Food Research 8 (Suppl. 2) : 154 - 161 (2024)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

The effect of jack bean (*Canavalia ensiformis* L.) starch modification annealing-heat moisture treatment on physical and chemical characteristics of biscuit

*Ariyantoro, A.R., Affandi, D.R. and Rahmah, A.S.

Food and Science Technology Department, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

Article history:
Received: 5 March 2023
Received in revised form: 27 September 2023
Accepted: 20 January 2024
Available Online: 21 April 2024

Keywords:
Annealing,
Biscuits,
HMT,
Jack bean,
Starch

DOI:
https://doi.org/10.26656/fr.2017.8(S2).113

Abstract

Biscuits are one of the food products that are in great demand by the people of Indonesia with a consumption growth rate of 4.25% from 2016 to 2020. Biscuits have the characteristics of low moisture content so they have a long shelf life. In this study, innovation was carried out on the main raw material of biscuits using the substitution of jack bean starch (*Canavalia ensiformis* L.) modified by annealing-heat moisture treatment (HMT). This study aimed to determine the effect of HMT and annealing-HMT on the physical and chemical characteristics of biscuits and to determine the best biscuit formulation. The design used in this study was completely randomized design (CRD) with one factor in the combination of modified starch and biscuit formula, namely control (100% flour), native starch (100%), native starch: wheat (50:50), native starch (100%), HMT modified starch: wheat (50:50), HMT modified starch (100%), annealing HMT modified starch: flour (50:50), and annealing HMT modified starch (100%). Based on the research, it was found that the substitution of wheat flour using annealing HMT modification starch affects brighter color, lower hardness and fracture strength, lower moisture content, ash content, fat content, and protein content, as well as increment in carbohydrate content. The best formula was determined based on multiple attributes, namely the F7 formula with 100% annealing HMT starch modification.

1. Introduction

Wheat flour is one of the raw materials with a high level of consumption in Indonesia. It is widely being used in both of household and industrial sector as the main ingredient in the form of end products such as bread, cakes and noodles. The high demand of wheat flour is presented by the United States Department of Agriculture (2022) statistic, which shows that wheat import in Indonesia from 2021 to 2022 is increasing to 11.2 million metric tons (MMT). The growth in national wheat consumption has also placed Indonesia as one of the largest importers of wheat in the world. This fact reflects that there has been an increase in the consumption of wheat-based foods in Indonesia. The continuous increment in the number of imports poses a threat to national food security. Food import activities could fulfill the national food supply, but on the other side it could harm local food production. For this reason, the concept of food diversification is one of the alternative solutions to achieve national food security. One alternative to reduce the consumption of wheat flour is by utilizing local legumes, one of which is jack bean (*Canavalia ensiformis* L.). Jack bean is a local food from legumes which is rich in carbohydrates and protein. The high carbohydrate content in jack bean makes jack bean suitable as an alternative source of starch. In fact, carbohydrates are the most abundant macromolecule in jack bean starch with an amount of about 79.2% followed by moisture content of about 11.3%, protein of 2.28%, lipid content by 6.41%, and low ash content of 0.19% (Akinyemi *et al*., 2020).

However, native starch has a limited use due to its incompatibility when used for processing, such as inert granules, insoluble in water, resistant to enzymatic hydrolysis, high hydrolysis and syneresis, and is unstable to changes in temperature and pH (Punia, 2020). Thus, to improve the characteristics of starch, it is necessary to modify starch properties. Modification of starch that can be done to improve the characteristics of jack bean starch is through physical modification. Physical modification was chosen with consideration of low operational costs and considerable as safe because no chemical reagents are used. Physical modifications that are widely used are annealing and heat moisture treatment (HMT). Annealing is a starch modification process through

*Corresponding author.
Email: *achmadridwan@staff.uns.ac.id*

eISSN: 2550-2166 / © 2024 The Authors.
Published by Rynnye Lyan Resources

heating by adjusting the moisture content of 40-50% w/w or >60% w/w by heating below the gelatinization temperature (Wang *et al*., 2018). HMT is a modification process by controlling the moisture content and heating above the starch gelatinization temperature for a certain time (Varatharajan *et al*., 2011).

One of the commercial food products that could be produced by jack bean starch is biscuits. It is widely consumed by the public and has a growing consumption rate every year. Based on Food Consumption Statistics (2020), biscuits experienced a consumption growth rate of 4.25% from 2016 to 2020. The main characteristic of biscuits is its low moisture content (maximum 5%), so they have a long shelf life. In general, biscuits are an energy source food that comes from carbohydrates and protein, have crunchy characteristics due to their fat content.

The utilization of modified jack bean starch annealing and HMT was chosen as an alternative to wheat flour in biscuit products because biscuits do not require large volume expansion as in bread (Di Cairano *et al*., 2018). The reason of flour substitution by starch is because it creates a texture that is preferred by consumers, by decreasing the hardness and fracture strength of the resulting biscuits (Di Cairano *et al.,* 2021). In addition, annealing and HMT can increase SDS (slowly digestible starch) and RS (resistant starch) for functional food products (Fonseca *et al*., 2021).

From this research, it is expected to know the difference in the effect of starch modification treatment by HMT and annealing-HMT on the physical and chemical characteristics of biscuits substituted with jack bean modified starch. In addition, it is expected to know the right formulation to produce biscuits with the best characteristics.

2. Materials and methods

2.1 Extraction of jack bean starch

The process of making jack bean starch is carried out based on previous research that has been done by Ariyantoro *et al*. (2022). The jack beans were soaked in distilled water containing 0.45% Na metabisulfite for 9 hrs and separated between the bean and the nutshell. Next, distilled water was added and jack bean was crushed using a blender with the ratio of distilled water and jack bean at 3:1. The solution of the jack bean was then squeezed using a filter cloth, and followed by 3 times washing with distilled water. The jack bean starch was then dried using a cabinet dryer at 50°C for 4 hrs. The dried jack bean starch was refined using a blender and sieved using a 100-mesh sieve to obtain jack bean starch.

2.2 Heat moisture treatment modification starch

HMT modification starch was carried out based on previous research conducted by Ariyantoro *et al*. (2022) which began with setting the moisture content to 33%, then stored in a closed container at 4°C for 24 hrs. Then, it was heated at 110°C for 16 hrs using an oven. Next, the starch was dried in a cabinet dryer at 40°C for 8 hrs. The starch was then ground using a blender and sieved using a 100-mesh sieve to obtain HMT modified starch

2.3 Modification of jack bean starch with annealing and heat moisture treatment

Annealing and HMT modification starch was carried out based on previous research conducted by Ariyantoro *et al*. (2022) and Wang *et al*. (2017) with modification. The starch modification was started by weighing 60 g of jack bean starch which was then added with 180 g of distilled water (starch: distilled water ratio of 1:3). Jack bean starch which has been mixed with distilled water then stirred at a speed of 500 rpm for 5 mins. Next, the starch was annealed at a temperature of 55°C for 24 hrs. The annealed starch of jack bean was then cooled and separated between water and wet starch. The wet starch was then dried in an oven at 50°C for 4 hrs. The starch was then grinded and sieved to obtain 100 mesh annealed jack bean starch. The annealed starch was adjusted to the moisture content up to 30% and left in the refrigerator at 4°C for 24 hrs. The starch was then re-measured on the moisture content and the HMT process was carried out using an oven at 110°C for 16 hrs. Furthermore, the modified annealing HMT jack bean starch was dried in an oven at 40°C for 8 hrs. The starch was grinded and sieved to obtain annealing- HMT modified jack bean starch.

2.4 Jack bean starch biscuits production

The process of making biscuits is carried out based on Cahyana *et al.* (2020), which begins with mixing 70 g of sugar with 80 g of margarine and shaking using a mixer for 10 mins. Next, 60 g of egg yolk and 100 g of skim milk were added and continued by mixing with a mixer for 5 mins at medium speed. When the dough is formed, jack bean starch and 1 g of sodium bicarbonate were added. The dough was kneaded until soft and then flatten into a thickness of 0.2 cm using a roller. The flattened biscuit dough is then molded into a circle with a diameter of 3 cm. The dough mold is baked in an oven at 160-165°C for 10 mins. Next, the biscuits were cooled for 30 mins and then packaged and stored at 25°C. The biscuit formula was showed in Table 1.

https://doi.org/10.26656/fr.2017.8(S2).113

Table 1. Jack bean starch biscuit formula design.

Ingredients (in g)	Samples (with native starch substitution, HMT modified starch, and Annealing HMT modified starch)						
	F1 (Control)	F2	F3	F4	F5	F6	F7
Flour	200	100	0	100	0	100	0
Native jack bean starch	0	100	200	0	0	0	0
HMT modified jack bean starch	0	0	0	100	200	0	0
Annealing HMT modified jack bean starch	0	0	0	0	0	100	200
Margarine	80	80	80	80	80	80	80
Sugar	70	70	70	70	70	70	70
Egg yolk	60	60	60	60	60	60	60
Skimmed milk	100	100	100	100	100	100	100
Sodium bicarbonate	1	1	1	1	1	1	1

Note: Heating treatment; jack bean starch: flour includes F1 = without heating; 0:100; F2 = no heating; 50:50; F3 = no heating;

3. Results and discussion

3.1. Physical characteristics of biscuit

3.1.1 Color

Color is one of the important parameters in determining consumer preferences for biscuit products. Based on Table 2, the lower L* (lightness) values in control biscuits and biscuits with HMT and annealing HMT modified starch substitution were thought to be affected by the use of wheat flour and the presence of pre-treatment on HMT and HMT annealed modified starch. Wheat flour with a higher protein can cause a Maillard reaction during biscuit baking. The less bright color of the biscuits with the full or partial use of wheat flour is thought to be the presence of high Maillard reaction between reducing sugars and protein amino groups that form melanoidin compounds when baking (Stoffel *et al*., 2021).

The increasing value of a* (redness) is thought to be related to the Maillard reaction which has a tendency toward positive a* values or browning tendency. According to Tamanna and Mahmood (2015), The use of high temperatures in the baking process will result in the breaking of the glycosidic bonds in carbohydrates and sucrose. Thus, sucrose is broken down into reducing sugars, such as glucose and fructose. After that, the reducing sugar will react with the free amino acid group to produce melanoidin compounds that form the brown color in biscuits. The higher the Maillard reaction lead to the higher a* value.

The color difference of the raw material with modified starch also affects the decrease in L* value and the increase in a* value in biscuits (Zielinska and Pankiewicz, 2020). This is in accordance to the previous research by Cahyana *et al.* (2020), which state that use of modified banana flour using HMT can give a darker appearance than the unmodified biscuits. The use of high temperatures in the HMT modification process and annealing-HMT can cause a browning reaction in starch, resulting in a decrease in whiteness in modified starch.

In the parameter value of b* (yellowness), there is a tendency to increase the value of b* on biscuits. The lower level of yellowness in unmodified biscuits was due to less melanoidin formation compared to control biscuits and biscuits with modified HMT and annealing-HMT (Passos *et al.,* 2017). The decrease in yellowish color was also influenced by an increase in the brown color (redness) of the biscuits. The biscuits appearance can be seen in Figure 1.

Table 2. Physical characteristics of biscuit.

Sample	Color			Texture	
	L*	a*	b*	Hardness (N)	Fracturability (N)
F1	68.57±2.01[a]	1.83±0.05[g]	39.93±0.34[a]	230.79±5.71[g]	6.22±0.25[c]
F2	79.39±1.13[cd]	-159±0.02[b]	41.83±1.58[a]	197.36±1.27[f]	4.36±0.21[b]
F3	81.84±0.99[d]	-3. 5±0.06[a]	41.84±2.07[a]	98.46±0.15[c]	3.85±0.42[ab]
F4	75.92±1.30[b]	1.25±0.05[e]	40.50±1.25[a]	117.96±1.88[e]	3.26±0.24[a]
F5	76.27±0.81[b]	1.72±0.02[f]	39.33±1.06[a]	86.72±0.52[a]	3.13±0.63[a]
F6	77.16±2.40[bc]	0.17±0.03[d]	40.83±0.68[a]	110.63±1.72[d]	3.32±0.44[a]
F7	78.44±0.60[bc]	-0. 74±0.06[c]	40.11±1.73[a]	92.73±0.45[b]	3.22±0.27[a]

Note: Heating treatment; jack bean starch: flour includes F1 = without heating; 0:100; F2 = no heating; 50:50; F3 = no heating;

https://doi.org/10.26656/fr.2017.8(S2).113

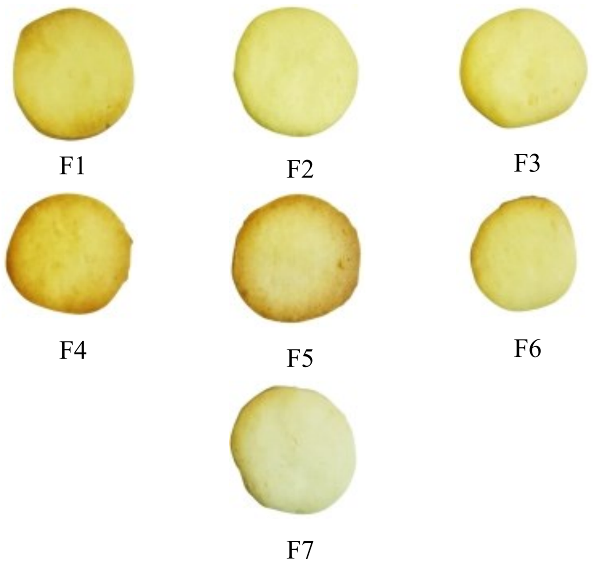

Figure 1. Appearance of the biscuits. Note: Heating treatment; jack bean starch: flour includes F1 = without heating; 0:100; F2 = no heating; 50:50; F3 = no heating; 100:0; F4 = HMT; 50:50; F5 = HMT; 100:0; F6 = Annealing

3.1.2 Texture

Texture is one of the important analyzes for biscuits. Texture can affect processing, handling, shelf-life stability, and as a determinant of consumer acceptance in consuming biscuits (Lara *et al.,* 2011). Texture parameters that are important in the analysis of biscuit products are the level of hardness and fractur ability. Based on Table 2, the decrease in the level of hardness in the biscuits were influenced by the use of wheat flour partially or fully substituted with jack bean starch. The increasing level of hardness illustrates that the texture of the biscuit is hard and less crunchy than the biscuit product with a lower hardness level (Jia *et al*., 2020). This finding is in accordance with the research conducted by Cahyana *et al.* (2020), where the higher substitution of wheat flour with banana flour that has been modified by HMT cause decreased the hardness level of biscuits. The level of hardness in biscuits were influenced by the type of protein. In the control biscuit, most of the protein was gluten protein which was able to form biscuit structure. The lower level of hardness in biscuits with full or partial starch substitution is due to the reduced gluten content which plays a role in the hardness level of biscuits. Gluten is the main component of wheat flour protein and consists of gluten and gliadin proteins. Gluten tissue can bind to water molecules to form a hard texture on biscuits (Aslam *et al.,* 2014). Based on Table 2, it can be seen that the decreasing fracture strength in biscuits with substitution of jack bean starch without modification of HMT and Annealing HMT was due to the low amount of gluten protein in the raw material for making biscuits. Low gluten in biscuits can weaken the structure of the product. According to Pauly *et al*. (2013), biscuits with the highest level of hardness, are biscuits with high protein content. Reducing the protein content can reduce the level of hardness and fracture strength, because a lot of starch was added.

Besides being influenced by gluten, the formation of hardness and fracture strength in biscuits was influenced by the starch content in the ingredients of biscuits. According to Ikuomola *et al.* (2017), it was stated that the starch content of wheat flour had a stronger bond than the starch content of beans. The amylose content in wheat flour is 28%, while the amylose content in jack bean starch without modification is 29.31% (Ariyantoro *et al.,* 2022), and the amylose content of starch with modified annealing HMT was in the range of 25.10-25.19%. Amylose has the characteristics of a straight and tight structure, and has a hydroxyl group at one end so that it can easily absorb water. In the baking process, starch binds to water undergoes gelatinization and forms a gel. During cooling, the starch will undergo retrogradation so that the amylose molecules will bind back, and some of the amylose will bind back to the amylopectin on the outside of the granule. In this retrogradation process, starch grains are formed again with a strong microcrystal network. These bonds that occur during retrogradation then form a strong matrix so that it can produce biscuits with a hard texture. Thus, the low amylose content in biscuit raw materials could make a nonoptimal retrogradation processes because the rate of crystallization of amylose during retrogradation is faster than amylopectin (Guo *et al*., 2021). In consequence, the biscuit with lower amylose content becomes easily broken.

3.2 Chemical characteristics of biscuit

3.2.1 Moisture content

Moisture content is the total amount of water contained in food that expressed by weight percentage. Based on Table 3, the different moisture content values in the control and partially substituted biscuits with modified starch by HMT or annealing-HMT were due to differences in moisture and protein content in biscuit materials. The results of the analysis of the moisture content obtained were in accordance with previous research by Ariyantoro *et al*. (2022), where the moisture content of the jack bean starch which was carried out by dual modification (annealing HMT) showed a lower value ranging from 3.48-3.86% compared to the starch treatment of annealing which ranged from 9.56-9.83%. Meanwhile, the moisture content in native starch is 10.5% and in the control treatment (the use of wheat flour) of 13.9-15.4% (Thanhaeuser *et al*., 2014). The lower moisture content value in biscuits that were

https://doi.org/10.26656/fr.2017.8(S2).113

Table 3. Chemical characteristics of biscuit.

Sample	Moisture Content	Ash	Fat	Protein	Carbohydrate
F1	5.08±0.39[de]	1.98±0.03[b]	17.19±1.08[b]	10.8±0.34[c]	71.48±1.12[a]
F2	5.40±0.28[e]	1.69±0.19[a]	15.04±0.31[ab]	9.13±0.37[b]	75.3±0.72[b]
F3	5.02±0.2[cd]	1.70±0.01[a]	13.31±1.29[a]	6.74±0.4[a]	79.2±1.52[d]
F4	4.64±0.18[bcd]	1.80±0.07[ab]	16.86±1.46[b]	8.84±0.37[b]	73.77±1.81[ab]
F5	4.53±0.25[abc]	1.77±0.06[a]	15.97±0.93[b]	7.02±0.72[a]	76.36±0.61[bc]
F6	4.4±0.38[ab]	1.69±0.15[a]	16.71±1.83[b]	8.66±0.76[b]	74.11±2.58[ab]
F7	4.04±0.1[a]	1.66±0.02[a]	13.61 ± 0.81[a]	7.22±0.24[a]	78.42±0.97[cd]

Note: Heating treatment; jack bean starch: flour includes F1 = without heating; 0:100; F2 = no heating; 50:50; F3 = no heating;

partially or fully substituted with starch modified by Annealing-HMT was also due to the decrease in gluten content, which is the largest protein constituent of flour in biscuits. Gluten is a protein that is not soluble in water and is hydrophilic which is able to bind water to wheat flour (Lynch *et al*., 2018).

The effect of protein on moisture content is also strengthen by the findings of Thongram *et al.* (2016), which stated that the high protein content in flour will make it absorbs more water because protein has a higher water holding capacity. The hydrophilic groups on the protein will bind the water contained in the dough through hydrogen bonds. The baking process make the water that has been absorbed will be trapped in the margarine fat, making it difficult for water to evaporate. Then, the hydrogen bonds between starch and protein are weakening when heating occurs, so water can enter it. The cooling process in biscuits will have an impact on reinforcing the hydrogen bonds so that the water molecules will be tightly bound and difficult to release through evaporation or baking (Chang *et al*., 2021).

3.2.2 Ash

The ash content of the biscuit was presented in Table 3. The ash content in the biscuits decreased with the use of jack bean starch either without modification or with modification of Annealing-HMT. The decrease in ash content was due to the lower ash content of jack bean starch compared to wheat flour in the control treatment. In the control treatment, the ash content ranging from 1.62% (Heshe *et al.,* 2016), while the starch of jack bean (*Canavalia ensiformis* L.) has an ash content in the range of 0.19% (Akinyemi *et al.,* 2020).

3.2.3 Fat

In baked goods such as biscuits, fat play important sensory function, such as texture, mouthfeel, aroma and flavor of food (Biguzzi *et al*., 2014). The different fat content values between biscuits of the control treatment and biscuits that were partially or fully substituted with jack bean starch were influenced by the fat content. The fat content of biscuits tends to decrease along with the use of jack bean starch. The decrease in fat content was due to the lower fat content of jack bean starch compared to the fat content of wheat flour. Based on Nwosu *et al*. (2014), the fat content in the control biscuit using medium protein wheat flour was 2.13%, while the fat content in the jack bean starch was 6.41% (Akinyemi *et al.,* 2020). Differences in fat content of raw materials that are not in accordance with the literatures may be due to differences in types and varieties of jack bean, environmental conditions, storage areas, differences in growing places, cultivation and harvesting age.

In the making of biscuits, margarine and egg yolks also contribute to the fat content of biscuits. Margarine is a vegetable fat that tastes and smells like butter. According to Hwang *et al*. (2016), commercial margarine contains about 80% fat. Adding margarine to biscuits can increase the fat content. In each formulation for making biscuits, 60 g of egg yolk were also used. According to Xiao *et al*. (2020), egg yolks contain 62.5% fat. The more fat content in the raw material for making biscuits tend to the higher the fat content.

3.2.4 Protein

Based on Table 3, the decrease in protein content in biscuits that were partially or completely substituted with jack bean starch was due to the protein content in jack bean starch. Jack bean starch has lower protein content than in wheat flour. In the control, the protein content in wheat flour was medium protein, which was 14.4% (Heshe *et al*., 2016), while the protein content of the jack bean starch is 2.28% (Akinyemi *et al*., 2020). Besides being influenced by raw materials, egg yolks also contribute to the protein content of biscuits. Not only high in fat, egg yolks also contain a fairly high protein content for 33% (Xiao *et al*., 2020), thus contributing to the protein content of the resulting biscuits.

3.2.5 Carbohydrate

The carbohydrate content of biscuits was influenced by differences in the composition of the raw materials. Biscuit with jack bean modified starch could increase the carbohydrate content of biscuits. Carbohydrate content in

https://doi.org/10.26656/fr.2017.8(S2).113

biscuits were influenced by other nutritional components such as water, ash, fat, and protein. The lower the components of water, ash, fat, and protein cause the higher the carbohydrate content. Thus, treatment with the use of wheat flour can reduce the carbohydrate content of biscuits, although there is an increase in other components such as protein and fat (Zielińska and Pankiewicz, 2020).

In addition, the carbohydrate content of biscuits was also influenced by the carbohydrate content of the biscuit materials. Wheat flour contains carbohydrates by 67.7%, while jack beans starch contains carbohydrates by 79.2% (Akinyemi *et al*., 2020).

3.2.6 Determination of best formulation

Determination of the best formulation in this research was based on a weighting test using multiple attribute method according to Bayes (2014). Bayes theorem is a decision-making technique based on the occurrence and evidence concept of probability. The best formulation of analysis stage was determined by the criteria of moisture, ash, protein, fat, carbohydrates, color, and texture of biscuits. For each parameter, the range and level of confidence are determined, followed by the calculation of the probability on each parameter which will produce an expected value as the basis for the decisions taken. The best treatment is taken from the treatment with the highest ranking based on the Bayes method. The best treatment results is showed in Table 4.

Table 4. Determination of best treatment.

Alternative	Calculation Results with Bayes method
F1	0.00003
F2	0.00127
F3	0.00120
F4	0.00297
F5	0.02703
F6	0.04545
F7	0.17949

Based on Table 4, It can be seen that the best treatment for biscuits with modified jack bean starch substitution is found in sample F7 or with annealing-HMT modified jack bean starch treatment of 100%. Biscuits with the best treatment were then further tested using the T-test. Biscuits with the best treatment for each replication were compared with biscuits in the control treatment (100% wheat flour) to see whether there was a significant difference between the two samples. Based on the T-test, the results of the best treatment showed significantly different characteristics on the parameters a* (redness), hardness, fracture, ash content, fat content, protein content, and carbohydrate content. Meanwhile, the parameters L* (lightness), b* (yellowness), and moisture content did not have a significant difference in characteristics. From the data obtained, the substitution of modified jack bean starch with 100% annealing HMT can increase consumer preferences in the selection of biscuits in terms of color and texture compared to biscuits made with wheat flour as raw material. Meanwhile, the chemical characteristics had a lower result than the control biscuits but were still within the defined biscuit standards.

4. Conclusion

Based on the results from the study, it can be concluded that the modified jack bean (*Canavalia ensiformis* L.) starch by annealing-HMT has an effect on the physical characteristics of the biscuits produced. Partial or total substitution using starch that has been modified by annealing HMT led to the color of the biscuits to be brighter, and have a lower hardness and fracture strength compare to the control. The chemical characteristics cause a decrease in moisture, ash, fat, protein content, and an increase in carbohydrate content. Meanwhile, the best formula in this study was F7 formulation or biscuits with 100% Annealing-HMT jack bean starch.

Conflict of interest

The authors declare no conflict of interest

Acknowledgements

This research was supported by a Fundamental Research Grant 2021 (221.1/UN27.22/HK.07.00/2021) from the Directorate General of Higher Education (DGHE), Republic of Indonesia.

References

Akinyemi, F.A., Orishadipe, A.T., Ebun-Oluwa, O., Augustine, O. and Aladesanmi. (2020). Physico-chemical properties and functional characteristics of Jack beans (*Canavalia ensiformis*) starch. *World Journal of Biology Pharmacy and Health Sciences*, 3 (2), 12-22. https://doi.org/10.30574/wjbphs.2020.3.2.0018

Ariyantoro, A.R., Yulviatun, A., Affandi, D.R. and Septiarani, A. (2022). The Effect of Moisture Content and Time of Heat Moisture Treatment (HMT) on The Properties of Jack Bean (*Canavalia ensiformis*) Starch. *IOP Conference Series: Earth and Environmental Science*, 1018, 012028. https://doi.org/10.1088/1755-1315/1018/1/012028.

Aslam, H.K.W., Ur Raheem, M.I., Ramzan, R., Shakeel, A., Shoaib, M. and Sakandar, H.A. (2014). Utilization of Mango Waste Material (Peel, Kernel)

To Enhance Dietary Fiber Content and Antioxidant Properties of Biscuit. *Journal of Global Innovations in Agricultural and Social Sciences*, 2(2), 76-81. https://doi.org/10.17957/jgiass/2.2.533.

Biguzzi, C., Schlich, P. and Lange, C. (2014). The impact of sugar and fat reduction on perception and liking of biscuits. *Food Quality and Preference*, 35, 41-47. https://doi.org/10.1016/j.foodqual.2014.02.001.

Cahyana, Y., Rangkuti, A., Siti Halimah, T., Marta, H. and Yuliana, T. (2020). Application of heat-moisture -treated banana flour as composite material in hard biscuit. *CYTA - Journal of Food*, 18(1), 599-605. https://doi.org/10.1080/19476337.2020.1805514.

Chang, Q., Zheng, B., Zhang, Y. and Zeng, H. (2021). A comprehensive review of the factors influencing the formation of retrograded starch. *International Journal of Biological Macromolecules*, 186, 163-173. https://doi.org/10.1016/j.ijbiomac.2021.07.050.

Di Cairano, M., Caruso, M.C., Galgano, F., Favati, F., Ekere, N. and Tchuenbou-Magaia, F. (2021). Effect of sucrose replacement and resistant starch addition on textural properties of gluten-free doughs and biscuits. *European Food Research and Technology*, 247(3), 707-718. https://doi.org/10.1007/s00217-020-03659-w.

Di Cairano, M., Galgano, F., Tolve, R., Caruso, M.C. and Condelli, N. (2018). Focus on gluten free biscuits: Ingredients and issues. *Trends in Food Science and Technology*, 81, 203-212. https://doi.org/10.1016/j.tifs.2018.09.006.

Fonseca, L.M., Halal, S.L.M. El, Dias, A.R.G. and Zavareze, E.D.R. (2021). Physical Modification of Starch by Heat-Moisture Treatment and Annealing and Their Applications: A Review. *Carbohydrate Polymers*, 274(1), 118665. https://doi.org/https://doi.org/10.1016/j.carbpol.2021.118665.

Guo, J., Yang, L., Wang, D., Lian, X. and Liu, C. (2021). Research on the influences of two alcohol soluble glutenins on the retrogradation of wheat amylopectin/amylose. *International Journal of Biological Macromolecules*, 183, 463-472. https://doi.org/10.1016/j.ijbiomac.2021.04.174.

Heshe, G.G., Haki, G.D., Woldegiorgis, A.Z. and Gemede, H.F. (2016). Effect of conventional milling on the nutritional value and antioxidant capacity of wheat types common in Ethiopia and a recovery attempt with bran supplementation in bread. *Food Science and Nutrition,* 4(4), 534-543. https://doi.org/10.1002/fsn3.315.

Hwang, H.S., Singh, M. and Lee, S. (2016). Properties of Cookies Made with Natural Wax-Vegetable Oil Organogels. *Journal of Food Science*, 81(5), C1045-C1054. https://doi.org/10.1111/1750-3841.13279.

Ikuomola, D.S., Otutu, O.L. and Oluniran, D.D. (2017). Quality assessment of cookies produced from wheat flour and malted barley (*Hordeum vulgare*) bran blends. *Cogent Food and Agriculture*, 3(1), 1293471. https://doi.org/10.1080/23311932.2017.1293471.

Jia, M., Yu, Q., Chen, J., He, Z., Chen, Y., Xie, J., Nie, S. and Xie, M. (2020). Physical quality and in vitro starch digestibility of biscuits as affected by addition of soluble dietary fiber from defatted rice bran. *Food Hydrocolloids*, 99, 105349. https://doi.org/10.1016/j.foodhyd.2019.105349.

Lara, E., Cortés, P., Briones, V. and Perez, M. (2011). Structural and physical modifications of corn biscuits during baking process. *LWT-Food Science and Technology*, 44(3), 622-630. https://doi.org/10.1016/j.lwt.2010.10.007.

Lynch, K.M., Coffey, A. and Arendt, E.K. (2018). Exopolysaccharide producing lactic acid bacteria: Their techno-functional role and potential application in gluten-free bread products. *Food Research International*, 110, 52-61. https://doi.org/10.1016/j.foodres.2017.03.012.

Nwosu, J.N., Owuamanam, C.I., Omeire, G.C. and Eke, C.C. (2014). Quality Parameters of Bread Produced From Substitution of Wheat Flour With Cassava Flour Using Soybean As an Improver. *American Journal of Research Communication*, 2(3), 99-118.

Passos, C.P., Kukurová, K., Basil, E., Fernandes, P.A.R., Neto, A., Nunes, F.M., Murkovic, M., Ciesarová, Z. and Coimbra, M.A. (2017). Instant coffee as a source of antioxidant-rich and sugar-free coloured compounds for use in bakery: Application in biscuits. *Food Chemistry*, 231, 114-121. https://doi.org/10.1016/j.foodchem.2017.03.105.

Pauly, A., Pareyt, B., Lambrecht, M.A., Fierens, E. and Delcour, J.A. (2013). Flour from wheat cultivars of varying hardness produces semi-sweet biscuits with varying textural and structural properties. *LWT*, 53 (2), 452-457. https://doi.org/10.1016/j.lwt.2013.03.014.

Punia, S. (2020). Barley starch modifications: Physical, chemical and enzymatic - A review. *International Journal of Biological Macromolecules*, 144, 578-585. https://doi.org/10.1016/j.ijbiomac.2019.12.088

Secretariat General of the Ministry of Agriculture. (2020). Food Consumption Statistics 2020. Jakarta, Indonesia: Ministry of Agriculture.

Singh, S.K. and Beillard, M.J. (2022). Report Name: India Grain and Feed Update - January 2022. Global

Agriculture Information Network. Retrieved from US FDA website: https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=India%20Grain%20and%20Feed%20Update%20%20-%20January%202022_New%20Delhi_India_01-03-2022

Stoffel, F., Santana, W.D.O., Fontana, R.C. and Camassola, M. (2021). Use of *Pleurotus albidus* mycoprotein flour to produce cookies: Evaluation of nutritional enrichment and biological activity. *Innovative Food Science and Emerging Technologies*, 68, 102642. https://doi.org/10.1016/j.ifset.2021.102642.

Tamanna, N. and Mahmood, N. (2015). Food processing and maillard reaction products: Effect on human health and nutrition. *International Journal of Food Science*, 2015, 526762. https://doi.org/10.1155/2015/526762.

Thanhaeuser, S.M., Wieser, H. and Koehler, P. (2014). Correlation of quality parameters with the baking performance of wheat flours. *Cereal Chemistry*, 91 (4), 333-341. https://doi.org/10.1094/CCHEM-09-13-0194-CESI.

Thongram, S., Tanwar, B., Chauhan, A. and Kumar, V. (2016). Physicochemical and organoleptic properties of cookies incorporated with legume flours. *Cogent Food and Agriculture*, 2(1), 2-7. https://doi.org/10.1080/23311932.2016.1172389.

Varatharajan, V., Hoover, R., Li, J., Vasanthan, T., Nantanga, K.K.M., Seetharaman, K., Liu, Q., Donner, E., Jaiswal, S. and Chibbar, R.N. (2011). Impact of structural changes due to heat-moisture treatment at different temperatures on the susceptibility of normal and waxy potato starches towards hydrolysis by porcine pancreatic alpha amylase. *Food Research International*, 44(9), 2594-2606. https://doi.org/10.1016/j.foodres.2011.04.050.

Wang, J., Guo, K., Fan, X., Feng, G. and Wei, C. (2018). Physicochemical Properties of C-Type Starch from Root Tuber of *Apios fortunei* in Comparison with Maize, Potato, and Pea Starches. *Molecules*, 23(9), 2132. https://doi.org/10.3390/molecules23092132.

Wang, S., Wang, J., Wang, S. and Wang, S. (2017). Annealing improves paste viscosity and stability of starch. *Food Hydrocolloids*, 62, 203-211. https://doi.org/10.1016/j.foodhyd.2016.08.006.

Xiao, N., Zhao, Y., Yao, Y., Wu, N., Xu, M., Du, H. and Tu, Y. (2020). Biological Activities of Egg Yolk Lipids: A Review. *Journal of Agricultural and Food Chemistry*, 68(7), 1948-1957. https://doi.org/10.1021/acs.jafc.9b06616.

Zielinska, E. and Pankiewicz, U. (2020). Nutritional, Physiochemical, and Antioxidative Characteristic of Shortcake Biscuits Enriched with *Tenebrio molitor* Flour. *Molecules*, 25, 5629. https://doi.org/10.3390/molecules25235629

Zielińska, E. and Pankiewicz, U. (2020). Characteristics of Shortcake Biscuits Enriched with. *Molecules*, *25*, 5629. https://doi.org/10.3390/molecules25235629

