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UTILIZATION OF DIOSCOREA TUBER IN SELF RISING STARCH: A REVIEW

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Abstract. *Self-rising starch is a development product of self-rising flour. This product appear to minimize the process, especially in the salt and leavening agent weighing stage so that it will minimize the time in the serving. Self-rising flour is generally made from wheat flour. For some people, due to medical considerations, they cannot consume this product, and based on research results, gluten contained in wheat flour or wheat is a trigger for type 1 diabetes. This causes Indonesia to be ranked fifth in the world for diabetes. Therefore, one way to overcome this problem is by utilizing raw materials originating from Indonesia, namely tubers. Indonesia has a variety of tubers, but some of these tubers have not been explored at all. These tubers not only function as carbohydrates but also contain bioactive compounds and functional value such as Water Soluble Polysaccharides (WSP), diosgenin, inulin, glycemic index and so on so that they will add to the functional properties of the starch produced. The tubers that have not been cultivated are the genus Dioscorea. The tubers included in dioscorea are uwi, gembili, gadung, tomberoso and jebubuk. All of these tubers are a source of carbohydrates. Uwi, gembili and gadung are tubers that have been cultivated by the community, but tomberoso and jebubuk are tubers that grow wild in the forest so that they only become the food for wild animals in the forest. Starch from disccorea tubers can be used as self rising starch because these tubers have the property to be developed. This tuber, in addition to containing high carbohydrates, also has bioactive compound. Therefore, it is healthier to consume*

Keywords: *self rising flour; dioscorea; starch; biocative compound*

1. Introduction

Self-rising starch is a product that comes from self-rising flour. The difference is that the raw materials used are self-rising starch from starch, while self-rising flour with raw materials comes from flour. Starch and flour are two very different raw materials even though they are made from the same material. According to Wang et al., (2020) basically, flour comes from sliced materials such as tubers which have been dried at a temperature of 40ºC and by using 100 mesh sieves, while starch comes from the extraction of materials that have undergone a crushing process by using a blender first, precipitation and by drying it at the temperature of 50ºC for 48 hours. The last process is crushing by using a blender (Behera, 2022).

This self rising flour arises because the current activities are very dense so that it requires a product that is practical and minimal in the presentation process. This product is a solution that can be used in various foods such as cakes, cookies and so on. Currently, many self-rising flours

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have sprung up on the market and can even be self-made. More research on self-rising flour need to been done. What has been done so far is indeed the type of wheat flour that is widely used (Singh et al., 2017; Tejinder et al., 2015; Ma & Baik, 2018; Guo et al., 2016; Aguirre et al., 2021; Chowdhury, 2018; Chikpah et al., 2021) thus , the flour is now almost used in all kinds of foods products.

Some people, because of health considerations, can not consume gluten from wheat flour which is called celiac (gluten intolerance). Celiac disease includes gastrointestinal symptoms, non-gastrointestinal symptoms, or no symptoms. The classic symptoms associated with the gastrointestinal tract include diarrhea, steatorrhea, and weight loss due to malabsorption. Prevention can be done by having a strict gluten-free diet for life (GFD) is the solution to lead to symptom improvement and recovery (Lebwohl, et al, 2018).

In addition, gluten has also been identified as a trigger for the type 1 diabetes and diabetes mellitus, which keep increasing in Indonesia (Marietta et al, 2013; Slidorf et al., 2012). According to the International Diabetes Federation (IDF) (2021) around 19.46 million people in Indonesia suffer from this disease. There is an increase of 81.8% compared to 2019. Indonesia is the country with the fifth highest diabetes in the world (after China, India, Pakistan and the United States) and Indonesia is the only one in Southeast Asia that is included in the top 10 countries with the most cases.

Research on self-rising flour has been carried out (Nugraheni et al., 2017) which carried out the functional manufacture of self rising flour in arrowroot flour that has undergone type 3 resistant starch and then mixed with composite flour. Observations made were the proximate value of self-rising flour and testing on experimental animals. Therefore, the there is an idea to utilize other carbohydrate sources which are domestic potentials in the form of starch from tubers.

Tuber is one type of local food that is widely available in Indonesia which can be used to support national food security. Local food ingredients are not only available in large quantities but also have a high productivity value and good nutritional content. Therefore, increasing the contribution of root crops as an alternative food source to meet the need for healthy food can have a significant effect on food security. Tubers also have functional values including resistant starch, inulin, anthocyanins, glucomannans, and low glycemic index (Hatmi & Djaafar, 2014). One type of tuber that has not been widely used is discorea. These tubers grow wild and are easy to cultivate. According to Padhan et al., (2020) some of these wild species of discorea have a better nutritional composition such as carbohydrates, protein and fiber, including high content of mineral. Anti-nutrient compounds such as diosgenin, amylase and trypsin-inhibitors are also significantly high in some wild dioscorea species. According to Purnomo et al., (2008) there are several types of dioscorea tubers, namely: uwi, gembili, gadung, tomboreso, jebubuk.

The use of dioscorea tubers, especially in self rising starch products, can increase the economic value. These tubers are known broadly and more people are interested in cultivating them because of the bioactive compounds and functional values. This article will discuss in more detail about self rising flour, dioscorea tubers and leavening agent.

2. *Self-Rising Flour*

According to Tejinder, et al., (2015) self-rising flour is flour that contains a leavening agents such as bicarbonate and when made into dough and baked produces CO_2 due to the aeration process and dough expansion which has a beneficial effect on the taste, texture and color of the product. One of the advantages of self-rising flour is that it has a high ash level, and shows a high mineral level (Nugraheni, et al., 2017). Self rising flour provides convenience to users because it can save time and energy so that it can eliminate difficulties in measuring and provide the desired quality for the product (Tejinder et al, 2015).

Self rising flour is strongly influenced by storage conditions, therefore it must be considered to maintain its quality which will affect the resulting product. The shelf life of self rising flour is 3 months if stored at low temperatures with acceptable microbiological quality. This flour with different yeast but still contains calcium phosphate will produce high quality cookies, muffins and cakes after 3 months of storage compared to fresh flour (plain flour) which has been stored for 1 and 2 months (Singh et al., 2017).

During the storage of self rising flour, changes occur directly which will affect the baking process and the rheological characteristics of the dough. During storage, flour aging occurs naturally (Miranda-Garcia, 2013). This occurs due to the oxidation of flour components including fatty acids and proteins (Cenkowski et al., 2000). Several factors that affect flour maturation are temperature, time, humidity, relative humidity (RH), packaging materials and microbial activity including storage environment which are very important factors in flour aging (Wang & Flores, 1999).

3. Dioscorea tubers

The tubers used in this self-rising starch are of the dioscorea group because they contain bioactive compounds and functional value, so that the produced starch is more valuable. According to Mignouna (2009) tubers of the dioscorea species are categorized as understudied and underutilized tubers. About 600 species of the dioscorea family have been identified from various origins, both tropical and subtropical. In general, Dioscorea are vines, (Kamaruddin et al., 2020, Nasriyah et al., 2011). Dioscorea contains about 75-84% starch including small compounds such as proteins, vitamins, lipids and minerals (Shajeela, 2011). The active compounds in Dioscorea,

such as steroidal sapogenins, glycans, alkaloids, tannins and saponins give the characteristic of spicy and bitter taste (Prakash et al., 2014).

The nutritional content of dioscorea is 25% starch, 0.1 - 0.3% fat and 1.3 - 2.8% protein so that it has the potential to produce carbohydrates. Dioscorea tubers also contain inulin which can function as a prebiotic (Winarti et al, 2011). Inulin is a polymer of fructose units with a terminal group of glucose. The fructose units in inulin are linked by (2-1) glycosidic bonds, so they cannot be digested by enzymes in the mammalian digestive system and reach the large intestine without undergoing structural changes, therefore inulin can function as a prebiotic (Robertfroid, 2005). The inulin contained in dioscorea tubers is quite high, between 2.88-14.77% and the highest inulin content is in dioscorea esculenta (gembili) tubers (Winarti et al., 2011).

3.1 *Uwi* (*Dioscorea alata*)

Uwi is a prospective local food plant and can be used as a source of functional food. These tubers, apart from being high in carbohydrates, also contain protein but low in sugar (Lebot et al., 2006). According to Senanayake et al., (2012), the chemical composition of *uwi* includes carbohydrates 86.81%, protein 2.10%, lipids 0.43% and ash content 0.33%.

According to Hsu et al., (2006) suggested that consumption *uwi* is beneficial for intestinal microflora health and as an antioxidant. *Uwi* has antioxidant content equivalent to or higher than 100 g BHA (butylhydroxyanisole) and -tocopherol (Lubag et al., 2008). *Uwi* starch granules have a size distribution between 6-100 μm (Peroni et al., 2006; Riley et al., 2006; Yeh et al., 2009) for this fairly large size range, the effect of granule size on physical and chemical characteristics is unknown. Chemistry of *uwi* starch, as well as its relationship to the functional properties of starch (Nadia et al., 2013). According to Chiranthika (2022) the shape of starch granules from Dioscorea alata tubers is round. The fiber and resistant starch content in this tuber were 6.83% and 4.65 g/100 g dry weight . Below you can see the shape of the starch granules of yam tubers using SEM (Scanning Electron Microscope) (fig.1).

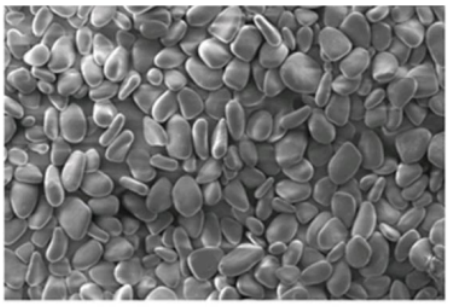


Figure 1. Form of starch granule Discorea alata magnification 300X with SEM (Oliveira et al., 2021)

3.2 Gembili (*Dioscorea esculenta*)

Although it has not been done in a larger scale, gembili has become the tuber of the Dioscorea genus that has been cultivated for years by rural people (Prabowo et al., 2014). The largest nutrinet component of gembili tubers is carbohydrates by 21.44% (Richana and Sunarti, 2004). Gembili also contains bioactive compounds that are beneficial for health, namely water-soluble polysaccharides, dietary fiber, diosgenin and inulin. WSP from the Dioscorea group contains polysaccharides, especially glucomannan, with a molecular weight between 200,000-2,000,000. Glucomannan is a hydrocolloid polysaccharide. Glucomannan is composed of D-mannose and D-glucose units in a ratio of 1.6 : 1 which are linked together in -1,4 bonds. Glucomannan has some special physical properties, including the development of glucomannan in water can reach 138-200% and occurs quickly (starch only expands 25%) (Ha et al., 2000). The fiber and resistant starch content of Discorea esculenta are 38.42% and 9.54% in dry weight. Fiber and resistant starch are very beneficial for health, especially for the digestion (Chiranthika et al, 2022).

Diosgenin is a class of natural saponins found in nuts and tubers of the Dioscorea sp. Diosgenin is a precursor of various synthetic steroids that are widely used in the pharmaceutical industry (Raju & Rao, 2012). Several studies have found that diosgenin can be absorbed through the intestines, plays an important role in regulating cholesterol metabolism, reduces the risk of heart disease, especially lung cancer and blood cancer (Okwu & Ndu, 2006), has esterogenic and anti-tumor effects (Moalic et al, 2001).

Inulin can function as a soluble fiber that can reduce blood cholesterol levels (Nasar et al., 2013). Gembili also contains oligosaccharides namely lactulose, inulin and raffinose by 0.231%, 2.541%, and 1.485%, respectively. Oligosaccharides can act as prebiotics and support probiotics with optimal prebiotic index at 24 hours incubation time (Khasanah et al, 2019). According to Prabowo et al (2014) starch from gembili tuber granules with a polygonal shape is 0.75% (Chiranthika et al., 2022). Its size is smaller than the tubers of canna, suweg, and coconut sweet potatoes. The shape of starch granules can be seen in Figure 2.

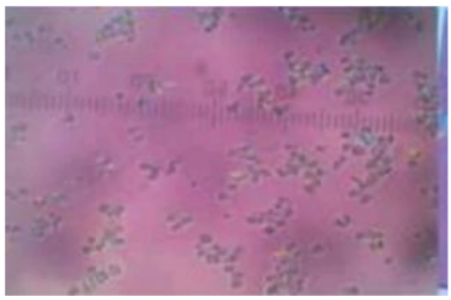
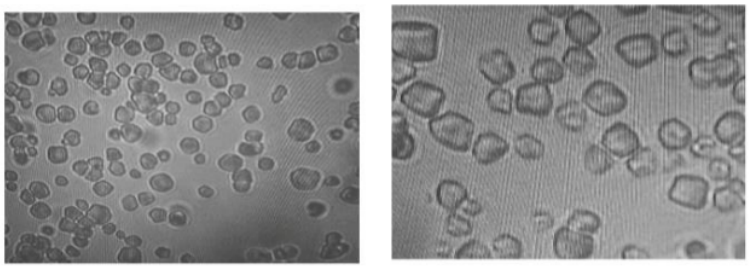


Figure 2. Gembili starch granules at 400 X magnification
(Richana & Sunarti, 2004)

3.3 Gadung *(Dioscorea hispida)*

Gadung contains quite high carbohydrates, about 18 g in every 100 g of wheat tubers (Pambayun, 2008). The starch value of gadung tubers is 38.80% with amylose starch content of 8.92% while the starch granule size of gadung starch is 4.32-4.25 μm (Santoso, 2015). Dioscorea hispida tubers contain dioscorine which can cause poisoning to humans if consumed with symptoms ranging from vomiting, nausea, stomach pain, and health complications (Gunawan et al. 2019). Dioscorine is an alkaloid compound that is soluble in deep water and has the molecular formula $C_{13}H_{19}O_2N$. The toxic in gadung must be removed before being consumed (Irmayadani et al., 2019). Dioscorea hispida tubers are natural fibers with abundant starch sources and it contain lignin, cellulose, hemicellulose, and fiber (Hamid et al., 2019). The process of reducing the amount of dioscorine toxic in Dioscorea hispida can be carried out by immersion in sodium chloride or distilled water (Kresnadipayana & Waty 2019).

Dioscorin is a protein found in the tubers of tropical plants of the family Dioscorea spp. Dioscorin functions as a protein reserve in yam tubers (Hou et al., 1999). Diosgenin is a major precursor in the production of synthetic steroids in the pharmaceutical industry. The biological activities of diosgenin and other steroidal saponins and alkaloids have been tested in vitro. The anti-cancer bioactivity of diosgenin is related to the presence of hetero-sugar bonds and 5,6-double bonds in its structure. The structural conformation at C-5 and C-25 carbon atoms also plays an important role in the biological activity of diosgenin (Raju & Rao, 2012). The shape of gadung starch granules can be seen in Figure 3.



(a) (b)

Figure 3. The shape of gadung starch granules with 1000X magnification a) before modification and b) after modification (Santoso et al., 2015)

3.4 Tomberoso *(Dioscorea pentaphylla L.)*

Discorea pentaphylla contains a lot of carbohydrates (85.65%) and little fat (0.03%) without fiber. This tuber has high carbohydrates with a lower amount of nitrogen which is an indicator that the extracted starch is pure and of good quality (Sharlina et al., 2017).

According to Lazim et al., (2021) the gelatinization temperature of starch from tomberoso tubers is 81.04 ± 0.02 °C and gelatinization will not occur below 76 °C. This type of tuber does not contain toxic so it can be used for the food and non-food industries. The amylose content in tomberoso starch is 64.10 ± 1.15% and amylopectin 35.90 ± 1.15%, respectively. The degree of crystallization of tomberoso tubers is 32.90 ± 2.59%. The starch granule shape of Dioscorea pentaphylla tubers is oval which represents 1.89 ± 0.44% starch content in it. Tomberoso tuber is a type of tuber that grows wild in the forest and is rarely used so it is eaten by wild animals (Maneenoon et al., 2008). The flesh of the tomberoso tuber is yellowish white and yellowish. Tomberoso tubers are a source of carbohydrates, and are used as a substitute for corn and sago, but it must be noted that before consuming these tubers, they must be processed first to neutralize cyanide acid (Purnomo et al., 2012). The shape of the tomeroso tuber granules can be seen in Figure 4.

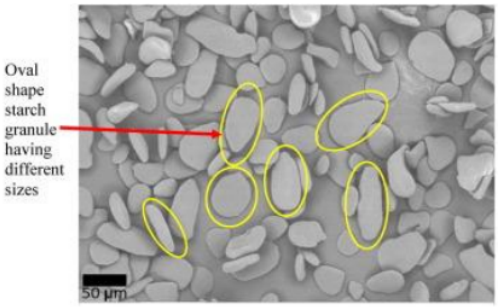


Figure 4. The form of starch granules from Discorea pentaphylla tubers (Lazim et al., 2021)

2.5 Jebubuk *(Discorea numularia)*

According to Purnomo et al., (2012) jebubuk tuber is a type of tuber that grows wild in the forest that has a variety of shapes. This powder is a source of carbohydrates and is also efficacious as a medicine. This jebubuk tuber is better but tastes a bit bitter. The chemical content of jebubuk tubers include water content 71.9%, energy 443 KJ, protein 2.04%, vitamin A 17 ug and Zn 0.5 mg (French, 2006). The percentage of dry matter is quite high, namely 33.11% and the starch content is 82.81% (Lebot et al., 2016). Dioscorea nummularia tuber starch the grains are triangular, sometimes oblong to ovoid, with a width-length ratio of 0.6 to 45 mm (Fullagar et al. 2006) (fig.5).

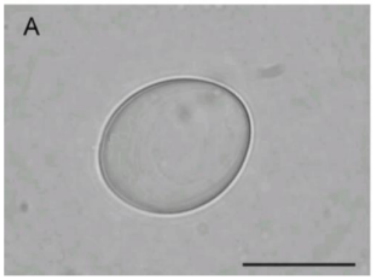


Figure 5. Starch grains from Discorea numularia with magnification bar scale : 20 m (Fullagar et al., 2006)

4. Leavening agents

The leavening agents used in self-rising flour is in the form of chemical yeast in the form of bicarbonate which is very useful during the baking process. According to Arepally et al., (2020) the addition of leavening agents to the dough will produce gases which are responsible for the development of the texture of the product during combustion. The most typical chemical leavening agents are baking powder (a mixture of sodium bicarbonate and acid), sodium pyrophosphate, sodium bicarbonate ($NaHCO_3$), and ammonium bicarbonate (NH_4HCO_3). The sodium bicarbonate dissolves and reacts with the acidulant in the dough and produces CO_2 as shown in Eq. (1).

$$2NaHCO_3 + H+ \rightarrow Na+ + CO_2 + H_2O \quad (1$$

The timing of CO_2 release is very important in establishing a uniform cell structure. When heated, the CO_2 is released and expands, which results in an increase in volume and the desired texture characteristics resulting in high quality baked goods. Some carbon dioxide carriers are used in baked goods. The three bicarbonates used as yeast bases are sodium bicarbonate ($NaHCO_3$), potassium bicarbonate ($KHCO_3$), and ammonium bicarbonate (NH_4HCO_3). Potassium and calcium carbonate (K_2CO_3 and $CaCO_3$) are also used (Brose & Becker, 2001).

In general, chemical yeast is considered as a process where CO_2 is introduced into a dough and then expands when heated. During baking, by the action of saturated steam from water and hot air, ammonia gas is also generated outside of carbon dioxide gas which plays an important role in the expansion of the dough during baking as it has been introduced during mixing. There are two basic types of chemical yeast decomposition and chemical neutralization. In decomposition, the chemical leavening agent is broken down in the presence of water or high temperatures and acquires a site to provide yeast gas to the system. In a neutralization system, the bicarbonate chemical is balanced in the presence of an acid such as calcium phosphoric acid. The combination of yeast acids such as calcium phosphoric acid with bicarbonate chemicals is very potential, especially to determine the rate and rate of reaction for optimal yeast effects. Acidic calcium phosphoric acid acts quickly when reacted with bicarbonate which will result in the release of as

much as 80% of yeast carbon dioxide gas during dough handling and proofing (Lajoie & Thomas, 1991).

Brose and Becker (2001) also reported that different chemical leavening agents helped improve product quality. The combination of different bicarbonates and acids with different acid levels will result in the release of yeast gas of different profiles which will be suitable for different bakery products. Product attributes such as color, taste, texture and overall acceptability are affected by the reaction between the leavening agents, acid and flour components. The choice of bicarbonate used, and the acid content can affect the physical and chemical characteristics of the product (Lajoie & Thomas, 1991; Lajoie & Thomas, 1994).

5. Conclusion

Self-rising starch is starch that has been added with developer and salt, and it is used for various foods to reduce the use of flour. Dioscorea is one of the tubers that can be used in the production of self rising starch because it has more benefits when consumed. Apart from being a source of carbohydrates, it but also contains bioactive compounds. Therefore, it is healthiert to consume. The bioactive compounds include Water Soluble Polysaccharides (WSP), low glycemic index, dioscorin, diosgenin and inulin. The leavening egent used in self-rising starch will aid in the development of product through heating. Leavening agents that can be used are Sodium bicarbonate, Potassium bicarbonate, Ammonium bicarbonate Potassium and Calcium carbonate.

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