticism: trendy thus become expensive	
Approval or acceptance from society	
Policy maker	7
Health issue	4
allergies and specific health condition	
Food safety	4
Toxicological issue	

4. Conclusion

Utilisation of BSG as a food ingredient is expected by the majority of participants. The willingness of participants to buy BSG-added food products in the future concerning the health beneficial of BSG and reducing negative impact of BSG to the environment. Based on the selected food preferences, BSG are potentially to be used in a variety types of food products including baked, pasta and dairy food products. However, some participants expected that taste, appearance and price should be customer friendly. The results show that this study successfully educates consumers about the benefits of the valorisation of BSG as a food ingredient which can be from their willingness to buy such products in the future. However, campaign education and communication to the potential consumers is still needed to a broad and specific group of consumers.

Ethics statement

Informed consent was obtained from the participants in collecting the responses.

Author contributions statement

Joncer Naibaho: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Malgorzata Korzeniowska: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Elisa Julianti, Nico Syahputra Sebayang, Baoru Yang: Conceived and designed the experiments; Wrote the paper.

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

influence the work reported in this paper.

Acknowledgement

Authors would like to thank the “Flavor Chemistry Team - IPN 2016” who helped in designing the survey questionnaire: Leoni, Mutiara, Petronela, Rachel and Safira.

This work was supported by UPWR 2.0, international and interdisciplinary programme of development of Wrocław University of Environmental and Life Sciences, co-financed by the European Social Fund under the Operational Programme Knowledge Education Development 2014–2020: Axis III Higher education for the economy and development; Action 3.5. Comprehensive programmes for schools of higher education (POWR.03.05.00–00-Z062/18).

It was also supported by ERA-NET CO-FUND Horzont 2020 - FACCE SURPLUS Sustainable and Resilient Agriculture for Food and Non-Food Systems and PROWASTE Protein-fibre biorefinery for scattered material streams (2019–2021).

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e19169>.

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