

Minireview Article

Cassava utilization for noodles production: a mini review

ABSTRACT

Due to the increasing cost of wheat flour in countries where it is not grown, other alternatives local flours are sought. Cassava (*Manihot esculenta Crantz*) is an affordable crop for most people in Asian and African countries due to its abundance. Starch and flour made from cassava are used as replacement for wheat as it can be incorporated into diverse food products to enhance their properties. Cassava noodles are products that contribute to food security and also address the health problem of celiac people who suffer from adverse health reactions due to the presence of gluten in conventional wheat pasta and noodles. This review addresses specifically the production of cassava noodles. Since cassava flour and starch lack gluten, many challenges occur in the noodles manufacturing process. Thus, in the light of the available research, strategies to obtain good quality cassava noodles are described in this paper to enhance the sensory properties, cooking properties and nutritional values.

Keywords: cassava; gluten free; starch; flour; noodles

1. INTRODUCTION

Noodles and pasta are similar products appreciated worldwide and have turned into comfort food for many people. The differences between pasta and noodles originate from the raw material and the processing methods. The main ingredient for pasta is semolina flour from Durum wheat, (*Triticum turgidum ssp*) and the processing method used is extrusion (Hager et al., 2012). In comparison, noodles can be produced not only from wheat (*Triticum aestivum*), but also from other cereals (rice, corn, sorghum, millet, buckwheat...), legumes (beans, soybeans, mung beans), pseudo cereals (amaranth, quinoa, etc.), roots and tubers (taro, cassava, yam, potato, sweet potato, etc.). Moreover, the method used in processing noodles has more steps than typical pasta. Originally, noodles processing included mixing the flour and water, followed by kneading, rolling, sheeting, and cutting the dough to obtain noodles strands of diverse lengths and shapes (Hou et al., 1998).

Cassava has gathered interest in recent years, particularly in Asian and African countries due to its availability, low cost and ability to substitute partially or totally wheat flour in the production of pastries and bakeries. Cassava starch is characterized by a neutral taste and odor, it provides a transparent, smooth and viscous gel suitable for many processed food items (Mbanjo et al., 2021). Globally, there are two trends, one related to the high cost of wheat flour in countries where it is imported (Akonor et al., 2017), and secondly the research for healthier alternatives to wheat flour for people suffering from celiac disease (Feyisa, 2021). Therefore, other options are being looking for to replace wheat partially or totally in diverse products such as pastries, pasta and noodles, etc. Most countries in Africa depend on wheat import. On the contrary many roots and tubers varieties are available locally such as cassava. Also, products such as pasta and noodles are widely consumed in Africa and are mostly imported or made out of wheat flour. Africa is home to some major cassava producers starting with Nigeria, ranking number 1 in the world with an estimated 63 million metric tons of cassava roots in 2021 which equals to 20% of the world production (Shahbandeh, M., 2023). Although previous investigations (Senanayake et al., 2024, Purwandari et al., 2014, Lawal et al., 2021, Theresa et al., 2020, Adetola et al., 2020) were carried out towards developing noodles from cassava,

there remain challenges related to the absence of gluten, a protein mostly found in wheat flour, which confers to wheat products their elasticity, texture and flavor. In addition, gluten-free noodles which are widely reviewed in the literature are from rice noodles. Literature review on cassava starch exists (Chisenga et al., 2019) due to its ability to enhance diverse food products and non-food products. However, review papers are scarce about cassava noodles. Hence, this paper aims to address cassava noodles production, particularly processing methods into noodles, challenges and enhancing methods to overcome the lack of gluten and the opportunities for future research.

2. CASSAVA NOODLES: TYPES, PROCESSING AND ENHANCING METHODS

2.1. Different types of cassava noodles

According to the thickness, noodles can be classified as thin (1.3–1.7mm), very thin (1.0–1.2 mm), standard (2.0–3.9 mm) or flat (5.0–7.5 mm) (Fu, 2008). The shape of cassava noodles is diverse from the most common such as spaghetti, vermicelli, shells, penne to unique form such as mesh. Fig. 1 illustrates some examples of cassava noodles around the world. The most atypical is the mesh-like shape from Vietnam. Fresh cassava noodles, can be approximately 40% water content (Abidin & Adeline, 2013). For longer preservation, water can be removed up to 12.5% to obtain dried noodles (Hager et al., 2012) that can be preserved under good packaging for up to 2 years.



Spaghetti (Italy, Vietnam)



Mesh (Vietnam)



Vermicelli (Indonesia)



Green colored shells (Nigeria)

Fig. 1. Some examples of noodles made from cassava around the world. Sources: (Natura Market, 2024, Chus, 2024, Aldentee, 2024)

2.2. Processing of cassava noodles

Fig. 2 illustrates the flow charts of wheat noodles and cassava noodles. As can be seen, cassava noodles' processing includes heating, cooling, steaming steps that are not found in wheat noodles. This is due to the absence of gluten which needs to be replaced by suitable processing or additives to obtain noodles with good characteristics.

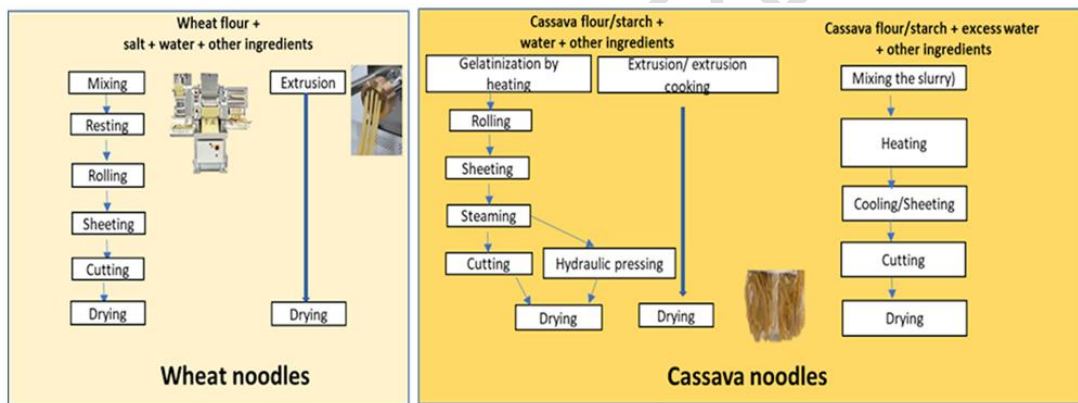


Fig. 2. Wheat noodle vs cassava noodles flow charts

Traditionally, manufacturing cassava noodles can be done as with common gluten-free flours such as rice and buckwheat. The first method consists of weighing raw material, mixing cassava flour with water, followed by kneading to form a dough, then steaming the dough until half-cooked, pushing dough through a die (small opening) to form noodles strands, cooling, washing, draining, and drying (Li et al., 2021). A slight variant of that method is to form sheets with the steamed dough, then slit, cut, and dry.

The second method consists of making a slurry with cassava flour and water as with rice flour (Ahmed et al., 2016), then steaming the slurry and cutting to noodles strands. Sometimes the slurry can be pushed through a perforated stainless plate or bowl to form strands that are directly put into boiling water to gelatinize and obtain noodles.

Nowadays, technology has helped to reduce the steps of making cassava noodles thanks to use of modern extrusion machines. Generally, as for most gluten-free flour, there is usage of pre-gelatinized flour which is mainly obtained through hydrothermal treatments (Marti & Pagani, 2013). There are two types of extrusion: conventional extrusion and extrusion-

cooking. In conventional extrusion method, the flour is pressed through a die to form noodles (Marti & Pagani, 2013). In the extrusion-cooking process, native flour is steamed and extruded at temperature above 100 °C inside the extruder and directly extruded through the die to form desired shape of noodles (Marti & Pagani, 2013).

Drying is an important step to preserve noodles and limit biochemical and microbiological degradations. It can be achieved through sun drying, oven drying, vacuum drying or deep frying. Nowadays for health reasons, air drying is preferred to frying to avoid oil absorption in instant noodles (Ahmed et al., 2016).

Final step of noodles processing is the packaging to preserve its shelf-life. The packaging used must keep the noodles from moisture, oxygen, dust and keep the products stable during the duration of the storage period (Lestari et al., 2019, Dunno et al., 2016, Souza & Fernando, 2016). Packaging materials used for noodles are usually films impermeable to air and water (Stanislaus, O. O., 2014).

2.3. Quality assessment

Visco-elastic, texture, and cooking properties are the main parameters measured to assess noodles quality. In addition, for cassava noodles, HCN content must be evaluated to ensure safety of consumers. FAO estimated 10 mg/kg d.w. as limit of HCN in cassava flour (FAO/WHO, 1991). Quality noodles must be chewy, springy, smooth, non-sticky and sustain cooking without disintegration. Good cooking behavior are low stickiness, cooking time, cooking loss and noodles with firm texture and high rehydration percentage (Ahmed. et al. 2016). Dried noodles must have water content around 12 % to avoid microbial growth during storage (Ahmed et al., 2016).

2.4. Enhancing methods

Cassava flour and starch do not contain gluten proteins contrary to wheat flour. Thus, challenges occur during cassava noodles manufacturing. Gluten proteins, namely gliadin and glutenin are responsible for promoting starch-protein network which provides the visco-elastic and cooking properties of pasta and noodles. Therefore, strategies are needed to make up for the lack of gluten and not compromise on the final product quality. In the absence of gluten, the role of starch increases in providing structure and texture to gluten-free products (Witczak et al., 2016). Research on improving gluten-free noodles and pasta have been ongoing for decades and this section includes the different strategies used to promote better quality of gluten-free flour particularly that of noodles made from cassava flour and starch.

2.4.1. Modification of cassava flour and starch

Native cassava flour does not contain gluten proteins which are responsible for the texture of pasta and noodles products. Therefore, noodles made solely from native cassava flour can be brittle, sticky, and have high cooking loss than wheat noodles. Both cassava flour and starch can be modified to enhance their functional properties for noodles production. Modification techniques consist of changing the structure of cassava starch and flour through various methods: physical, fermentation, enzymatic and chemical modifications.

2.4.1.1. Physical modification

Physical modification consists mainly of hydrothermal treatments such as annealing and high moisture treatment of starch and flour.

Annealing consists of treating high water content starch (more than 40% and less than 60%) also known as a slurry, to low temperature below the gelatinization (around 60-70°C for cassava starch), (Tan et al., 2009, Abdullah et al., 2018). Starches obtained through annealing are utilized in the manufacturing of noodles due to the enhancing effect on thermal stability and reduction of the degree of set-back of starches (Mathobo et al., 2021, Adebawale & Lawal, 2002). Whereas, high moisture treatment (HMT) involves low water content starch (<35%) which is heated to high temperature above the gelatinization temperature (Tan et al., 2009). Both annealing and HMT induced physico-chemical changes in starch (Marti & Pagani, 2013) which benefits the product quality. However, heat-moisture treatment is more suitable for semi-dried and dried noodles due to the great tensile strength and gel hardness (Padalino et al., 2016). Whereas annealing which induced soft texture is suitable for fresh noodles (Padalino et al., 2016).

2.4.1.2. Fermentation and enzymatic treatments

Fermentation generally by lactic acid fermentation has been effective to confer positive characteristics to gluten-free noodles such as rice, corn and cassava noodles. Fermentation alters the crystalline regions of starch granules and chemical components, thus changing the physical characteristics of starch and the texture of noodles (Lu et al., 2005). Fermented cassava flour also known as mocaf flour is achieved through microbial fermentation, which involves yeast, mold or bacteria as fermentation agents (Gunawan et al., 2015). The fermentation process can last 24 hours at least, followed by drying at 50 °C until low moisture content, generally 13% (Seveline et al., 2020), then milled to obtain modified cassava flour (Sulistyo & kahara, 2013). The fermentation enhances the viscosity, gelation ability, rehydration, and confers a neutral flavor. Table 1 shows different microorganisms involved and the fermentation conditions. The most common used are *Lactobacillus*, others as *Rhizopus oryzae*, *Sacharomyces cerevisiae* and *Xanthomonas campestris*. In general, fermentation enhanced the protein and nutrient contents of cassava flour along with a decrease in starch and carbohydrate contents.

Table 1. Some studies on fermented cassava flour and the microorganisms involved

Microorganisms	Fermentation conditions	Key findings	References
<i>L. plantarum</i> , <i>L. fermentum</i> , and <i>L. paracasei</i>	48 hours 72 hours Ratio of lactic acid bacteria culture: cassava: distilled water is 1:1: 0.01	Improved protein content, better color, odor and taste	(Seveline et al., 2020)
<i>R. oryzae</i>	72 hours; room temperature; fungi culture was inoculated into 1 kg of the mash, as the starter culture and 730mL nutrient solution	Increasing the protein level of Cassava Flour and at the same time reducing the level of some antinutrients, specifically total cyanide	(Akindahunsi et al., 1999)
<i>L. plantarum</i> , <i>S. cerevisiae</i> , and <i>R. oryzae</i>	Microbial to cassava mass ratio of 1% for fermentation time of 120 h	Increased the protein level, reduced the level of starch and cyanide	(Gunawan et al., 2015)

<i>Lactobacillus plantarum</i> , <i>Xanthomonas campestris</i> and <i>Saccharomyces cerevisiae</i>	Cassava to tap water ratio of 1:2, v/v mixed with 2.0% (w/v) of microbial culture; 25 °C for 24-72 h.	Increase of swelling power and solubility, Increase of protein and fat and lower levels of cyanide	(Sulistyo & kahara, K., 2013)
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Enzymatic modification is made through microbial fermentation or addition of enzymes to starch in controlled conditions. Starch is then hydrolyzed into low molecules weight such as maltodextrin (Oh et al., 2019). Enzymes are used to modify gluten-free flour to give them appropriate characteristics for food processing. They can create new protein aggregates close to that created by gluten and induce proteins modification (Cappelli et al., 2020). Different enzymes are used, most common are amylases, proteases, cyclo dextrinases, hemicellulases, lipases, oxydases and transglutaminases (Cappelli et al., 2020).

2.4.1.3. Chemical treatment

Chemical modifications create consistency, smoothness and transparency in starch paste along with freeze thaw and refrigeration stability (Singh et al., 2007). The common methods are acetylation, oxidation, acid hydrolysis and crosslinking (Obadi & Xu, 2021). Violalita et al., (2020) partially replaced potato starch with phosphorylated tapioca starch and observed that uncooked noodles had improved strength, and after cooking, noodles had low stickiness and cooking loss.

2.4.2. Extrusion conditions

Although noodles were initially manufactured through a different process than pasta, extrusion is adopted due to its advantages in simplifying the process and improving the final product. Many authors agreed that in the case of gluten-free pasta or noodles, extrusion-cooking is usually more suitable than conventional extrusion used in typical durum-wheat pasta. Extrusion-cooking is applying high temperature and short time on the food product (Ahmed et al., 2024), then a pressure is applied and forced the dough through a die to form pasta or noodles' strand. Extrusion used the principle of starch gelatinization which converts the crystalline starch macromolecules into a more amorphous material (Wolf, 2010) that exhibits high viscosity and plasticity (Liu et al., 2011). The products become more malleable and easier to form a dough. The resultant pasta achieves high quality firmness, texture and flavor after cooking (Wang et al., 1999, Giménez et al., 2013). The cooking step consists of heating or injecting steam onto the flour (Ahmed et al., 2024). Extrusion-cooking reduces work-load of gluten free-pasta by skipping use of pre-gelatinized starch/flour and avoiding the numerous steps of typical noodles process (steaming, boiling, rinsing) before drying. What is generally found in the literature is that usage of pre-gelatinized flour, high temperature above 100 °C, optimal water addition, high extruder screw driver speed has contributed in better pasta/noodles quality of gluten-free flour. Temperature of extrusion chamber plays a crucial role in the quality of gluten-free pasta. For instance, extrusion temperature of 115 °C compared with 50°C gave better cooking quality of rice-based pasta (Marti et al., 2010). Giménez et al. (2013) investigated extrusion-cooking of corn and bean spaghetti-type. They observed that extrusion at 100 °C and 28% moisture was optimum for good product quality. Similarly, Wang et al. (2012) by using high temperature extrusion obtained pea starch noodles with reduced cooking loss and stickiness.

2.4.3. Other flours for technological and nutrient improvement

Cassava noodles can be based on cassava flour/starch or mixed with other flours to improve their characteristics. Rice and corn flours are commonly used to enhance cassava noodles. Sabbatini et al. (2015) investigated the use of rice flour with cassava flour and used additives to improve the noodles' quality. Fermented cassava flour was partially mixed with wheat flour, corn and rice in a study by Purwadi et al. (2021). They added hydrocolloid agents such as xanthan gum, guar gum, arabic gum, carboxy-methylcellulose (CMC) and eggs. The best pasta formulation was composed of fermented cassava flour:rice:corn flour by 70:10:20 and addition of 2,5% xanthan gum. The pasta presented strong and elastic texture thanks to rice and corn flour addition, while hydrocolloid increased water-binding of the pasta. Other flours which improved noodles' characteristics were sorghum (Hamidah et al., 2023), banana (Rachman et al., 2020), yam bean (Theresa, et al., 2020), millet (Prema et al., 2018) and *porang* (indonesian tuber rich in glucomannan) (Kamsiati et al., 2022).

Cassava flour are poor in proteins (less than 2%) compared to wheat flour (10-12%). Therefore, researchers have investigated fortification of cassava noodles through addition of ingredients which are rich in proteins. Al-Baarri et al. (2021) have investigated the usage of basil and spirulina leaf extracts to fortify cassava noodles made from mocaf. They obtained noodles with characteristics such as chewy, dense and not easily broken. Other studies have utilized various flours and starches from diverse sources such as cereals (sorghum, wheat, millet,), pseudocereals (quinoa, buckwheat, amaranth), legumes (pea, beans, soybeans, cassava leaves, moringa), egg proteins, milk proteins, seaweed, pumpkin flour (Padalino et al., 2016, Hager. et al., 2012, Lawal et al., 2021) and succeeded in enhancing cassava noodles proteins content.

2.4.4. Addition of additives

The additives used to enhance gluten-free products such as cassava noodles are hydrocolloids, emulsifiers or mineral salts.

2.4.4.1. Hydrocolloids

The main challenges in developing gluten-free noodles are obtaining good texture. Hydrocolloids are polysaccharides which have high water binding ability (Padalino et al., 2016) and are used as partial substitutes for gluten. They are used as texture and taste improvers and also for extending food product shelf life (Padalino et al., 2016). Incorporation of polysaccharides such as xanthan gum, gellan gum, pectin, agar, chitosan, Carboxymethyl cellulose (CMC), guar gum, basil seed gum, karaya gum, tragacanth gum, locust bean, etc., lead to better quality noodles.

One hydrocolloid which is widely used in the manufacturing of gluten-free noodle is xanthan gum. It requires only small quantity, less than 5%. Xanthan gum has the ability to bind, thicken, bring better stability and extrudability to the noodles without changing their taste. Some studies have investigated the benefits of hydrocolloids in gluten-free noodles manufacturing. Parassih et al. (2020) investigated the effect of two hydrocolloids on two types of cassava flours. Xanthan gum and Konjac Glucomannan were incorporated in addition to pea protein isolate to native cassava and pregelatinized cassava flour. Xanthan gum gave better properties to the noodles obtained compared to konjac glucomannan. The optimal formulation was pregelatinized cassava flour + 2% xanthan gum + 4% protein isolate. The control was wheat flour without any additives. Another example of incorporating xanthan gum was made by (Acosta. et al., 2018) with noodles made from cassava bran (10, 20 and 30%) and xanthan gum in a proportion of 0.5, 1 and 1.5%. Though increase of cassava bran reduced the acceptance of the pasta, addition of xanthan gum improved its sensory properties. The best formulation was found to be 20% cassava bran and 1.5% xanthan gum.

2.4.4.2. Emulsifier

Emulsifiers improve rheological properties of a gluten-free dough by decreasing stickiness, and enhancing positive properties such as elasticity and plasticity (Kosiński & Cacak-Pietrzak, 2020). Common emulsifiers used for gluten-free pasta and bread are lecithins, mono- and diglycerides of fatty acids, soy and sunflower lecithin (Nunes et al., 2009, Kosiński & Cacak-Pietrzak, 2020). Emulsifiers form complex structure with starch and prevent enzymatic hydrolysis. They have similar properties as hydrocolloids and reduce cooking loss. Kosiński & Cacak-Pietrzak (2020) confirmed these statements when comparing commercial gluten-free pasta to conventional wheat pasta. The authors observed that pasta from maize and rice flours with emulsifiers were comparable to wheat pasta in having lowest cooking loss compared to pasta samples without emulsifier.

2.4.4.3. Mineral salts

Al-Baarri et al. (2022) researched the effect of mineral salts on cassava noodles by using a combination of potassium chloride (KCl) and magnesium chloride (MgCl). They compared based on the color and salinity three noodles' formulations: noodles with wheat flour, wheat flour + mocaf (MF), mocaf with mineral salt (MFM). The addition of mineral salts improved the texture and brightened the color and salinity of all the noodles and particularly increased the acceptability of MFM noodles. Alkaline salts can be used as artificial gluten as they help the texture become chewy and can induce elasticity due to its ability to form a gel-like structure in the dough (Al-Baarri et al., 2022). Alkaline salts (bicarbonate mixed with carbonate salt or sodium carbonate) at 0.5-1.5% improved the tensile strength of wheat noodles, hardness and chewiness (Li et al., 2018). However, there are few studies including alkaline salts in gluten-free-noodles and cassava noodles in particular, therefore further research is needed in this area.

2.4.5. Drying conditions

Drying reduces noodles moisture content to 11-12% to extend their shelf life for up to two years. If conducted properly drying can impact positively pasta and noodles firmness and reduce stickiness and cooking loss (Ahmed et al. 2024). Inversely, wrong drying method can bring cracks and uneven texture to the noodles with stickiness and breakage during cooking (Ahmed et al. 2024). The drying conditions particularly temperature affect gluten-free products (Martí & Pagani, 2013). Multiple stages of noodles/pasta drying have been identified by Ahmed et al. (2024): surface drying, pre-drying, resting stage, final drying. After final drying, pasta is cooled at ambient temperature before packaging. Pasta can be dried at low (<60°C), high (60°C-80°C) or ultra-high temperature (80°C-120°C). Some studies have concluded that high temperatures give the best pasta/noodles quality. For instance, cassava-based noodles were dried using a cabinet dryer at a temperature of 65-75°C for 2-3 hours (Pato et al., 2016). Nonetheless the majority of studies on cassava noodles have used mild to low temperature for cassava noodles. This may also be related to rapid browning of the noodles strands when submitted to high temperatures. Two drying temperatures (45 °C and 35 °C) were investigated by Milde et al. (2021) with good results on a cassava-corn based pasta (80:20) fortified with egg albumen. Purwandari et al. (2014) dried fermented cassava flour noodles in a cabinet drier at 55 °C until dried. Mocaf flour, wheat flour, and *latoh* flour were combined in a basin and mixed with water at a dry matter-to-water ratio of 1:0.3 (m/v). These wet noodles were subsequently dried for 12 hours at 50°C.

3. CONCLUSIONS

Interest is rising about substituting wheat flour to produce noodles and pasta. Although cassava starch and flour are used in many food products, their utilization in manufacturing noodles is limited. This review indicated that pregelatinized cassava flour and starch is the best material to use for cassava noodles with extrusion cooking method and addition of additives such as hydrocolloids and emulsifiers. There could be good potential to use salts and alkaline salts to improve the quality. Though cassava is poor in proteins and certain nutrients, research is ongoing to improve their resultant noodles' nutritional characteristics through composite flour from other cereals, roots and tubers, legumes, pseudo cereals, and plant leaves. Research towards the improvement of genotypes of cassava is also of importance to increase the amylose/amylopectin ratio and biofortification of the cassava roots in vitamins and minerals to provide better quality and nutritious derivative products.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

REFERENCES

- Abdullah, A. H. D., Chalimah, S., Primadona, I., & Hanantyo, M. H. G. (2018). Physical and chemical properties of corn, cassava, and potato starches. *IOP Conference Series: Earth and Environmental Science*, 160, 012003. <https://doi.org/10.1088/1755-1315/160/1/012003>
- Abidin, A. Z., & Adeline, A. (2013). Development of Wet Noodles Based on Cassava Flour. *Journal of Engineering and Technological Sciences*, 45(1), 97–111. <https://doi.org/10.5614/j.eng.technol.sci.2013.45.1.7>
- Adebowale, K. O., & Lawal, O. S. (2002). Effect of annealing and heat moisture conditioning on the physicochemical characteristics of Bambarra groundnut (*Voandzeia subterranea*) starch. *Nahrung/Food*, 46(5), 311–316. [https://doi.org/10.1002/1521-3803\(20020901\)46:5<311::AID-FOOD311>3.0.CO;2-Z](https://doi.org/10.1002/1521-3803(20020901)46:5<311::AID-FOOD311>3.0.CO;2-Z)
- Adetola, O. A., Olukunle, O. J., & Adedeji, A. A. (2020). Effect of extrusion conditions on pasta quality from wheat flour and cassava starch. *2020 ASABE Annual International Virtual Meeting, July 13-15, 2020*. 2020 ASABE Annual International Virtual Meeting, July 13-15, 2020. <https://doi.org/10.13031/aim.202000202>
- Ahmed, I., Qazi, I. M., Li, Z., & Ullah, J. (2016). Rice Noodles: Materials, Processing and Quality Evaluation: Rice Noodles: Materials, Processing and Quality Evaluation. *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences*, 53(3), 215–238.
- Ahmed, M. W., Jothi, J. S., Saifullah, M., Hannan, Md. A., & Mohibullah, Md. (2024). Impact of drying temperature on textural, cooking quality, and microstructure of gluten-free pasta. In *Development of Gluten-Free Pasta* (pp. 65–110). Elsevier. <https://doi.org/10.1016/B978-0-443-13238-4.00010-1>
- Akindahunsi, A. A., Oboh, G., & Oshodi, A. A. (1999). Effect of fermenting cassava with *Rhizopus oryzae* on the chemical composition of its flour and gari products. *Rivista Italiana Delle Sostanze Grasse*, 76.
- Akonor, P. T., Tortoe, C., Buckman, E. S., & Hagan, L. (2017). Proximate composition and sensory evaluation of root and tuber composite flour noodles. *Cogent Food & Agriculture*, 3(1), 1292586. <https://doi.org/10.1080/23311932.2017.1292586>
- Al-Baarri, A. N., Widayat, Aulia, R., Prahasiwi, E. K., Mawarid, A. A., Pangestika, W., & Lestari, F. P. (2021). The hardness analysis of noodles made from modified cassava flour,

spirulina (*Spirulina platensis*) and basil leaves extract (*Ocimum sanctum* L.). *IOP Conference Series: Earth and Environmental Science*, 653(1), 012051. <https://doi.org/10.1088/1755-1315/653/1/012051>

Al-Baarri, A. N., Widayat, Legowo, A. M., Mawarid, A. A., Dewanti, A., Zain, N. D. J., Rohma, Z. A., Lestari, F. P., & Pangestika, W. (2022). The Visible Characteristic of Modified Cassava Flour-Noodle after Treatment with Mineral Salt. *IOP Conference Series: Earth and Environmental Science*, 1024(1), 012048. <https://doi.org/10.1088/1755-1315/1024/1/012048>

Aldentee. (2024). <https://www.instagram.com/aldenteeee/>

Cappelli, A., Bettaccini, L., & Cini, E. (2020). The kneading process: A systematic review of the effects on dough rheology and resulting bread characteristics, including improvement strategies. *Trends in Food Science & Technology*, 104, 91–101. <https://doi.org/10.1016/j.tifs.2020.08.008>

Chisenga, S. M., Workneh, T. S., Bultosa, G., & Alimi, B. A. (2019). Progress in research and applications of cassava flour and starch: A review. *Journal of Food Science and Technology*, 56(6), 2799–2813. <https://doi.org/10.1007/s13197-019-03814-6>

Chus. (2024). <https://chus.vn/cassava-noodles-250g/>

Dunno, K., Cooksey, K., Gerard, P., Thomas, R., & Whiteside, W. (2016). The effects of transportation hazards on shelf life of packaged potato chips. *Food Packaging and Shelf Life*, 8, 9–13. <https://doi.org/10.1016/j.fpsl.2016.02.003>

Duodu, K. G., & Taylor, J. R. N. (2012). The quality of breads made with non-wheat flours. In *Breadmaking* (pp. 754–782). Elsevier. <https://doi.org/10.1533/9780857095695.4.754>

FAO/WHO. (1991). *Pesticide residues in food. Part-I - Residues. Joint FAO/WHO Meeting on Pesticide Residues. FAO Plant Production and Protection Paper 113/1.*

Feyisa, A. S. (2021). Current Status, Opportunities, and Constraints of Cassava Production in Ethiopia-A Review. *Journal of Agriculture and Food Research*, 11(5), 51.

Fiorda, F. A., Soares Júnior, M. S., Da Silva, F. A., Souto, L. R. F., & Grosmann, M. V. E. (2013). Amaranth flour, cassava starch and cassava bagasse in the production of gluten-free pasta: Technological and sensory aspects. *International Journal of Food Science & Technology*, 48(9), 1977–1984. <https://doi.org/10.1111/ijfs.12179>

Fu, B. X. (2008). Asian noodles: History, classification, raw materials, and processing. *Food Research International*, 41(9), 888–902. <https://doi.org/10.1016/j.foodres.2007.11.007>

Giménez, M. A., González, R. J., Wagner, J., Torres, R., Lobo, M. O., & Samman, N. C. (2013). Effect of extrusion conditions on physicochemical and sensorial properties of corn-broad beans (*Vicia faba*) spaghetti type pasta. *Food Chemistry*, 136(2), 538–545. <https://doi.org/10.1016/j.foodchem.2012.08.068>

Gunawan, S., Widjaja, T., Zullaikah, S., Ernawati, L., Istianah, N., Apamarta, H. W., & Prasetyoko, D. (2015). Effect of fermenting cassava with *Lactobacillus plantarum*, *Saccharomyces cerevisiae*, and *Rhizopus oryzae* on the chemical composition of their flour. *International Food Research Journal*, 22(3), p1280.

Hager, A. S., Zannini, E., & Arendt, E. K. (2012). Advances in research and commercialization. *Cereal Foods World*, 57((5)), 225-229. <http://dx.doi.org/10.1094/CFW-57-5-0225>

Hamidah, R. S., Sadek, N. F., & Murwani, I. A. (2023). Physicochemical and organoleptic characterization of dried tapioca noodles with sorghum-moringa substitution. *IOP Conference Series: Earth and Environmental Science*, 1241(1), 012089. <https://doi.org/10.1088/1755-1315/1241/1/012089>

Hou, G., Kruk, M., & Center, W. (1998). *Asian noodle technology. Technical Bulletin*. 20(12), 1–10.

Kamsiati, E., Widowati, S., & Herawati, H. (2022). Utilization of Porang Flour for Producing Tapioca Based Gluten-Free Noodles and Characteristics of the Product. *IOP Conference Series: Earth and Environmental Science*, 1024(1), 012024. <https://doi.org/10.1088/1755-1315/1024/1/012024>

Kosiński, J., & Cacak-Pietrzak, G. (2020). Estimation of quality of spaghetti-form commercial gluten-free pastas. *Acta Agrophysica*, 27, 5–16. <https://doi.org/10.31545/aagr/125721>

Lawal, O. M., Talsma, E. F., Bakker, E., Fogliano, V., & Linnemann, A. R. (2021). Novel application of biofortified crops: Consumer acceptance of pasta from yellow cassava and leafy vegetables. *Journal of the Science of Food and Agriculture*, 101(14), 6027–6035. <https://doi.org/10.1002/jsfa.11259>

Lestari, D., Liandro, Y., Ang, E., & Kresnowati, M. T. A. P. (2019). Shelf-life Evaluation of Packaged Fermented Cassava Flour. *Journal of Engineering and Technological Sciences*, 51(1), 64–82. <https://doi.org/10.5614/j.eng.technol.sci.2019.51.1.5>

Li, C., You, Y., Chen, D., Gu, Z., Zhang, Y., Holler, T. P., Ban, X., Hong, Y., Cheng, L., & Li, Z. (2021). A systematic review of rice noodles: Raw material, processing method and quality improvement. *Trends in Food Science & Technology*, 107, 389–400. <https://doi.org/10.1016/j.tifs.2020.11.009>

Li, M., Sun, Q.-J., Han, C.-W., Chen, H.-H., & Tang, W.-T. (2018). Comparative study of the quality characteristics of fresh noodles with regular salt and alkali and the underlying mechanisms. *Food Chemistry*, 246, 335–342. <https://doi.org/10.1016/j.foodchem.2017.11.020>

Liu, C., Zhang, Y., Liu, W., Wan, J., Wang, W., Wu, L., Zuo, N., Zhou, Y., & Yin, Z. (2011). Preparation, physicochemical and texture properties of texturized rice produce by Improved Extrusion Cooking Technology. *Journal of Cereal Science*, 54(3), 473–480. <https://doi.org/10.1016/j.jcs.2011.09.001>

Lu, Z., Li, L., Min, W., Wang, F., & Tatsumi, E. (2005). The effects of natural fermentation on the physical properties of rice flour and the rheological characteristics of rice noodles. *International Journal of Food Science & Technology*, 40(9), 985–992. <https://doi.org/10.1111/j.1365-2621.2005.01032.x>

Marti, A., & Pagani, M. A. (2013). What can play the role of gluten in gluten free pasta? *Trends in Food Science & Technology*, 31(1), 63–71. <https://doi.org/10.1016/j.tifs.2013.03.001>

Marti, A., Seetharaman, K., & Pagani, M. A. (2010). Rice-based pasta: A comparison between conventional pasta-making and extrusion-cooking. *Journal of Cereal Science*, 52(3), 404–409. <https://doi.org/10.1016/j.jcs.2010.07.002>

Mathobo, V. M., Silungwe, H., Ramashia, S. E., & Anyasi, T. A. (2021). Effects of heat-moisture treatment on the thermal, functional properties and composition of cereal, legume and tuber starches—A review. *Journal of Food Science and Technology*, 58(2), 412–426. <https://doi.org/10.1007/s13197-020-04520-4>

Mbanjo, E. G. N., Rabbi, I. Y., Ferguson, M. E., Kayondo, S. I., Eng, N. H., Tripathi, L., Kulakow, P., & Egesi, C. (2021). Technological Innovations for Improving Cassava Production in Sub-Saharan Africa. *Frontiers in Genetics*, 11, 623736. <https://doi.org/10.3389/fgene.2020.623736>

Milde, L. B., Rivero, D. A., Chigal, P. S., Zubreski, E., Chade, M., & Brumovsky, L. A. (2021). Changes in the physical, textural and chemical properties of the enriched pasta elaborated with cassava starch. *International Journal of Gastronomy and Food Science*, 25, 100396. <https://doi.org/10.1016/j.ijgfs.2021.100396>

Natura Market. (2024). <https://ringnaturshop.com/en/produkt/jovial-getreidefreie-cassava-spaghetti/>

Nunes, M. H. B., Moore, M. M., Ryan, L. A., & Arendt, E. K. (2009). Moore, M. M., Ryan, L. A., & Arendt, E. K. (2009). Impact of emulsifiers on the quality and rheological properties of gluten-free breads and batters. *European Food Research and Technology*, 228, 633–642.

Obadi, M., & Xu, B. (2021). Review on the physicochemical properties, modifications, and applications of starches and its common modified forms used in noodle products. *Food Hydrocolloids*, 112, 106286. <https://doi.org/10.1016/j.foodhyd.2020.106286>

Oh, S. M., Kim, H. Y., Bae, J. E., Ye, S. J., Kim, B. Y., Choi, H. D., & Baik, M. Y. (2019). Physicochemical and retrogradation properties of modified chestnut starches. *Food Science and Biotechnology*, 28, 1723–1731.

Padalino, L., Conte, A., & Del Nobile, M. (2016). Overview on the General Approaches to Improve Gluten-Free Pasta and Bread. *Foods*, 5(4), 87. <https://doi.org/10.3390/foods5040087>

Parassih, E. K., Purwani, E. Y., & El Kiyat, W. (2020). Optimization of cassava dried noodle using hydrocolloid and protein isolates: A tropical noodle. 8(4), 1–9. <https://doi.org/10.17170/KOBRA-202010131943>

Pato, U., Isnaini, R. F., & Dira, D. M. (2016). The Quality of Instant Noodle Made from Local Corn Flour and Tapioca Flour. *Journal of Advanced Agricultural Technologies*, 3(2), 118–123. <https://doi.org/10.18178/joaat.3.2.118-123>

Prema, R. S., Abirami, A., Nandhini, R., & Kumar, G. R. (2018). Optimization of ingredients composition of non wheat pasta based on cooking quality using response surface methodology (RSM). *Asian Journal of Dairy and Food Research*, 37(3), 227–231. <https://doi.org/10.18805/ajdfr.DR-1331>

Purwadi, R., Teguh, C. F., & Mazaya, D. (2021). Fermented cassava as an alternative flour for pasta noodle. *IOP Conference Series: Materials Science and Engineering*, 1143(1), 012042. <https://doi.org/10.1088/1757-899X/1143/1/012042>

Purwandari, U., Hidayati, D., Tamam, B., & Arifin, S. (2014). Gluten-free noodle made from gathotan (an Indonesian fungal fermented cassava) flour: Cooking quality, textural, and sensory properties. *International Food Research Journal*, 21(4), 1615–1621.

Rachman, A., Brennan, M. A., Morton, J., & Brennan, C. S. (2020). Gluten-free pasta production from banana and cassava flours with egg white protein and soy protein addition. *International Journal of Food Science & Technology*, 55(8), 3053–3060. <https://doi.org/10.1111/ijfs.14608>

Senanayake, S. M. C. N., Jayasinghe, M. A., Somendrika, M. A. D., Jayathilake, C., & Dyabalanage, R. S. (2024). Cassava Flour as a Possible Replacement for Wheat Flour: A Comprehensive Review Considering the Sri Lankan Scenario. *Vidyodaya Journal of Science*, 27(01), 63–78.

Seveline, S., Kurniawati, Siti, & HELDYANA, Riskya. (2020). The Use of Three Species of Lactic Acid Bacteria in the Mocaf (Modified Cassava Flour) Production. *Industria: Jurnal Teknologi Dan Manajemen Agroindustri*, 9(3), 163–172. <https://doi.org/10.21776/ub.industria.2020.009.03.1>

Shahbandeh, M. (2023). *Global-Leading-Cassava-Producing-Countries/Leading Cassava Producing Countries Worldwide in 2021*. <https://www.statista.com/statistics/1391572/global-leading-cassava-producing-countries/>

Silvana Beatriz Sabbatini, Hugo Diego Sánchez, María Adela de la Torre, & Carlos Alberto Osella. (2015). Influence of Raw Materials Rich in Proteins on the Quality of Gluten-Free Noodles. *International Journal of Nutrition and Food Sciences*, 4(2), 169. <https://doi.org/10.11648/j.ijnfs.20150402.17>

Singh, J., Kaur, L., & McCarthy, O. J. (2007). Factors influencing the physico-chemical, morphological, thermal and rheological properties of some chemically modified starches for food applications—A review. *Food Hydrocolloids*, 21(1), 1–22. <https://doi.org/10.1016/j.foodhyd.2006.02.006>

Souza, V. G. L., & Fernando, A. L. (2016). Nanoparticles in food packaging: Biodegradability and potential migration to food—A review. *Food Packaging and Shelf Life*, 8, 63–70. <https://doi.org/10.1016/j.fpsl.2016.04.001>

Stanislaus, O. O. (2014). *Processing of fresh cassava tubers into instant noodle food (Doctoral dissertation, Bachelor's Thesis, University of Benin, Benin City, Nigeria)*.

Sulistyo, J. & kahara, K. (2013). Cassava flour modification by microorganism. *In The 1st International Symposium on Microbial Technology for Food and Energy.*, 10(2.1), 3702–4966.

- Tan, H.-Z., Li, Z.-G., & Tan, B. (2009). Starch noodles: History, classification, materials, processing, structure, nutrition, quality evaluating and improving. *Food Research International*, 42(5–6), 551–576. <https://doi.org/10.1016/j.foodres.2009.02.015>
- Theresa, A., Christopher, O., Nuria, N., & Mary, I. (2020). Production and evaluation of pasta using two varieties of cassava flour enriched with African Yam Bean. *American Journal of Food and Nutrition*, 8(2), 37–39.
- Violalita, F., Evawati, Syahrul, S., Yanti, H. F., & Fahmy, K. (2020). Characteristics of Gluten-Free Wet Noodles Substituted with Soy Flour. *IOP Conference Series: Earth and Environmental Science*, 515(1), 012047. <https://doi.org/10.1088/1755-1315/515/1/012047>
- Wang, N., Bhirud, P. R., Sosulski, F. W., & Tyler, R. T. (1999). Pasta-Like Product from Pea Flour by Twin-Screw Extrusion. *Journal of Food Science*, 64(4), 671–678. <https://doi.org/10.1111/j.1365-2621.1999.tb15108.x>
- Wang, N., Maximiuk, L., & 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>
- Witczak, M., Ziobro, R., Juszcak, L., & Korus, J. (2016). Starch and starch derivatives in gluten-free systems – A review. *Journal of Cereal Science*, 67, 46–57. <https://doi.org/10.1016/j.jcs.2015.07.007>
- Wolf, B. (2010). Polysaccharide functionality through extrusion processing. *Current Opinion in Colloid & Interface Science*, 15(1–2), 50–54. <https://doi.org/10.1016/j.cocis.2009.11.011>