Food Research 6 (3) : 396 - 402 (June 2022)

Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Replacing a part of wheat flour with starchy food containing high levels of resistant starch in noodles processing

[1]Vuong, K.M., [1]Tram, N.B., [1]Tuyen, L.N., [1]Vy, L.T.T., [2]Tai, N.V. and [1,*]Thuy, N.M.

[1]*College of Agriculture, Can Tho University, Can Tho City, Can Tho, Vietnam*

[2]*School of Food Industry, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand*

Article history:

Received: 22 December 2021

Received in revised form: 26 January 2022

Accepted: 12 April 2022

Available Online: 26 June 2022

Keywords:

Flours/starches,

Noodles,

Resistant starch,

Sensory evaluation,

Texture

DOI:

https://doi.org/10.26656/fr.2017.6(3).1020

Abstract

Resistant starch has been shown to be associated with many health benefits. The study was conducted to analyze amylose and resistant starch content in selected starchy materials (black beans, red beans, green Xiem bananas, and potatoes) and investigate the influence of their flour/starch mixing ratio on the quality of noodles. The microstructure of noodles was analyzed by scanning electron microscopy. The results showed that potato starch had the highest resistant starch content (56.70%), followed by green Xiem banana flour (41.55%), black bean flour (16.51%), and red bean flour (15.55%). The raw materials with higher resistant starch also had higher amylose content. Amylose content, resistant starch content, and hardness of noodles increased when partly replacing wheat flour with the high level of RS flours/starches in the formulation. The data rank some tests revealed that formula A3 (replacing 50% of wheat flour with other starchy food containing high levels of resistant starch) was chosen due to the product containing relatively high RS content (14.78%), well structured and well accepted by panellists. The texture of the cooked noodles was assessed to be similar to that of the control sample (100% wheat flour). This study proved that it is possible to elaborate noodles to replace a part of wheat flour with starchy food containing high levels of the well-accepted formulation.

1. Introduction

Resistant starch (RS) is defined as the total starch and starch breakdown products not absorbed in the small intestine of healthy individuals (McCleary and Monaghan, 2002). RS is a natural ingredient present in many foods such as grains, legumes, fruits, vegetables, and many processed foods in content up to 15% of their weight (Dhital *et al*., 2010). RS is often considered one of the components that make up total dietary fibre (Ovando-Martinez *et al*., 2009). Intake of RS in the diet would be an effective method to protect the sigmoid colon and produce lower-energy food products (Nugent, 2005). RS also acts as a prebiotic by supporting the growth of probiotics, which contribute to the prevention of various human diseases such as inflammatory bowel disease and cancer (Raigond *et al*., 2015). Green bananas, legumes, and tubers are typical starch sources rich in RS (Chen *et al*., 2010). The RS content of legumes varied from 11.4% to 32.2%. Beans have also been considered an essential part of a healthy human diet for centuries (Food and Agriculture Organization, 2016) as a source of complex carbohydrates, proteins, bioactive compounds, minerals, and vitamins (Messina, 2014). Besides, green bananas and potatoes are common ingredients with high RS content of up to 40-50% (Ovando-Martinez *et al*., 2009; Chen *et al*., 2010). Increasing the RS amount in noodles may result in lower glycaemic carbohydrate content, suitable for people with diabetes or obesity.

Noodles are also familiar products for Vietnamese consumers. However, wheat flour, the basic ingredient in noodle production, is a very poor source of RS, containing less than 0.4 g RS/100 g dry matter (Kim *et al*., 2006) and is a product with a high glycemic index. In addition, the high gluten content of wheat flour can cause allergies in some people with gluten intolerance (Hischenhuber *et al*., 2006). Therefore, replacing wheat flour with other flour such as bean flour, green banana flour, etc., can create a new food product and mitigate food allergies. However, substituting wheat flour with other flours may alter the noodle texture, cooking quality, edible quality, and sensory appearance. Chickpea-based spaghetti is acceptable to the consumer and has reasonable noodle quality, including reduced

*Corresponding author.

Email: *nmthuy@ctu.edu.vn*

eISSN: 2550-2166 /

Published by Rynnye Lyan Resources

cooking loss and less stickiness than control spaghetti and better firmness retention than durum after cooling (Wood, 2009). Kolaric *et al*. (2020) showed that replacing 20% semolina with sweet potato starch significantly improved the RS content of noodle products while also making small changes in quality, such as reducing cooking time and hardness while increasing swelling index and changing colour. However, information on the effects of using different combinations of ingredients on the RS content and quality of noodle products is minimal. The study aimed to formulate noodles with combined starchy sources, determine the resistant starch content of noodles made with several starchy flours, and evaluate the effect of supplementing noodles with black bean flour, red bean flour, green banana flour, and potato starch on the quality of noodles.

2. Materials and methods

2.1 Flours/starches preparation

The materials used in the experiments were black bean flour, red bean flour, potato starch, wheat flour, semolina, salt, eggs, water and xanthan gum (E415) purchased from the local market and MegaMarket in Can Tho, Vietnam. The green banana powder was produced by soaking the banana pulp in 300 ppm $NaHSO_3$ solution for 10 minutes to inhibit browning enzymes, then draining and drying at 60°C until the moisture content in the dried banana reached 10%. All the dried samples were ground and sieved (flour should pass through a 212 µm sieve - US Standard Mesh No. 70). The obtained powder was placed in sealed PE bags and stored at room temperature (25°C) for further experiments.

2.2 Preparation of noodles

The flours were mixed into four formulas according to the specified ratio of flours for noodles processing (Table 1) The control sample (A0) was formulated with whole wheat flour, while other formulations had high RS flours of 30% in A1, 40% in A2, 50% in A3, and 60% in A4 of total components of the wheat flour. The noodle-making process was according to Thuy *et al*. (2020). The fresh noodles were analyzed for RS and amylose content.

Noodles were cut into pieces about 20 cm in length and boiled (20 g of noodles in 200 mL of boiling water for 150 seconds). The boiled noodle was analyzed for hardness, microstructure and sensory evaluation.

2.3 Moisture content determination

The moisture content of noodles was determined according to the Association of Official Analytical Chemistry method (AOAC 950.46).

Table 1. Formulation of noodles

Ingredients	A0 (%)	A1 (%)	A2 (%)	A3 (%)	A4 (%)
Black bean flour	0	3.52	4.70	5.87	7.05
Red bean flour	0	3.52	4.70	5.87	7.05
Banana flour	0	3.52	4.70	5.87	7.05
Wheat flour	46.97	32.88	28.18	23.49	18.79
Semolina	9.39	9.39	9.39	9.39	9.39
Potato starch	11.74	15.27	16.44	17.61	18.79
Salt	0.47	0.47	0.47	0.47	0.47
Egg	15.27	15.27	15.27	15.27	15.27
Water	14.80	14.80	14.80	14.80	14.80
Xanthan gum	1.36	1.36	1.36	1.36	1.36
Total (%)	100	100	100	100	100

2.4 Resistant starch and amylose measurement

RS tests were adapted for each matrix of formulation using the Association of Official Analytical Chemists (AOAC) Method 2002.02 (McCleary and Monaghan, 2002). The content of amylose was determined using the method described by Avaro *et al*. (2011).

2.5 Hardness testing

Texture attribute hardness of noodles was analyzed with a Brookfield CT3 Texture Analyzer equipped with a 1,500 g load cell and software version 1.8 (Brookfield Engineering Laboratories, Middleboro, MA, USA) as described by Thuy *et al*. (2020).

2.6 Sensory evaluation

Preference testing was applied for sensory evaluation. Thirty consumers aged 20-24 were recruited to rate overall preference using a Hedonic scale with 9 points (1 = strongly dislike and 9 = strongly like with intermediate descriptions between scores 2 and 8) (Lawless and Heymann, 2010).

2.7 Scanning Electron Microscopy

Dried cooked noodles were cut using a razor blade, and the sample was mounted onto brass stubs using double-sided carbon conductive adhesive tape. A gold coating (0.5 nanometers thick) was then applied under an 8-9 pascal vacuum. Bulk samples were examined at 15 kV, the sample distance to the 7 cm ejection glass, 230× magnification using a JEOL model J550 scanning electron microscope (Japan).

2.8 Statistical analysis

The experiments were performed with three replicates. One-way analysis of variance (ANOVA) was performed to test the differences among formulas. Differences at $p<0.05$ were considered to be statistically

eISSN: 2550-2166

significant. Experimental results were expressed as the mean±standard deviation (SD).

3. Results and discussion

3.1 Amylose and RS content in starchy food

The moisture content, amylose, and RS content of various flours and starch were determined and shown in Table 2. The moisture content of the black bean and red bean flours was the lowest (8.32-8.49%), followed by green banana powder (9.84%), and potato starch (15.39%). These values are within acceptable limits (<20.0%) for stable shelf life (Amarasinghe *et al*., 2021).

Table 2. Moisture content, amylose and RS content of various flours and starch

Raw materials	Moisture content (%)	Amylose content (%)	RS content (%)
Black bean flour	8.32±0.02[a]	13.03±0.28[a]	16.51±0.02[a]
Red bean flour	8.49±0.01[a]	14.04±0.57[b]	15.55±0.05[a]
Green banana flour	9.84±0.03[b]	24.80±0.27[c]	41.55±0.85[b]
Potato starch	15.39±0.21[c]	24.64±0.17[c]	56.70±1.44[c]

Values are presented as mean±SD. Values with different superscripts within the same column per column are significantly different p<0.05.

Potato starch has the highest RS content (56.70%), followed by green banana powder (41.55%), black bean powder (16.51%), and red bean powder (15.55%). In this study, the RS content of potato starch was significantly lower than that determined by Chen *et al*. (2010), who showed that potato starch has 79.3% RS. The RS content of green banana powder was similar to the research results of Moongngarm (2013), showing that the RS content ranged from 35.14 to 45.87%, depending on the banana variety. However, Menezes *et al*. (2011) showed that green banana powder has higher RS content (48.99%). Guajardo-Flores *et al*. (2017) reported that black bean flour had about 14.5% RS, while Rosa-Millán *et al*. (2019) showed that black bean powder had a higher RS content (30.2%) than the results obtained in this study. Moongngarm (2013) found very low RS content (9.54%) in red bean paste. However, Chen *et al*. (2010) showed that red beans had significantly higher RS content (30.2%). RS has attracted the attention of nutritionists and food processors because of its potential physiological benefits and unique functional properties (Raigond *et al*., 2015).

The amylose contents of potato starch, green banana powder, black bean, and red bean powder were 24.64%, 24.80%, 13.03%, and 14.04%, respectively, which are quite consistent with the results of previous research (Pycia *et al*., 2012; Moongngarm, 2013), wherein the amylose content of potato starch, green bananas, and some legumes range from 25.7-30%, 17.65-24.11% and 22.15-30.47%, respectively. The flours and starches with higher RS content also had higher amylose content (Table 2), which indicates that amylose content was correlated with RS content. The amylose content of starch positively affects the ability to resist digestion by digestive enzymes, when this content is high, the digestion process takes place more slowly. This is because amylose has a compact linear structure that limits access to digestive enzymes (Sajilata *et al*., 2006). Similarly, Noda *et al*. (2003) showed that amylose content in rice starch was inversely proportional to digestibility. Vaidya and Sheth (2011) also showed a close relationship between amylose and RS content in corn products. Differences in amylose and RS concentrations between studies may be due to differences in cultivars, growing conditions, soils, maturity stages, and analytical methods.

3.2 Effect of flour/starch mixing ratio (black bean flour: red bean flour: green banana powder: potato starch: wheat flour) on the quality of noodles

3.2.1 Amylose and RS contents of noodles

Significant increases in amylose and RS contents were found in the noodles upon the addition of RS-rich flours and starch (Table 3). The control sample (A0) (Figure 1a) had the lowest amylose and RS contents (12.12% and 9.07%, respectively), followed by sample A1 with 13.46% amylose and 13.46% RS, sample A2 with 15.21% amylose and 14.20% RS, sample A3 with 16.77% amylose and 14.78% RS and sample A4 with the highest amylose and RS content (16.90% and 18.64%, respectively) (Figure 1b). The increase in RS content in noodles can be seen due to the increase in the ratio of flours and starch supplements rich in RS used in the recipes.

Figure 1. Noodles products – Control sample A0 (a) and Supplemental sample of flour/starch source containing resistant starch (b)

The RS content of sample A0 in this study was lower than the RS content of the noodles made from 100% wheat flour (13.83% RS) in the study of Tian *et al*.

eISSN: 2550-2166

Table 3. Amylose and RS content of fresh noodles made from different recipes

Formulas	Ratio of BBF:RF:BF:PS:WF (%)	Amylose content (%)	RS content (%)
A0	0: 0: 0: 11.74: 46.97	12.12±0.61[a]	9.07±0.30[a]
A1	3.52: 3.52: 3.52: 15.27: 32.88	13.46±0.67[b]	13.46±0.42[b]
A2	4.70: 4.70: 4.70: 16.44: 28.18	15.21±0.76[c]	14.20±0.51[bc]
A3	5.87: 5.87: 5.87: 17.61: 23.49	16.77±0.52[d]	14.78±0.09[c]
A4	7.05: 7.05: 7.05: 18.79: 18.79	16.90±1.54[d]	18.64±0.55[d]

Values are presented as mean±SD. Values with different superscripts within the same column per column are significantly different p<0.05BBF: Black bean flour, RF: Red bean flour, BF: Banana flour, PS: Potato starch, WF: Wheat flour.

(2020), but this RS value is higher than RS in spaghetti made from 100% semolina (1.14% RS) in the study of Kolaric *et al.* (2020). This may be due to differences in the recipe and used supplements. The RS content of spaghetti was reported to increase markedly with the addition of RS-rich ingredients such as sweet potato starch (Kolaric *et al.*, 2020) and green banana powder (Ovando-Martinez *et al.*, 2009). Wood (2009) also showed that the amylose content of pasta significantly increased when adding 30% chickpea flour.

3.2.2 The firmness of noodles

Hardness is one of the structural parameters often related to sensory perception (Yao *et al.*, 2020). The results showed that the firmness increased gradually with the addition ratio of RS-rich flours and starch (Table 4). The lowest measure of stiffness was found in the A0, A1 and A2 samples (83.56 to 88.56 g force) and did not represent a significant difference between them. The lowest measure of stiffness was found in the A0, A1 and A2 samples (83.56 to 88.56 g force) and did not represent a significant difference between them. The higher value was found in sample A3 (94.33 g force), and the A4 sample had the highest stiffness (99.33 g force). The noodle firmness is positively correlated with protein content and amylose content (Baik and Lee, 2003; Liu *et al.*, 2018). Although the addition of flours and starches reduces the gluten content of the flour, the gluten network of the dough can be strengthened by the cooperation between wheat flour protein and bean flour protein (such as the beans used in this study - black and red bean) through weak forces including H-bonding and van der Waals interactions and other electrostatic interactions as covalent bond (Li *et al.*, 2016). High amylose content showed high levels of retrogradation and absorbed limited water content during cooking (Yu *et al.*, 2009).

The percentage of consumers' preferences for the noodle samples was shown in Figure 2. It was observed that sample A0 is the most preferred by consumers (80-90%), and sample A3 also received the most favourable. The popularity from consumers is quite high (60-70%) whereas samples A1, A2, and A4 are less accepted (<30%). The collected results showed that the sample of A3 with the ratio of black bean flour: red bean flour: green banana flour: potato starch: wheat flour is 5.87: 5.87: 5.87: 17.61: 23.49%, respectively, is the most suitable to improve RS content compared with the control sample (A0) with high sensory quality and much loved by consumers.

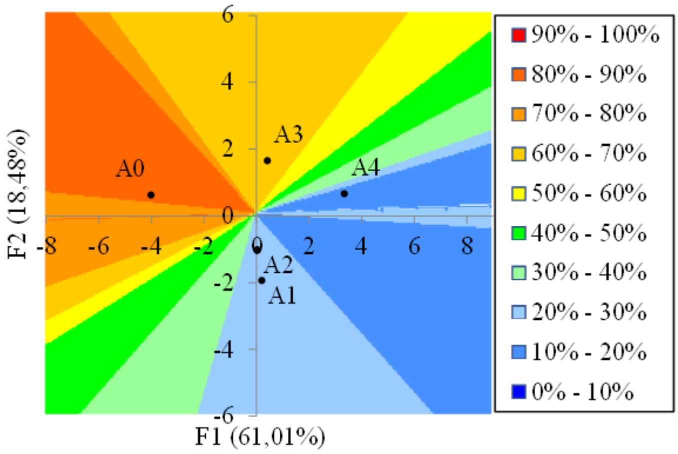

Figure 2. The preference mapping of consumers for noodles processed according to different recipes

3.2.3 Microstructure of noodles

The microstructure images provided information on the size, shape, and arrangement of particles in the noodle matrix. Based on images obtained from the SEM

Table 4. The firmness of cooked noodles processed according to different recipes

Formulas	Ratio of BBF:RF:BF:PS:WF (%)	Firmness (g force)
A0	0:0:0:11.74:46.97	83.56±6.35[a]
A1	3.52:3.52:3.52:15.27:32.88	85.78±9.60[a]
A2	4.70:4.70:4.70:16.44:28.18	88.56±2.70[ab]
A3	5.87:5.87:5.87:17.61:23.49	94.33±11.97[bc]
A4	7.05:7.05:7.05:18.79:18.79	99.33±5.57[c]

Values are presented as mean±SD. Values with different superscripts within the same column per column are significantly different p<0.05BBF: Black bean flour, RF: Red bean flour, BF: Banana flour, PS: Potato starch, WF: Wheat flour.

technique, it is possible to analyze food products' appearance, structure, or integrity. The cross-sectional image of noodles shows that the binding force between the protein substrate and starch granules of two samples A0 and A3 are different. In general, the two noodles sample has a smooth and uniform surface, but some starch particles have not been gelatinized and mixed or completely covered by the gluten network. From the image, it could be seen that the surface of both noodle samples had small holes, which can allow water to penetrate inside during the cooking process; however, sample A3 appears large holes than sample A0 (Figure 3).

Besides, sample A0 appeared long fault lines (Figure 3a) while no fault lines were found in sample A3 (Figure 3b). Therefore, it can be seen that replacing 50% of wheat flour with RS-rich flours and starch (A3 sample) did not change much of the structure of the noodles and improved the bonding between ingredients. This is consistent with the increase in firmness of sample A3 compared to A0 (as mentioned in Table 4). Liu *et al.* (2018) also reported that increasing the content of germinated mung beans improved the interaction and binding between protein and starch in noodles.

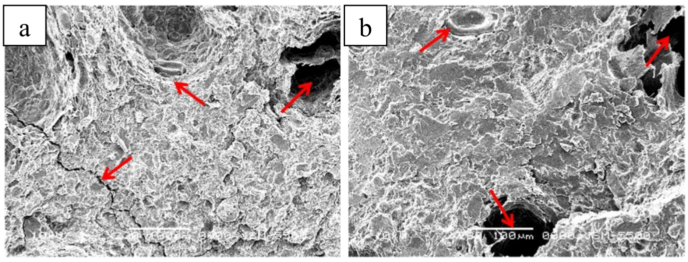

Figure 3. Cross-section of noodles observed with SEM (230× magnification) a. Control sample A0 with wheat flour 100%, b. Sample A3 with the ratio of BF:RF:BF:PS:WF are 5.87: 5.87: 5.87: 17.61: 23.49% respectively.

4. Conclusion

The materials with high RS content (black bean, red bean, green banana, and potato starch) were recorded and shown to correlate with their amylose content. The incorporation of these flours and starches into noodle formulations improved the RS content and acceptability of the product. It was possible to replace up to 50% wheat flour in noodle recipes with RS-rich flours and starch without significantly changing the microstructure of the product. The organoleptic properties of the new product have been highly appreciated by the senses and enjoyed by consumers. Furthermore, studies will be continued on digestion resistance, developing novel plants and starches, and modifying foods to incorporate these starches, addressing the impact of digestion-resistant starches on the prevention and control of chronic human diseases, including diabetes and obesity.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

The authors acknowledge the financial support to Can Tho University, Vietnam from the Research fund project number TSV2021-110.

References

Amarasinghe, N.K., Wickramasinghe, I., Wijesekara, I., Thilakarathna, G. and Deyalage, S.T. (2021). Functional, Physicochemical, and Antioxidant Properties of Flour and Cookies from Two Different Banana Varieties (*Musa acuminata* cv. Pisang awak and *Musa acuminata* cv. Red dacca). *International Journal of Food Science,* 2021, 6681687. https://doi.org/10.1155/2021/6681687

Avaro, M.R.A., Pan, Z., Yoshida, T. and Wada, Y. (2011). Two Alternative Methods to Predict Amylose Content of Rice Grain by Using Tristimulus CIE LabValues and Developing a Specific Color Board of Starch-iodine Complex Solution. *Plant Production Science*, 14(2), 164-168. https://doi.org/10.1626/pps.14.164

Baik, B. and Lee, M. (2003). Effects of Starch Amylose Content of Wheat on Textural Properties of White Salted Noodles. *Cereal Chemistry*, 80(3), 304-309. https://doi.org/10.1094/CCHEM.2003.80.3.304

Chen, L., Liu, R., Qin, C., Meng, Y., Zhang, J., Wang, Y. and Xu, G. (2010). Sources and intake of resistant starch in the Chinese diet. *Asia Pacific Journal of Clinical Nutrition,* 19(2), 274-82.

Dhital, S., Katawal, S.B. and Shrestha, A.K. (2010). Formation of resistant starch during processing and storage of instant noodles. *International Journal of Food Properties,* 13(3), 454-463.https://doi.org/10.1080/10942910802627091

Food and Agriculture Organization of the United Nations (FAO). (2016). Pulses: Nutritious seeds for asustainable future. Retrieved on April 1, 2021 from FAO website: www.fao.org/3/i5528e/i5528e.pdf

Guajardo-Flores, D., Pérez-Carrillo, E., Romo-López, I., Ramírez-Valdez, L.E., Moreno-Garcia, B.E. and Gutiérrez-Uribe, J.A. (2017). Effect of dehulling and germination on physicochemical and pasting properties of black beans (*Phaseolus vulgaris L.*). *Cereal Chemistry,* 94(1), 98-103. https://doi.org/10.1094/CCHEM-02-16-0017-FI

Hischenhuber, C., Crevel, R., Jarry, B., Mäki, M., Moneret-Vautrin, D.A., Romano, A., Troncone, R., and Ward, R. (2006). Review article: safe amounts of gluten for patients with wheat allergy or coeliac disease. *Alimentary Pharmacology and Therapeutics,* 23(5), 559-575. https://doi.org/10.1111/j.1365-2036.2006.02768.x

Kim, J.H., Tanhehco, E.J. and Ng, P.K.W. (2006). Effect of extrusion conditions on resistant starch formation from pastry wheat flour. *Food Chemistry,* 99(4), 718-723.https://doi.org/10.1016/j.foodchem.2005.08.054

Kolaric, L., Minarovičová, L., Lauková, M., Karovičová, J. and Kohajdová, Z. (2020). Pasta noodles enriched with sweet potato starch: Impact on quality parameters and resistant starch content. *Journal of Texture Studies,* 51(2), 464-474. https://doi.org/10.1111/jtxs.12489

Lawless, H. and Heymann, H. (2010). Sensory Evaluation of Food. 2nd ed. New York, USA: Springer. https://doi.org/10.1007/978-1-4419-6488-5

Li, Z., Li, W., Gao, P., Hu, Y. and Zan, L. (2016). Influence of milk and milk-born active peptide addition on textural and sensory characteristics of noodle. *Journal of Texture Studies*, 48(1), 23-30. https://doi.org/10.1111/jtxs.12198

Liu, Y., Xu, M., Wu, H., Jing, L., Gong, B., Gou, M., Zhao, K. and Li, W. (2018). The compositional, physicochemical and functional properties of germinated mung bean flour and its addition on quality of wheat flour noodle. *Journal of Food Science and Technology,* 55, 5142-5152.https://doi.org/10.1007/s13197-018-3460-z

McCleary, B.V. and Monaghan, D.A. (2002). Measurement of Resistant Starch. *Journal of AOAC International*, 85(3), 665-675. https://doi.org/10.1093/jaoac/85.3.665

Menezes, E.W., Tadini, C.C., Tribess, T.B., Zuleta, A., Binaghi, J., Pak, N., Vera, G., Dan, M.C.T., Bertolini, A.C., Cordenunsi, B.R. and Lajolo, F.M. (2011). Chemical composition and nutritional value of unripe banana flour (*Musa acuminata*, var. Nanico). *Plant Foods for Human Nutrition*, 66(3), 231-237.https://doi.org/10.1007/s11130-011-0238-0

Messina, V. (2014). Nutritional and health benefits of dried beans. *American Journal of Clinical Nutrition*, 100(Suppl. 1), 437-442. https://doi.org/10.3945/ajcn.113.071472

Moongngarm, A. (2013). Chemical compositions and resistant starch content in starchy foods. *American Journal of Agricultural and Biological Science*, 8(2), 107-113. https://doi.org/10.3844/ajabssp.2013.107.113

Noda, T., Nishiba, Y., Sato, T. and Suda, I. (2003). Properties of starches from several Low-Amylose Rice Cultivars. *Cereal Chemistry*, 80(2), 193-197. https://doi.org/10.1094/CCHEM.2003.80.2.193

Nugent, A.P. (2005). Health properties of resistant starch. *Nutrition Bulletin*, 30(1), 27-54.http://dx.doi.org/10.1111/J.1467-3010.2005.00481.X

Ovando-Martinez, M., Sayago-Ayerdi, S., Agama-Acevedo, E., Goni, I. and Bello-Perez, L.A. (2009). Unripe banana flour as an ingredient to increase the undigestible carbohydrates of pasta. *Food Chemistry*, 113(1), 121-126.http://dx.doi.org/10.1016/J.FOODCHEM.2008.07.035

Pycia, K., Juszczak, L., Gałkowska, D. and Witczak, M. (2012). Physicochemical properties of starches obtained from Polish potato cultivars. *Starch-Staerke*, 64(2), 105-114. https://doi.org/10.1002/star.201100072

Raigond, P., Ezekiel, R. and Raigond, B. (2015). Resistant starch in food: A review. *Journal of the Science of Food and Agriculture*, 95(10), 1968-1978. https://doi.org/10.1002/jsfa.6966

Rosa-Millán, J.D., Heredia-Olea, E., Pérez-Carrillo, E., Guajardo-Flores, D. and Serna-Saldívar, S. (2019). Effect of decortication, germination and extrusion on physicochemical and *in vitro* protein and starch digestion characteristics of black beans (*Phaseolus vulgaris* L.). *Food Science and Technology*, 102, 330-337.https://doi.org/10.1016/j.lwt.2018.12.039

Sajilata, M.G., Singhal, R.S. and 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

Thuy, N.M., Chi, N.T.D., Huyen, T.H.B. and Tai, N.V. (2020). Orange-fleshed sweet potato grown in Viet nam as a potential source for making noodles. *Food Research*, 4(3), 712-721. https://doi.org/10.26656/fr.2017.4(3).390

Tian, Y., Li, M., Tang, A., Jane, J.L., Dhital, S. and Guo, B. (2020). RS Content and EGI value of cooked noodles (I): Effect of cooking methods. *Foods*, 9(3), 328. https://doi.org/10.3390/foods9030328

Vaidya, R.H. and Sheth, M.K. (2011). Processing and storage of Indian cereal and cereal products alters its resistant starch content. *Journal of Food Science and Technology*, 48(5), 622-627. https://doi.org/10.1007/s13197-010-0151-9

Wang, N., Maximiuk, L. and Toews, R. (2012). Pea starch noodles: Effect of processing variables on characteristics and optimisation of twin-screw extrusion process. *Food Chemistry*, 133(3), 742-753. https://doi.org/10.1016/j.foodchem.2012.01.087

Wood, J. (2009). Texture, processing and organoleptic properties of chickpea-fortified spaghetti with insights to the underlying mechanisms of traditional durum pasta quality. *Journal of Cereal Science,* 49 (1), 128-133. https://doi.org/10.1016/j.jcs.2008.07.016

Yao, M., Li, M., Dhital, S., Tian, Y. and Guo, B. (2020). Texture and digestion of noodles with varied gluten contents and cooking time: The view from protein matrix and inner structure. *Food Chemistry*, 315, 126230. https://doi.org/10.1016/j.foodchem.2020.126230

Yu, S., Ma, Y. and Sun, D. (2009). Impact of amylose content on starch retrogradation and texture of cooked milled rice during storage. *Journal of Cereal Science*, 50(2), 139-144. https://doi.org/10.1016/j.jcs.2009.04.003

