

# Assessment of Corn-Based Rice Analogues Made from Modified Corn Flour and Cassava Starch Which Processed by Granulation Method as Functional Food

*By Bambang Suhada*

6  
**Assessment of Corn-Based Rice Analogues Made from Modified Corn Flour and Cassava Starch Which Processed by Granulation Method as Functional Food**

Beni Hidayat<sup>1\*</sup> Syamsu Akmal<sup>1</sup> M. Muslihudin<sup>1</sup> Bambang Suhada<sup>2</sup>

1. Agricultural Technology Department, State Polytechnic of Lampung, 10 Soekarno-Hatta Street, Bandar Lampung 35144, Indonesia

2. Economy Faculty, Muhammadiyah University of Metro, Indonesia

3  
**Abstract**

Compared to extrusion method, granulation method will produce rice analogues more characterised as a functional food. Corn-based rice analogues granulation method (CRAGM) made from modified corn flour and cassava starch have a good cooking quality and have a potency to be developed as a functional food. The objective of this research was to assess the potential of CRAGM made from modified corn flour (MCF) and cassava starch (CS) as a functional food. CRAGM made from MCF and CS (with formulation of CS as 20%, 30%, dan 40%) have characteristics as functional food reflected from the lower of glycemic index value (34.79 to 40.77), the higher content of dietary fiber (14.53% to 15.48%), the higher content of resistant starch (6.17% to 10.44%), and the lower content of digestible starch (57.64% to 62.71%).

**Keywords:** rice analogues, granulation method, functional food

**1. Introduction**

The increasing of cases of obesity, diabetes, and cardiovascular diseases has attracted many researchers to develop staple food with a low glycemic index (GI). Development of staple food with low glycemic index (GI) has been reported by Noviasari et al. (2015); Hidayat et al. (2016<sup>a</sup>) in the form of rice analogues and by Walter et al. (2005) in the form of parboiled rice. Compared to parboiled rice, rice analogues more potential to be developed cause by easier to be fortified (Mishra et al., 2012) and can be developed into a functional food with lower GI, lower digestible starch (DS), higher resistant starch (RS), and higher dietary fiber (Hidayat et al., 2016<sup>a,b</sup>). Rice analogues with higher resistant starch content also potential to be developed as a new source of prebiotic food.

Rice analogues can be processed by extrusion method (Noviasari et al., 2015; Mishra et al., 2012) and granulation method (Hidayat et al., 2016<sup>a,b</sup>). Processing of rice analogues by extrusion method will decrease the functional component content, resistant starch especially. Haralampu reported that extruded cereal will be lost as 22% of the RS due to high shear damage in the extruder. Compared to extrusion method, granulation method will produce rice analogues more characterized as a functional food; due to the lack of shear damage effect (Haralampu, 2000) and the presence of the cooling stage (Perdon et al., 1999). Hidayat et al. (2016<sup>a</sup>), reported that corn-based rice analogues granulation method (CRAGM) made from modified corn flour (MCF) and cassava flour (CF) have characteristics as functional food that is reflected from the lower of GI value, the higher of resistant starch (RS) content, and the lower of digestible starch (DS) content. Although have characteristics as functional food, corn-based rice analogues granulation method (CRAGM) made from modified corn flour and cassava flour have a poor cooking quality. Therefore, need to be developed CRAGM which have characteristics as functional food but have a good quality cooking.

The further research by Hidayat et al. (2016<sup>b</sup>), showed that CRAGM made from MCF and cassava starch (CS) with the formulation of CS as 20%, 30%, and 40% have a good quality cooking and preferred by the organoleptic panelist. The objective of this research was to assess the potential of CRAGM made from MCF and CS (formulation of CS as 20%, 30%, dan 40%) as a functional food.

**2. Materials and Methods**

**2.1 Preparation of Corn-Based Rice Analogues**

The raw materials were yellow corn var. Bisi II from Practice Gardens of Lampung State Polytechnic, harvested in July 2016. Modified corn flour was prepared by the wet milling and pre-gelatinization method based on Hidayat et al. (2013), through the stages of sorting of whole maize, coarse grinding (20 mesh), separation of the epidermis and core by soaking, wet milling, partial pre-gelatinization, drying followed by fine grinding (60 mesh).

Production of corn-based rice analogues granulation method (CRAGM) were done through the following stages: mixing of modified corn flour (MCF) with cassava starch (CS) and water according as treatment (Table 1), granulating with granulator, steaming, cooling for 12 hours, and drying with cabinet dryer to obtain instant CRAGM.

Table 1. Formulation of CRAGM with addition of cassava starch

| Formulation        | Modified Corn Flour (%) | Cassava starch (%) | Water (%) |
|--------------------|-------------------------|--------------------|-----------|
| Cassava starch 20% | 80                      | 20                 | 45        |
| Cassava starch 30% | 70                      | 30                 | 45        |
| Cassava starch 40% | 60                      | 40                 | 45        |

## 2.2 Analysis of Chemical Compositions

Analysis of chemical compositions was done to modified corn flour (MCF). The moisture, crude protein, crude ash, and lipid content were measured according to the method of AOAC International (1999). Dietary fiber was determined by the enzymatic method (Asp et al., 1983), to starch based on Goni, et al. (1997) method with slight modifications by using DNS, and amylose content by colorimetric measurement of the blue amylose-iodine complex (Juliano, 1971).

## 2.4 Analysis of Functional Component

Analysis of functional component, included: dietary fiber by enzymatic method (Asp et al., 1983), resistant starch (RS) and digestible starch (DS) based on Englyst et al. (1992).

## 2.4 Analysis of The Glycemic Index Value

The tests of glycemic index were carried out on ten healthy volunteers, i.e. non-diabetic, have the normal level of fasting blood glucose (70-120 mg/dl) and value of Body Mass Index (BMI) in the normal range of 18.5 to 25 kg/m<sup>2</sup>. The tests were conducted based on the ethical clearance issued by the Faculty of Medicine, University of Lampung with number 1396/UN26/8/DT/2015.

Preparation of CRAGM various formulations were conducted by cooking using the rice cooker with the ratio of CRAGM and water were 1 : 1. The measurement method of GI value was based on Jenkins et al. (1981) with slight modifications, by providing CRAGM on an amount equivalent to 50 g of carbohydrates.

As standard testing, was used 50 g of pure glucose. Blood sampling for determination of GI value of pure glucose was performed on different days with a minimum interval of three days. Blood sampling for pure glucose was made by the same procedure as the samples. The GI, was calculated following the procedure of Wolever et al. (1991).

## 2.5 Data Analysis

analysis was carried out in six replicates for all determinations, except GI data. The data were analyzed by one-way analysis of variance (ANOVA) and the results are reported as mean  $\pm$  SD on the dry basis (db). The significance of the differences was defined as  $P < 0.05$ . Data of GI (glycemic index) was the average value of the 10 volunteers.

## 3. Results and Discussion

### 3.1 Chemical Composition

Modified corn flour has higher content of amylose as 43.91% (Table 1), compared to conventional corn flour as 25.13% (Hidayat et al., 2013). Pereira and Leonel (2010) reported that the higher of amylose content will promote the formation of resistant starch type 3 (RS 3); due to the presence of higher amounts of the linear component of starch (Sagum and Arcot, 2000). The higher of amylose content will also decrease starch digestibility (Hu et al., 2004; Themeier et al, 2005), increase dietary fiber content (Zhu et al., 2011) and decrease IG value (Foster-Powell et al., 2002).

Table 1. Chemical composition of modified corn flour (mean  $\pm$  SD), % dry basis (db)

| Component     | Composition      |
|---------------|------------------|
| Ash           | 0.23 $\pm$ 0.03  |
| Dietary fiber | 4.22 $\pm$ 0.23  |
| Lipid         | 1.82 $\pm$ 0.18  |
| Protein       | 10.31 $\pm$ 0.12 |
| Total starch  | 81.88 $\pm$ 0.22 |
| Amylose       | 43.91 $\pm$ 0.02 |

### 3.2 Resistant Starch (RS)

Increasing of cassava starch formulation will be significantly ( $p < 0.05$ ) decreased the resistant starch content of corn-based rice analogues granulation method (CRAGM) from 10.14% to 6.17% (Table 2). Decreasing of resistant starch content was associated with decreased of amylose content. Modified corn flour has amylose content as 43.91% higher than cassava starch as 84.28% (Hidayat et al., 2009). The amylose content will

promote the formation of resistant starch type 3 (Pereira and Leonel, 2014). The formation of resistant starch type 3 (RS 3) also initiate by cooling stage for 12 hours on granulation method which leads the intensification of retrogradation process. The formation of RS 3 due to retrogradation process were reported also by Fredriksson et al. (1998); Vasanthan and Bhatta (1998); Farhat et al. (2001); Thompson (2001); Fuentes-Zaragoza et al. (2011). Fabbri et al. (2016) and Perdon, et al. (1999) reported that cooling process will stimulate the formation of RS 3.

Tabel 2. Resistant Starch (RS) and Digestible Starch (DS) of CRAGM on various formulations of cassava starch (mean  $\pm$  SD), % dry basis

| Formulation        | RS                | DS                |
|--------------------|-------------------|-------------------|
| Cassava starch 20% | 10.44 $\pm$ 0.48c | 57.64 $\pm$ 0.32a |
| Cassava starch 30% | 8.72 $\pm$ 0.52b  | 59.64 $\pm$ 0.85b |
| Cassava starch 40% | 6.17 $\pm$ 0.33a  | 62.71 $\pm$ 0.33c |

For each parameter (column), values with the same letters are not significantly different ( $P > 0.05$ ).

Based on resistant starch (RS) content as 6.17%-10.44%, CRAGM have potency as functional food. The content of RS can be used to identify of functional food (Walter et al., 2005). Compare to RS content of rice as 0.77%-0.94% (Zhang et al., 2007) and RS content of corn-based rice analogues processed by extrusion method as 2.59% (Noviasari, et al., 2015); CRAGM have higher content of RS. The lower of RS content of corn-based rice analogues processed by extrusion method due to high shear damage in the extruder (Haralampu, 2000; Unlu and Faller, 1998). The food with high resistant starch content can be considered as prebiotic (Fuentes-Zaragoza et al., 2011).

### 3.3 Digestible Starch (DS)

Table 2 shows, the increasing of cassava starch formulation will be significantly ( $p < 0.05$ ) increased the digestible starch content of corn-based rice analogues granulation method (CRAGM) from 57.64% to 62.71% (Table 2). The content of digestible starch has been positively correlated to resistant starch of CRAGM. CRAGM has lower DS as 57.64%-62.71% compared to DS of rice as 79.69% (Goni et al., 1997), and has DS equal with parboiled rice as 62.6% (Walter et al., 2005).

The lower of DS content is due to the increasing of RS content (Table 2). Resistant starch on CRAGM has been dominated by RS 3 as a result of retrogradation. Retrogradation will increase crystallinity degree of starch (Alsaffar, 2011; Haralampu, 2000). As a result starch becomes less susceptible to hydrolysis with amylolytic enzymes and decrease of starch digestibility (Gallant et al., 1992; Buleon et al., 1998). The decreasing of starch digestibility along with the increasing of RS content, also reported by Chung et al. (2006); Mir et al. (2013); and Zhu et al. (2011).

Based on the lower of DS content, CRAGM has potency as functional food. Food with lower DS has potential as functional food to improve human health (Ai et al., 2013). Ludwig et al. (2009) and Willett et al. (2002) reported, over-consumption of starchy foods with fast starch hydrolysis rates has been criticized for causing metabolic syndrome, including Type-2 diabetes, obesity, and cardiovascular diseases.

### 3.4 Dietary Fiber

Increasing of cassava starch formulation will be significantly ( $p < 0.05$ ) decreased the dietary fiber content of corn-based rice analogues granulation method (CRAGM) from 14.53% to 15.48% (Table 3). Decreasing of the dietary fiber content is closely related to decreasing of resistant starch content. The lower of resistant starch content causes the lower of dietary fiber content of CRAGM. Resistant starch is defined as the amount of degradation product of starch that can not be absorbed by the human intestine and are grouped into dietary fiber (Fuentes-Zaragoza et al., 2011; Thompson, 2001; Fabbri et al., 2016).

Compared to corn-based rice analogues processed by extrusion method, CRAGM has higher dietary fiber content. Noviasari et al. (2015), reported that corn-based rice analogues use white corn as raw material which is processed by extrusion method has a total dietary fiber content as 5.35%. Onyango et al. (2005) reported that extrusion reduced total dietary fiber by 39–68%, redistributed soluble to insoluble fiber ratios and had a negligible effect on the formation of resistant starch (less than 1 g/100 g).

Tabel 3. Dietary fiber of CRAGM on various formulations of cassava starch (mean  $\pm$  SD), % dry basis (db)

| Formulation        | Dietary fiber     |
|--------------------|-------------------|
| Cassava starch 20% | 15.48 $\pm$ 0.36a |
| Cassava starch 30% | 14.90 $\pm$ 0.52b |
| Cassava starch 40% | 14.53 $\pm$ 0.35c |

Values with the same letters are not significantly different ( $P > 0.05$ )

According to the CAC (2009), food can be referred to as a source of dietary fiber if it content at least 3% dietary fiber, and called high-fiber if it content minimum of 6% dietary fiber. Based on CAC (2009), CRAGM can be



categorized as high-fiber foods. The higher of dietary fiber content (14.53%-15.48%) shows that CRAGM has the characteristics as functional food.

### 3.5 The Glycemic Index Values

Increasing of cassava starch formulation will increased glycemic index value of of corn-based rice analogues granulation method (CRAGM) from 34.79 to 40.77 (Table 4). The higher of glycemic index value of CRAGM is related to the higher of starch digestibility, the lower of dietary fiber content, and the lower of resistant starch content.

Table 4. Glycemic index value of CRAGM on various formulation of cassava starch (mean  $\pm$  SD)

| Formulation        | Glycemic index value |
|--------------------|----------------------|
| Cassava starch 20% | 34.79 $\pm$ 2.11     |
| Cassava starch 30% | 37.47 $\pm$ 2.16     |
| Cassava starch 40% | 40.77 $\pm$ 2.12     |

Based on Table 4, CRAGM have a low of GI value (34.79-40.77), lower than rice which high GI value of 69 (Foster-Powell et al., 2002) or 81 (Goni et al., 1997); corn-based rice analogues processed by extruder method with GI value of 50-69 (Noviasari et al., 2015). The content of dietary fiber, resistant starch, and starch digestibility are all factors that interact to cause CRAGM have a low glycemic index value.

According to Elleuch et al. (2011), dietary fiber can decrease the glycemic response through the mechanism of the formation matrix beyond the starch granules that can inhibit the digestion of carbohydrates. Dietary fiber, especially dietary fiber water soluble can reduce the response of blood glucose caused by (1) an increase in viscosity in the stomach thereby slowing down the emptying of the stomach or intestines and cause a decrease in the amount of carbohydrates that can be digested (barrier against the enzyme) and simple sugars that can be absorbed, (2) dietary fiber causes changes in hormone levels in the digestive tract, absorption of nutrients and insulin secretion, (3) dietary fiber helps improve insulin sensitivity, stabilize blood glucose levels thereby protecting complications from diabetic (Turner and Lupton, 2011).

Resistant starch is included in insoluble dietary fiber, but has properties such as soluble dietary fiber. Resistant starch content has been positively correlated to the glycemic index (GI) of starchy foods (Alsaffar, 2011; Wolever et al., 1991). Resistant starch has slow digest so that the release of glucose in slowdown process. Resistant starch metabolism occurs 5-7 hours after ingestion. Digestion of resistant starch for 5-7 hours will increase the period of satiety so can reduce the IG value (Sajilata et al., 2006; Yamada et al., 2005; Ashraf et al., 2012).

## 1 Conclusion

Corn based-rice analogues granulation method (CRAGM) made from modified corn flour (MCF) and cassava starch (CS) with formulation of CS as 20%, 30%, dan 40% have characteristics as functional food reflected from the lower of glycemic index value (34.79 to 40.77), higher content of dietary fiber (14.53% to 15.48%), higher content of resistant starch (6.17% to 10.44%), and the lower content of digestible starch (57.64% to 62.71%).

## References

- Ai, Y., Jane, J., & Lamsal, B. P. (2013). Structures, properties, and digestibility of resistant starch. Digital Repository, Iowa State University, 184 pp.
- Alsaffar, A. A. (2011). Effect of food processing on the resistant starch content of cereals and cereal products – a review. *International Journal of Food Science and Technology*, 46, 455–462. <https://doi.org/10.1111/j.1365-2621.2010.02529.x>
- AOAC International. (1999). *AOAC Official Methods of Analysis*. Association of Official Agricultural Chemists. Washington, D.C. Vol. 16<sup>th</sup>, ed.5th. The Association: Gaithersburg, MD.
- Ashraf, S., Anjum, F. M., Nadeem, M., & Riaz, A. (2012). Functional and technological aspects of resistant starch. *Pakistan Journal of Food Sciences*, 22(2), 90–95. Retrieved from [http://www.psfst.com/\\_jpd\\_fstr/f7aca043d16b6e22b52dbc8529860c22.pdf](http://www.psfst.com/_jpd_fstr/f7aca043d16b6e22b52dbc8529860c22.pdf)
- Asp, N. G., Johansson, C. G., Hallmer, H., & Siljestroem, M. (1983). Rapid enzymatic assay of insoluble and soluble dietary fiber. *Journal of Agricultural and Food Chemistry*, 31(3), 476–482. <https://doi.org/10.1021/jf00117a003>
- Buleon, A., Colona, P., Planchot, V., & Ball, S. (1998). Starch granules: structure and biosynthesis. *International Journal of Biological Macromolecules*, 23, 85–112.
- CAC. (2009). Codex alimentarius commission. *Report of the 30th Session of the Codex Committee on Nutrition and Foods for Special Dietary Uses*, (November 2008), 83. Retrieved from [http://www.codexalimentarius.org/input/download/report/710/al32\\_26e.pdf](http://www.codexalimentarius.org/input/download/report/710/al32_26e.pdf)
- Chung, H., Lim, H. S., & Lim, S. (2006). Effect of partial gelatinization and retrogradation on the enzymatic

- digestion of waxy rice starch. *Journal of Cereal Science*, 43, 353–359. <https://doi.org/10.1016/j.jcs.2005.12.001>
- Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C., & Attia, H. (2011). Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. *Food Chemistry*, 124(2), 411–421. <https://doi.org/10.1016/j.foodchem.2010.06.077>
- Englyst, H. N., Kingman, S. M., & Cummings, J. H. (1992). Classification and measurement of nutritionally important starch fractions. *European Journal of Clinical Nutrition*. <https://doi.org/10.1111/j.1750-3841.2010.01627.x>
- Fabbri, A. D. T., Schacht, R. W., & Crosby, G. A. (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>
- Farhat, I. A., Protzmann, J., Becker, A., Valles-Pamies, B., Neale, R., & Hill, S. E. (2001). Effect of the extent of conversion and retrogradation on the digestibility of potato starch. *Starch/Staerke*, 53(9), 431–436. [https://doi.org/10.1002/1521-379X\(200109\)53:9<431::AID-STAR431>3.0.CO;2-R](https://doi.org/10.1002/1521-379X(200109)53:9<431::AID-STAR431>3.0.CO;2-R)
- Foster-Powell, K., Susanna, H. H., & Brand-Miller, J. (2002). International table of glycemic index and glycemic load. *Am J Clin Nutr*. 76(1):274S-80S.
- Fredriksson, H., Silverio, J., Andersson, R., Eliasson, A. C., & Åman, P. (1998). The influence of amylose and amylopectin characteristics on gelatinization and retrogradation properties of different starches. *Carbohydrate Polymers*, 35, 119–134. [https://doi.org/10.1016/S0144-8617\(97\)00247-6](https://doi.org/10.1016/S0144-8617(97)00247-6)
- Fuentes-Zaragoza, E., Sánchez-Zapata, E., Sendra, E., Sayas, E., Navarro, C., Fernández-López, J., & Pérez-Alvarez, J. A. (2011). Resistant starch as prebiotic: A review. *Starch/Staerke*, 63(7), 406–415. <https://doi.org/10.1002/star.201000099>
- Gallant, D. J., Bouchet, B., Buléon, a, & Pérez, S. (1992). Physical characteristics of starch granules and susceptibility to enzymatic degradation. *European Journal of Clinical Nutrition*, 46 Suppl 2:S3-16..
- Goni, I., Garcia-Alonso, A., & 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](https://doi.org/10.1016/S0271-5317(97)00010-9)
- Haralampu, S. . (2000). Resistant starch—a review of the physical properties and biological impact of RS3. *Carbohydrate Polymers*, 41(3), 285–292. [https://doi.org/10.1016/S0144-8617\(99\)00147-2](https://doi.org/10.1016/S0144-8617(99)00147-2)
- Hidayat, B., Akmal, S., Surfiana, & Suhada, B. (2016<sup>a</sup>). *Potential of Rice Analogues Made From Modified Corn Flour and Cassava Flour Processed by Granulation Method as Functional Food with Low Glycemic Index*. Proceeding of The USR International Seminar on Food Security (UISFS), 286–295.
- Hidayat, B., Akmal, S., & Suhada, B. (2016<sup>b</sup>). Penambahan Tapioka untuk Memperbaiki Kualitas Tanak Beras Analog Jagung Metode Granulasi dalam Rangka Pengembangan Pangan Fungsional Berbasis Bahan Lokal. Prosiding Seminar Nasional Pengembangan Teknologi Pertanian, ISBN 978-602-70530-4-5, 241-249
- Hidayat, B., Kalsum, N., & Surfiana. (2009). Karakterisasi tepung ubi kayu modifikasi yang diproses menggunakan metode pragelatinisasi parsial. *Jurnal Teknologi Industri Dan Hasil Pertanian*, 14(2) 148-149.
- Hidayat, B., Nurbani, K., & Surfiana. (2013). Characterization of Modified Corn Flour Processed with Partial Pregelatinisation Method. In *Science and Technology Conference* (pp. 884–891).
- Hu, P., Zhao, H., Duan, Z., Linlin, Z., & Wu, D. (2004). Starch digestibility and the estimated glycemic score of different types of rice differing in amylose contents. *Journal of Cereal Science*, 40(3), 231–237. <https://doi.org/10.1016/j.jcs.2004.06.001>
- Jenkins, D. J. A., Wolever, T. M. S., & Taylor, R. H. (1981). Glycemic index of foods: A physiological basis for carbohydrate exchange. *Am J Clin Nutr*. 34(3):362-6.
- Juliano, B. O. (1971). Simplified assay for milled-rice amylose. *Cereal Science Today*, 16, 334–340, 360.
- Ludwig, D. S. (2009). The Glycemic Index: Physiological Mechanisms Relating to Obesity, Diabetes, and Cardiovascular Disease. *JAMA*. 8;287(18):2414-23. <https://doi.org/10.1001/jama.287.18.2414>
- Mir, J. A., Srikaeo, K. & García, J. (2013). Effects of amylose and resistant starch on starch digestibility of rice flours and starches. *International Food Research Journal*, 20(3): 1329-1335.
- Mishra, A., Mishra, H. N., & Srinivasa Rao, P. (2012). Preparation of rice analogues using extrusion technology. *International Journal of Food Science and Technology*, 47(9), 1789–1797. <https://doi.org/10.1111/j.1365-2621.2012.03035.x>
- Noviasari, S., Kusnandar, F., Setiyono, A., & Budijanto, S. (2015). Beras analog sebagai pangan fungsional. *Jurnal Gizi Pangan*, 10(3), 225–232.
- Onyango, C., Noetzdold, H., Ziems, A., Hofmann, T., Bley, T., & Henle, T. (2005). Digestibility and antinutrient properties of acidified and extruded maize – finger millet blend in the production of uji. *Swiss Society of Food Science and Technology*, 38, 697–707. <https://doi.org/10.1016/j.lwt.2004.09.010>
- Perdon, A. A., Siebenmorgen, T. J., Buescher, R. W., & Gbur, E. E. (1999). Starch retrogradation and texture of

- cooked milled rice during storage. *Journal of Food Science*, 64(5), 828–832. <https://doi.org/10.1111/j.1365-2621.1999.tb15921.x>
- Pereira, B. L.B. & Leonel, M. (2014). Resistant starch in cassava products. *Food Science and Technology*, 298–302.
- Sagum, R., & Arcot, J. (2000). Effect of domestic processing methods on the starch, non-starch polysaccharides and in vitro starch and protein digestibility of three varieties of rice with varying levels of amylose. *Food Chemistry*, 70(1), 107–111. [https://doi.org/10.1016/S0308-8146\(00\)00041-8](https://doi.org/10.1016/S0308-8146(00)00041-8)
- Sajilata, M. G., Singhal, R. S., & Kulkarni, P. R. (2006). Resistant starch - A review; *Comprehensive Reviews in Food Science and Food Safety*, 5(1), 1–17. <https://doi.org/10.1111/j.1541-4337.2006.tb00076.x>
- Themeier, H., Hollmann, J., Neese, U., & Lindhauer, M. G. (2005). Structural and morphological factors influencing the quantification of resistant starch II in starches of different botanical origin. *Carbohydrate Polymers*, 61(1), 72–79. <https://doi.org/10.1016/j.carbpol.2005.02.017>
- Thompson, D. B. (2001). Strategies for the manufacture of resistant starch. *Trends in Food Science and Technology*, 11(7), 245–253. [https://doi.org/10.1016/S0924-2244\(01\)00005-X](https://doi.org/10.1016/S0924-2244(01)00005-X)
- Turner, N., & Lupton, J. (2011). Dietary Fiber. *American Society for Nutrition*, (3), 151–152. <https://doi.org/10.3945/an.110.000281.151>
- Unlu, E., & Faller, J. F. (1998). Formation of resistant starch by a twin-screw extruder. *Cereal Chemistry*, 75 (3), 346–350. <https://doi.org/10.1094/CCHEM.1998.75.3.346>
- Vasanthan, T., & Bhatta, R. S. (1998). Enhancement of Resistant Starch (RS3) in Amylomaize, Barley, Field Pea and Lentil Starches. *Starch - Stärke*, 50(7), 286–291. [https://doi.org/10.1002/\(SICI\)1521-379X\(199807\)50:7<286::AID-STAR286>3.0.CO;2-O](https://doi.org/10.1002/(SICI)1521-379X(199807)50:7<286::AID-STAR286>3.0.CO;2-O)
- Walter, M., da Silva, L. P., & Denardin, C. C. (2005). Rice and resistant starch: Different content depending on chosen methodology. *Journal of Food Composition and Analysis*, 18(4), 279–285. <https://doi.org/10.1016/j.jfca.2004.09.007>
- Willett, W., Manson, J., & Liu, S. (2002). Glycemic index, glycemic load, and risk of type 2 diabetes. *American Journal of Clinical Nutrition*, 76(1):274S–80S.
- Wolever, T. M. S., Jenkins, D. J., Jenkins, A. L., & Josse, R. G. (1991). The glycemic index: methodology and clinical implications. *Am. J. Clin. Nutr.*, 54 (5), 846–854.
- Yamada, Y., Hosoya, S., Nishimura, S., Tanaka, T., Kajimoto, Y., Nishimura, A., & Kajimoto, O. (2005). Effect of bread containing resistant starch on postprandial blood glucose levels in humans. *Biosci Biotechnol Biochem*, 69(3), 559–566. <https://doi.org/10.1271/bbb.69.559>
- Zhang, W., Bi, J., Yan, X., Wang, H., Zhu, C., Wang, J., & Wan, J. (2007). In vitro measurement of resistant starch of cooked milled rice and physico-chemical characteristics affecting its formation. *Food Chemistry*, 105(2), 462–468. <https://doi.org/10.1016/j.foodchem.2007.04.002>
- Zhu, L., Liu, Q., Wilson, J. D., Gu, M., & Shi, Y. (2011). Digestibility and physicochemical properties of rice ( *Oryza sativa* L. ) flours and starches differing in amylose content. *Carbohydrate Polymers*, 86(4), 1751–1759. <https://doi.org/10.1016/j.carbpol.2011.07.017>

# Assessment of Corn-Based Rice Analogues Made from Modified Corn Flour and Cassava Starch Which Processed by Granulation Method as Functional Food

## ORIGINALITY REPORT

17%

SIMILARITY INDEX

## PRIMARY SOURCES

|   |                                                                                                                                                                                              |               |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 1 | <a href="http://ps-tepa.polinela.ac.id">ps-tepa.polinela.ac.id</a><br>Internet                                                                                                               | 50 words — 2% |
| 2 | <a href="http://www.iiste.org">www.iiste.org</a><br>Internet                                                                                                                                 | 41 words — 1% |
| 3 | <a href="http://www.volontegenerale.nl">www.volontegenerale.nl</a><br>Internet                                                                                                               | 35 words — 1% |
| 4 | <a href="http://www.asianjab.com">www.asianjab.com</a><br>Internet                                                                                                                           | 34 words — 1% |
| 5 | Onyango, C.. "Digestibility and antinutrient properties of acidified and extruded maize-finger millet blend in the production of uji", LWT - Food Science and Technology, 200511<br>Crossref | 29 words — 1% |
| 6 | <a href="http://iiste.org">iiste.org</a><br>Internet                                                                                                                                         | 26 words — 1% |
| 7 | <a href="http://citeseerx.ist.psu.edu">citeseerx.ist.psu.edu</a><br>Internet                                                                                                                 | 25 words — 1% |
| 8 | <a href="http://www.ideals.illinois.edu">www.ideals.illinois.edu</a><br>Internet                                                                                                             | 22 words — 1% |



|    |                                                                                                                                                                                                                                                                    |                 |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 9  | <a href="http://media.neliti.com">media.neliti.com</a><br>Internet                                                                                                                                                                                                 | 20 words — 1%   |
| 10 | <a href="http://epubs.surrey.ac.uk">epubs.surrey.ac.uk</a><br>Internet                                                                                                                                                                                             | 19 words — 1%   |
| 11 | <a href="http://ddd.uab.cat">ddd.uab.cat</a><br>Internet                                                                                                                                                                                                           | 17 words — 1%   |
| 12 | <a href="http://hdl.handle.net">hdl.handle.net</a><br>Internet                                                                                                                                                                                                     | 14 words — 1%   |
| 13 | <a href="http://repozitorium.omikk.bme.hu">repozitorium.omikk.bme.hu</a><br>Internet                                                                                                                                                                               | 14 words — 1%   |
| 14 | <a href="http://www.jcdr.net">www.jcdr.net</a><br>Internet                                                                                                                                                                                                         | 14 words — 1%   |
| 15 | <a href="http://www.sweetpotatoknowledge.org">www.sweetpotatoknowledge.org</a><br>Internet                                                                                                                                                                         | 14 words — 1%   |
| 16 | Zhu, L.J.. "Digestibility and physicochemical properties of rice ( <i>Oryza sativa</i> L.) flours and starches differing in amylose content", <i>Carbohydrate Polymers</i> , 20111015<br>Crossref                                                                  | 13 words — < 1% |
| 17 | Ghavidel, R.A.. "The impact of germination and dehulling on nutrients, antinutrients, in vitro iron and calcium bioavailability and in vitro starch and protein digestibility of some legume seeds", <i>LWT - Food Science and Technology</i> , 200709<br>Crossref | 12 words — < 1% |
| 18 | S.G Haralampu. "Resistant starch—a review of the physical properties and biological impact of                                                                                                                                                                      | 12 words — < 1% |

---

19 scholarworks.uark.edu 12 words — < 1 %  
Internet

---

20 "OATS: Chemistry and Technology", Scientific Societies, 2011 11 words — < 1 %  
Crossref

---

21 Hardeep Singh Gujral, Bharati Sharma, Pardeep Singh. "Utilization of flour from rice brokens in wheat flour chapatti: evaluation of dough rheology, starch digestibility, glycemic index and retrogradation behavior", Journal of Food Science and Technology, 2019 11 words — < 1 %  
Crossref

---

22 cyberleninka.org 11 words — < 1 %  
Internet

---

23 ifrj.upm.edu.my 11 words — < 1 %  
Internet

---

24 P Luna, M R K Putra, A E Mulyono, A. A. Sulaiman. "The Effect of Autoclaving-Cooling Cycling Treatment on Functional, Sensory and Microstructure Properties of Artificial Rice", IOP Conference Series: Earth and Environmental Science, 2019 10 words — < 1 %  
Crossref