Theresia Endang Widoeri Widyastuti

Controlling mung bean soaking time as a simple way to obtain alternative sources of healthy food for the diabetics

Controlling mung bean soaking time as a simple way to obtain alternative sources of healthy food for the diabetics

Document Details

2% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text

Exclusions

- 18 Excluded Matches

Match Groups

2 Not Cited or Quoted 2%
Matches with neither in-text citation nor quotation marks

0 Missing Quotations 0%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

2% Internet sources
1% Publications
2% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **2** Not Cited or Quoted 2%
  Matches with neither in-text citation nor quotation marks
- **0** Missing Quotations 0%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

- 2% Internet sources
- 1% Publications
- 2% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1 Student papers

Udayana University on 2025-01-29 **2%**

Food Research 9 (2) : 190 - 195 (April 2025)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

RESEARCH PAPER

Controlling mung bean soaking time as a simple way to obtain alternative sources of healthy food for the diabetics

*Widyastuti, T.E.W. and Widjajaseputra, A.I.

Food Technology Department, Widya Mandala Catholic, University Surabaya, Jl. Dinoyo 42-44 Surabaya 60265, East Java, Indonesia

Article history:
Received: 23 February 2023
Received in revised form: 26 April 2023
Accepted: 30 May 2024
Available Online: 26 March 2025

Keywords:
In vitro digestibility,
Starch,
Protein,
Mung beans,
Soaking time

DOI:
https://doi.org/10.26656/fr.2017.9(3).081

Abstract

Mung bean is one of the commodities with potency sources of starch and protein that is available and inexpensive. However, healthy food ingredients which are needed by diabetics must be high in slow-digest starch and protein. This research examined the effect of soaking time on the *in vitro* digestibility of starch and protein of mung bean, to obtain an alternative source of healthy food simply. A single factor of randomized block design was used in this study. Each treatment level was conducted in triplicates. The whole mung bean seeds were subjected to five different times of soaking, namely control (without soaking) and soaking for 2, 4, 6, and 8 hrs. Total starch, *in vitro* starch digestibility, protein content, and *in vitro* protein digestibility of freeze-dried and grounded whole mung beans were analyzed. The results showed a trend of the total starch content and starch digestibility decreasing during the longer soaking time, in a range of 39.14-33.52% and 57.46-49.82%, respectively. Based on the rate of starch hydrolysis, the digestibility of mung bean starch classified as slowly digestible starch. There was a trend of increasing protein digestibility of mung bean seeds during soaking up to 6 hrs of soaking time (in a range of 46.93-51.29%). Based on these results, the suggested soaking time was 6 hrs which gave optimum digestibility of starch and protein for human consumption. The recommendation is to obtain the benefits of a healthy food source for people with diabetes mellitus.

1. Introduction

Mung bean (*Vigna radiata*) has been consumed in China for over 2,000 years, in the form of many kinds of food such as sprouts, noodles, cookies, and others (Fayyaz *et al*., 2018). Mung bean, as one of the legumes, is an important part of the dietaries of Indonesian people and contributes substantially to the nutrient intake of human beings, including children. Mung bean is less flatulent and is well tolerated by children (Dahiya *et al*., 2015).

Mung bean is one of the commodities with potency sources of starch and protein. Starch is the most important component of carbohydrates in mung beans, about 30.74±3.39% (Widjajaseputra *et al*., 2019a). Since starch is the most significant component in mung bean, the characteristics of starch will determine its suitability for its end use. Mung bean with its high amylose content can improve the swelling power and gel texture of a starch noodle product. This is as reported by Li *et al*. (2008), that the high-quality starch noodle made from mung bean starch result from its high amylose content. Menon *et al.* (2016) studied gluten-free starch noodles from sweet potatoes and found that fortification with mung bean starch reduced the rate of release of glucose from cooked noodles *in vitro* conditions. The high amylose content showed higher viscosities which could be used in certain food products such as thickeners for creams, sauces, soups, and puddings. Besides as a source of starch, mung bean is an excellent source of vitamins, minerals, and protein with an ideal essential amino acid profile (Mubarak, 2005). The specific profile of mung bean amino acid allows its use to supplement cereals and rice in particular. Mung bean flour could be used as a supplement for wheat flour, increasing the nutritional quality of bakery products (Marquezi *et al*., 2016). However, the original properties of the components in the mung bean will change depending on the applied processing.

Soaking is the beginning of legume processing which is usually done in preparation before use. During soaking, water enters the bean, its tissues hydrated, and some enzymes can be activated to break down complex structures such as starch and protein into simpler compounds. The treatment results in an alteration of their

*Corresponding author.
Email: *widberi@ukwms.ac.id*

nutritional quality which could either be a reduction in nutrients and antinutrients or an improvement in the digestibility or availability of nutrients (Kaur *et al*., 2015). Pagar *et al*. (2021) who studied the horse gram, found that 6 hrs soaking, 72 hrs germination, and drying at 70°C treatment was the best for a maximum decrease in the anti-nutritional factors and at the same time enhanced functional properties due to the soaking and germination.

In a previous study, it was reported that the digestible (total sugar) and indigestible carbohydrates (resistant starch) of the mung bean increased during four hours of soaking (Widjajaseputra *et al*., 2019a). There are five types of resistant starches (RS1-RS5) and type RS2 is predominant in legumes as legume starches are physically enclosed within intact cell (protein) structures (Kaur *et al*., 2015). Such starches are indigestible by human digestive enzymes in the small intestine and pass to the large intestine or colon, thereby modifying postprandial glycemic responses. Widjajaseputra *et al*. (2019b) also reported that the soaking treatment improved the protein quality. In relation to the provision of healthy food for people with diabetes, high-quality protein sources are needed, but the type and quality of carbohydrate digestibility need to be considered. The study of the potency of soaked mung bean as a healthy food source, especially for diabetic people, based on the digestibility perspective is needed.

2. Materials and methods

2.1 Materials

The commercial mung bean was obtained from a local market in Surabaya, East Java, Indonesia. All the chemicals, standards, and reagents were of analytical grade.

2.2 Soaking procedure

According to Widjajaseputra *et al*. (2019b), the mung bean was sorted. Only intact and sound grains were washed and soaked (1:5 w/v) in distilled water at 30°C for 0 (control), 2, 4, 6, and 8 hrs, afterward the grains were drained and freeze-dried (Bluewave B-10B Vacuum Freeze Drier; China) to 2-3% moisture content. The dried grains were ground with a blender (Miyako, Indonesia), wrapped in an airtight plastic container and aluminum foil bag as secondary packaging, and then stored in a refrigerator (LG, Indonesia) at 5±1°C until analyzed.

2.3 Experimental design and statistical analysis

The experimental design used in this study was a single factor with a randomized block design. The whole mung bean seeds were subjected to five different times of soaking, control (without soaking/P0) and soaking for 2 (P1), 4 (P2), 6 (P3), and 8 hrs (P4). Each treatment level was conducted in triplicates. Total starch, *in vitro* starch digestibility, protein content, and *in vitro* protein digestibility of freeze-dried and grounded whole mung beans were analyzed. Water content analysis was used for dry basis (db) calculation. Data were expressed as mean ± standard deviation (SD) for the three in each group ($n = 3$). The data were subjected to ANOVA ($p<0.05$) with a least significant difference (LSD) test at $p < 0.05$ using SPSS (version 19) for comparative analysis.

2.4 Analysis methods

2.4.1 Total starch analysis

According to Goni *et al.* (1997), total starch was measured by incubating the sample suspension in the optimum condition of amyloglucosidase, at 60°C in a controlled shaking water bath, for 45 mins measuring activity. Starch was measured as glucose with Peridochrom Glucose GOD-PAP (Ref 676 543, Boehringer). The glucose content was measured by the enzymatic photometric test. A red quinone imine as the reaction product was measured at a wavelength of 500 nm. The absorbance of the colored complex was proportional to the concentration of glucose. The factor conversion of glucose to starch was 0.9.

2.4.2 In vitro starch digestibility analysis

Starch digestibility was determined by measuring digestible starch *in vitro* (Goni *et al*., 1996; Goni *et al.,* 1997). The principle of digestible starch determination was to analyze total starch with enzymes and measured undigested starch for 180 mins within a 30 mins interval. Then calculated the percentage of hydrolyzed starch (digestible starch) in equations (1) and (2) as follows:

$$\text{Digestible starch} = (\text{total starch} - \text{undigested starch}) \quad (1)$$

$$\text{Starch digestibility (\%)} = (\text{total starch} - \text{undigested starch})/\text{total starch} \times 100\% \quad (2)$$

2.4.3 Protein content analysis

The protein content analysis used the macro Kjeldahl method (Association of the Official Analytical Collaboration (AOAC) International, 2010). The protein in the sample was determined by measuring the amount of nitrogen (N) through three steps, namely digestion, distillation, and titration. The measured nitrogen content was multiplied by the conversion factor resulting in protein content. The conversion factor used was 6.25.

https://doi.org/10.26656/fr.2017.9(3).081

2.4.4 In vitro protein digestibility

The principle of determining in vitro protein digestibility is to compare the total nitrogen content after the sample is treated with protein digestive enzymes (pepsin) with the total N of the initial sample (Mertz *et al.*, 1984). Nitrogen content was measured using the micro Kjeldahl method.

3. Results and discussion

3.1 Effects of soaking time on total starch, undigested starch, and starch digestibility

The total starch of mung bean seeds decreased significantly from 41.13% db to 33.52% db during 8 hrs of soaking, because more intensive hydrolysis occurred during the longer soaking time (Table 1). The decrease in total starch was due to the leaching out of the soluble part of starch in soaking water and the hydrolysis process to simpler compounds such as sugars and dextrin. The same thing was also found by Grewal and Jood (2009), that a significant decrease in starch content was followed by increased sugar content due to soaking and cooking of green gram.

Table 1. Effects of soaking time on total starch, undigested starch and starch digestibility.

Soaking time (hr)	Total starch (% db)	Undigested starch (% db)	Starch digestibility (%)
P0	41.13±0.19[c]	19.16±0.45[b]	53.42±1.31[b]
P1	39.14±0.72[b]	16.65±0.13[a]	57.46±1.12[c]
P2	38.85±0.18[b]	18.70±0.56[b]	51.87±1.67[ab]
P3	38.18±0.44[b]	18.53±0.34[b]	51.47±0.31[a]
P4	33.52±1.29[a]	16.82±0.21[a]	49.82±1.30[a]

Values are presented as mean±SD, n = 3. Values with different superscripts within the same column are statistically significantly different based on the LSD Test ($p<0.05$). P0: control (without soaking), P1: soaked for 2 hrs, P2: soaked for 4 hrs, P3: soaked for 6 hrs, P4: soaked for 8 hrs.

Legume starch contains amylose higher than cereal or tuber starch. This starch has a lower bioavailability than most other starches when it is raw or retrograded (Guillon and Champ, 2002). Widjajaseputra *et al.* (2019a) stated that the amylose level of mung beans (32.56±0.31%) is higher than cereal (around 25%) and tuber starch (around 17-19%). Singh *et al.* (2003) state that the factors which could influence starch retrogradation were the amylopectin content, intermediate materials, size and shape of the granules, the botanical source, and the amylose content. A higher proportion of amylose content being linked to a higher tendency to retrograde would affect the level of digestibility.

The starch digestibility decreases (from 57.46% to 49.82%) with the longer soaking time and the decrease of total starch during the soaking treatment up to 8 hrs of soaking from 39.14% to 33.52% (Table 1). If compared with the control, soaking for 2 hrs resulted in a significant increase in starch digestibility. This is due to part of the starch granules that were more readily hydrolyzed by enzymes that were affected by the imbibition of water in the soaked mung bean seeds. After 4 hrs of soaking time, the decrease in starch digestibility was not significantly different. Figure 1 shows that based on the rate of starch hydrolysis, the digestibility of mung bean starch is a slow-digesting starch.

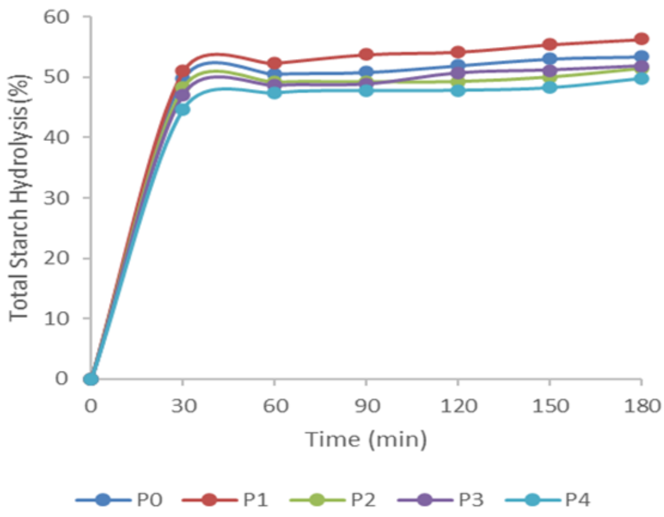

Figure 1. Mung bean starch hydrolysis rate. P0: control (without soaking), P1: soaked for 2 hrs, P2: soaked for 4 hrs, P3: soaked for 6 hrs, P4: soaked for 8 hrs.

The increasing of undigested starch up to 3 hrs of digestion (*in vitro*) can be affected by the number of resistant starch (RS). RS is defined as the portion of starch and starch products that resist digestion, passing directly through the small intestine (Fabbri *et al.*, 2016). Widjajaseputra *et al.* (2019a) found that the RS of mung bean was increased from 11.12% db to 18.49% db if soaked for 4 hrs, although it was decreased significantly (13.65% db) if soaking was continued for up to 8 hrs. This phenomenon is in line with the statement of Lang *et al.* (1999) that mung bean starch contains RS 11% db and has a long absorption period, which within 4.5 hrs after consumption has not been completely digested. It was due to the high level of amylose in mung bean starch (around 32%-34%). The difference in RS can be influenced by differences in starch structure in various amylose-amylopectin ratios among different starch granules which affect the RS level in processed food, including during seeds soaking and freeze-drying treatment in sample preparation. Retrogradation of amylose can occur during soaking and freeze-drying treatment in sample preparation, and part of starch was to exist as RS3. RS3 is starch that has been retrograded into

https://doi.org/10.26656/fr.2017.9(3).081

more highly stabile crystalline structures. In addition, Fabbri *et al.* (2016) found that the cooling process of legumes can increase RS as a result of retrogradation. These phenomena caused a decrease in the level of starch digestibility. RS is one kind of dietary fiber. Dietary fiber is bound together in such a way that it can not be ready in the small intestine. Besides it, dietary fiber may make humans feel full longer. This causes mung bean to help keep blood sugar levels low. Nevertheless, the different processes following the soaking would give different effects on starch digestibility, as example, if soaking was followed by dehulling and cooking, the level of starch digestibility would increase as obtained by Grewal and Jood (2009).

3.2 Effects of soaking time on protein content and protein digestibility

The values of protein digestibility were significantly different on 6 hrs (P3) and 8 hrs (P4) of treated soaking time compared to P0, P1, and P2 as shown in Table 2. Protein digestibility increased during soaking treatment, up to 6 hrs of soaking time, and then the protein digestibility slightly decreased on 8 hrs of seed soaking.

Table 2. Effects of soaking time on protein content and protein digestibility.

Soaking time (hr)	Protein content (% db)	Protein digestibility (%)
P0	26.29±0.27	46.93±1.53[a]
P1	25.88±0.40	48.41±0.38[ab]
P2	25.90±0.25	48.56±0.54[ab]
P3	25.68±0.33	51.29±1.20[c]
P4	26.10±0.82	49.83±3.00[bc]

Values are presented as mean±SD, n = 3. Values with different superscripts within the same column are statistically significantly different based on the LSD Test ($p<0.05$). P0: control (without soaking), P1: soaked for 2 hrs, P2: soaked for 4 hrs, P3: soaked for 6 hrs, P4: soaked for 8 hrs.

This phenomenon was affected by increasing the soluble protein of mung bean seeds from 108.96 mg/g of dry weight in raw seeds without soaking to 159.81 mg/g of dry weight in seeds with 6 hrs of soaking time (Widjajaseputra *et al.*, 2019b). The higher soluble protein indicated the readiness of proteins to be digested. Based on protein digestibility shown in Table 2, the recommended soaking time for mung bean seed was 6 hrs, because a germination process has taken place longer than 6 hrs of soaking. During germination periods there were hydrolyzing processes that would affect protein and starch degradation to produce energy for the new plant. These phenomena were revealed by Grewal and Jood (2009) that the germination process decreased starch content, thereby increasing soluble sugars and improved starch digestibility to 49% and 48% in two different green gram (*Vigna radiata* L.) cultivars respectively.

3.3 Perspective of mung bean as a healthy food source for the diabetics

The high protein digestibility of mung beans as a result of soaking for 6 hrs can support its usage as a good food source of protein. A combination of mung bean protein and rice protein in a 3:4 ratio respectively can increase the chemical amino acid score to 72 (Dahiya *et al*., 2015). Based on this recommendation, an increase in protein bioavailability can be obtained. Consumption of legumes provides qualified protein along with other micronutrients without adding extra energy or fat. According to Mak *et al.* (2018), a diet high in protein-low starch was associated with a lower risk for gestational diabetes mellitus among women who were overweight at pre-pregnancy. Mung bean seeds are an affordable source of not only protein but also starch, which has the advantage of consisting of higher resistant starch compared to cereal, root, and tuber starch. Based on these characteristics, mung bean can be used as a good source of resistant starch with a high protein content in various food applications.

Mung beans as one kind of variety of pulses, are high in fiber and have a low glycemic index, making them particularly beneficial to people with diabetes by assisting in maintaining healthy blood glucose and insulin levels (Dipnaiki and Bathere, 2017). Previously, the same thing was also reported by Rebello *et al.* (2014), that mung bean like other legumes had a medium glycemic index (GI) and high content of dietary fibers, which makes benefit to be a healthy food source. High resistant starch content combined with medium GI is a positive attribute that could promote the product as a better food choice not only for diabetes mellitus patients but also for people which is suffered from celiac disease, obesity, and other malnutrition symptoms (Rebello *et al.*, 2014). In particular, for the nutrition management of gestational diabetes mellitus, it is important to focus on the quality of carbohydrates and encourage the consumption of vegetables, fruits, complex carbohydrates, and high-fiber foods (Kapur *et al*., 2020). A balanced diet consisting of healthy carbohydrate sources with adequate proteins and fats based on individual and cultural food preferences as well as based on physical activity and physiological status will result in weight control as well as diabetes management (Devi *et al*., 2021).

4. Conclusion

Based on the rate of starch hydrolysis of soaked mung beans, mung bean starch is a slow-digesting starch. There was a trend of increasing protein digestibility of mung bean seeds during soaking up to 6 hrs of soaking time (in a range of 46.93-51.29%). Based on the obtained data, the recommended soaking time was 6 hrs which revealed the optimum digestibility of starch and protein for diabetics. Further investigation in the processing field will be needed to get better food choices for diabetics.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

Authors would thank the Directorate of Research and Community Service, Directorate General of Research and Development Strengthening, Ministry of Research; Technology and Higher Education, Republic of Indonesia, for research fund through the Decentralization Research Program of 2018 and 2019 (Penelitian Dasar Unggulan Perguruan Tinggi with contract number of 115O/WM01.5/N/2018 and 200U/WM01.5/N/2019 respectively).

References

Association of the Official Analytical Collaboration (AOAC) International. (2010). Official Methods of Analysis. 18th ed. Washington, D.C. USA: AOAC International.

Dahiya, P.K., Linnemann, A.R., Van Boekel, M.A., Khetarpaul, N., Grewal, R.B. and Nout, M.J. (2015). Mung bean: technological and nutritional potential. *Critical Reviews in Food Science and Nutrition*, 55 (5), 670-688. https://doi.org/10.1080/10408398.2012.671202

Devi, M.P., Mudraganam, S. and Saraf, V. (2021). A Review on the role of carbohydrates in the management of diabetes and obesity. *International Journal of Food Science and Nutrition* 6(6), 33-38.

Dipnaiki, K. and Bathere, D. (2017). Effect of soaking and sprouting on protein content and transaminase activity in pulses. *International Journal of Research in Medical Sciences*, 5(10), 4271-4276. https://doi.org/10.18203/2320-6012.ijrms20174158

Fabbri, A.D.T., Schacht, R.W. and Crosby, G. (2016). Evaluation of resistant starch content of cooked black beans, pinto beans, and chickpeas. *NFS Journal,* 3, 8-12. https://doi.org/10.1016/j.nfs.2016.02.002

Fayyaz, N., Mohebbi, M. and Milani, E. (2018). Effect of germination on nutrients, mineral, phytic acid and enzyme activity of mung bean. *Acta Medica Mediterranea*, 34, 597-604.

Goni, I., Garcia-Alonso, A. and Saura-Calixto, F. (1997). A starch hydrolysis procedure to estimate glycemic index. *Nutrition Research*, 17(3), 427-437. https://doi.org/10.1016/S0271-5317(97)00010-9

Goni, I., Garcia-Diz, L., Manas, E. and Saura-Calixto, F. (1996). Analysis of resistant starch: a method for foods and food products. *Food Chemistry*, 56(4), 445-449. https://doi.org/10.1016/0308-8146(95)00222-7

Grewal, A. and Jood, S. (2009). Chemical composition and digestibility (*in vitro*) of green grain as affected by processing and cooking methods. *British Food Journal*, 111(3), 235-242. https://doi.org/10.1108/00070700910941444

Guillon, F. and Champ, M.M.J. (2002). Carbohydrate fractions of legumes: uses in human nutrition and potential for health. *British Journal of Nutrition*, 88 (3), S293-S306. http://doi.org/ 10.1079/BJN2002720

Kapur, K., Kapur, A. and Hod, M. (2020). Nutrition management of gestational diabetes mellitus. *Annals of Nutrition and Metabolism*, 76(suppl 3), 17-29. https://doi.org/10.1159/000509900

Kaur, M., Sandhu, K.S., Ahlawat, R.P. and Sharma, S. (2015). In vitro starch digestibility, pasting and textural properties of mung bean: effect of different processing methods. *Journal of Food Science and Technology*, 52(3), 1642-1648. http://doi.org/10.1007/s13197-013-1136-2

Lang, V., Bornet, F.R.J., Vaugelade, Strihou, M., Luo J. and Pacher, N. (1999). Euglycemic hyperinsulinemic clamp to assess posthepatic glucose appearance after carbohydrate loading. 2. Evaluation of corn and mung bean starches in healthy men1-3. *The American Journal of Clinical Nutrition*, 69, 1183-1188. https://doi.org/10.1093/ajcn/69.6.1174

Li, Z.G., Liu, W.J., Shen, Q., Zheng, W. and Tan, B. (2008). Properties and qualities of vermicelli made from sour liquid processing and configuration starch. *Journal of Food Engineering*, 86(2), 162-166. https://doi.org/10.1016/j.jfoodeng.2007.09.013

Mak, J.K.L., Pham, N.M., Lee, A.H., Tang, L., Xiong-Fei Pan, Binns, C.W. and Sun, X. (2018). Dietary patterns during pregnancy and risk of gestational diabetes: a prospective cohort study in Western China. *Nutrition Journal,* 17, 107. https://doi.org/10.1186/s12937-018-0413-3

Marquezi, M., Gervin, V.M., Watanabe, L.B., Bassinello, P.Z. and Amante, E.R. (2016). Physical and chemical properties of starch and flour from different common bean (*Phaseolus vulgaris* L.) cultivars. *Brazilian Journal and Food Technology*, 19, e2016005. https://doi.org/10.1590/1981-6723.0516

Menon, R., Padmaja, G., Jyothi, A.N., Asha, V. and

Sajeev, M.S. (2016). Gluten-free starch noodles from sweet potato with reduced starch digestibility and enhanced protein content. *Journal of Food Science and Technology*, 53, 3532-3542. https://doi.org/10.1007/s13197-016-2330-9

Mertz, E.T., Hassen, M.M., Cairns-Whittern, C, Kirleis, A.W., Tut, L. and Axtell, J.D. (1984). Pepsin digestibility of proteins in sorghum and other major cereals. *Proceedings of the National Academy of Sciences of the United States of America*, 81, 1-2. https://doi.org/10.1073/pnas.81.1.1

Mubarak, A.E. (2005). Nutritional composition and antinutritional factors of mung bean seeds (*Phaseolus aureus*) as affected by some home traditional processes. *Food Chemistry*, 89(1), 485-495. http://doi.org10.1016/j.foodchem.2004.01.007

Pagar, H., Athawale, G. and Raichurkar, S. (2021). Effect of soaking, germination, and drying on anti-nutrients, minerals, and functional properties of horse gram along with its commercial application. *International Journal of Food Science and Nutrition,* 6(2), 50-54.

Rebello, C.J., Greenway, F.L. and Finley, J.W. (2014). A review of the nutritional value of legumes and their effects on obesity and its related co-morbidities. *Obesity Reviews*, 15(5), 392-407. https://doi.org/10.1111/obr.12144

Singh, N., Sing, J., Kaur, L., Sodhi, N.S. and Gill, B.S. (2003). Morphological, thermal, and rheological properties of starches from different botanical sources. *Food Chemistry*, 81(2), 219-231. https://doi.org/10.1016/S0308-8146(02)00416-8

Widjajaseputra, A.I., Widyastuti, T.E.W. and Trisnawati, C.Y. (2019a). Mung bean as a food source for breastfeeding women with diabetes mellitus in Indonesia: Carbohydrate profiles at different soaking times. *Food Research,* 3(6), 828-832 hrsttps://doi.org/10.26656/fr.2017.3(6).209

Widjajaseputra, A.I., Widyastuti, T.E.W. and Trisnawati, C.Y. (2019b). Potency of mung bean with different soaking times as protein source for breastfeeding women in Indonesia. *Food Research,* 3(5), 501-505. https://doi.org/10.26656/fr.2017.3(5).105.