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The effect of autoclaving method on sago starch as a functional food source: a review from a gastronomy perspective

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ABSTRACT

Starch is a carbohydrate that is a polymer of glucose, and consists of amylose and amylopectin. Starch is found abundantly in the gastrointestinal tract and is slightly fermented by the intestinal microflora. RS is often identified as a food starch that cannot be digested in the small intestine so that it functions properly for the health of the human body. This study aims to investigate the effect of autoclaving method on sago starch as a functional food source, with emphasis on gastronomic aspects. Through this approach, we can gain a more comprehensive understanding of the potential of sago starch in providing healthy and tasty food for consumers. This research method was carried out under the condition of modification of sago starch by autoclaving-cooling including modification cycles, among others: no cycle, one cycle, 2 cycles, and 3 cycles. The results showed T0 starch showed 1.26% and 3 cycles showed 5.62%. The best modification of RS starch is shown in the cycle process 3.

1. Introduction

Starch is a carbohydrate that is a polymer of glucose, and consists of amylose and amylopectin [1]. Most of the starch is stored in tubers (cassava, sweet potatoes, potatoes), seeds (corn, rice, wheat), stems (sorghum, oats) and fruits. In addition, starch is an important nutrient in everyday life, in the human body almost 80% of energy needs are met by carbohydrates. The use of natural starch is still very limited because its physical

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and chemical properties have not been widely used. Starch consists of at least three main components, amylose, amylopectin, and intermediates such as proteins and fats. In general, starch contains 15-30% amylose, 70, 85% amylopectin, and 5-10% intermediate. The structure and type of material of each starch source vary depending on the botanical characteristics of the starch source [2].

Starch will increase in economic value by modification physically, chemically or a combination of both [3]. Starch can be divided into two types, namely Natural Starch (Native Starch) and Modified Starch (Modified Starch). Natural starch is obtained from the separation of starch found in plants, both tubers, seeds and stems. In its original form, starch is naturally small grains that are often called granules. The shape and size of starch granules are characteristic of each type of starch, therefore it is used for identification. Starch modification aims to change the chemical or physical properties of starch naturally, namely by cutting the molecular structure, rearranging the molecular structure, oxidation, or substitution of chemical groups in starch molecules [4]. One type of modified starch is resistant starch (RS).

Resistant starch was first discovered by [5] and defined as a fraction of starch resistant to hydrolysis by digestive enzyme amylase and pulunase treatment in vitro. Starch is found abundantly in the gastrointestinal tract and is slightly fermented by the intestinal microflora. RS is often identified as a food starch that cannot be digested in the small intestine so that it functions properly for the health of the human body. RS has properties similar to dietary fiber, some are insoluble and some are soluble [6]. Some sources of carbohydrates such as sugars and starches can be quickly digested and absorbed in the small intestine in the form of glucose, which is then converted into energy.

Sago grows in tropical regions located at 10o North Latitude (N) and 10o South Latitude (LS) in Southeast Asia and Pacific Island countries k, with warm air temperatures around 29–32o C (minimum 15o C). Indonesia has the largest area where sago grows (area of wild and semi-cultivated sago stands), followed by PNG, Malaysia, Thailand, the Philippines, and Pacific Island countries with semi-cultivated sago stands. [7] mentions sago trees growing in brackish swamps and wet lowlands up to an altitude of 700 m above sea level. In brackish swamps, sago grows at the boundary of nipa groves that are resistant to high-salt marsh water. Sago trees can absorb large amounts of carbon dioxide (CO2) so that it can help reduce global warming. Sago trees can grow up to 20 m tall and store starch in their trunks. The area of sago trees can appear as natural sago tree forests and semi-cultivated sago trees in the southwest. Most of the sago area in Papua and West Papua is still low-yield natural sago forest. According to [8], sago plantation forests are found on the coast to locations at an altitude of 1000 m above sea level, on river banks, around lakes or swamps. In Indonesia, sago is not spread in large plantations, but rather on islands, making it difficult to document its distribution. In addition, the sago growing environment on the banks of rivers and swamps where puddles are quite deep, as well as the dense population in sago forests, make it difficult to collect data.

Sago is one of the staple foods commonly consumed by the people of Maluku and Papua. In addition to domestic consumption, Indonesian sago is widely exported to Asian countries in the form of flour and starch. To meet these needs, Indonesia is a large sago producing country. According to the Ministry of Agriculture, sago production in Indonesia will reach 367,132 tons in 2021. Sago is a plant that has minimal maintenance so that it can reduce production costs. According to [9] the net income of sago farmers in Luwu Regency averages Rp. 2,920,474/month and the R/C value is 5.46. This shows that sago planting is profitable and very appropriate to do.

The basis for consumer consideration in developed countries in determining food choices is not only based on nutritional content and taste but also the impact on body health [10]. This fact requires foodstuffs that no longer only meet the basic needs of the body (i.e. nutritious and tasty) but are also functional. This is where the concept of functional food was born which has recently been very popular among people around the world. Understanding functional food according to BPOM is natural or processed food that contains one or more compounds that based on scientific studies are considered to have certain physiological functions that are beneficial to health which are then consumed as food or beverages, have sensory characteristics in the form of appearance, color, texture and taste that can be accepted by consumers. In addition to providing no contraindications and no side effects in terms of recommended intake for the metabolism of other nutrients. The limited functional properties of natural starch also limit its use in food, which requires physical, chemical, and enzymatic starch modification or a combination of these methods [11]. One way of physically modifying starch to change starch properties is through intensive heating and cooling methods (autoclave and cooling). Physical changes are usually made by heating. This modification is relatively safe compared to other modifications because it does not use chemical reagents and does not leave any chemical residue. The autoclaving-cooling method or the so-called high-temperature heating-cooling technique can change the gelatinization characteristics of starch, namely increasing the gelatinization temperature, increasing the viscosity of starch paste, limiting swelling, increasing the stability of starch paste and increasing the tendency of starch to undergo retrogradation [12]. Resistant starch physiologically has health effects so that resistant starch can be used for the manufacture of functional foods.

Sago starch is a basic food that plays a vital role in a number of societies in the tropics, especially in the Pacific and Southeast Asia. In addition to being the main source of carbohydrates, sago starch also has potential as a source of functional food, which is a food that has additional health benefits in addition to basic nutrients. In an effort to maximize the health benefits of sago starch, processing methods become a key factor to consider. One processing method that is increasingly attracting interest to researchers is autoclaving. Autoclaving is a high-pressure heating technique that has been shown to be effective in altering the chemical and physical properties of starch, which can affect its glycemic profile and prebiotic properties. However, despite promising preliminary evidence, research exploring the effect of autoclaving methods on sago starch is limited. In this context, the gastronomic perspective provides an additional dimension in the understanding of sago starch as a functional food source. Gastronomy refers to the art and science of food and beverage, which includes processing, presentation, and culinary experiences. By understanding how autoclaving methods affect the organoleptic properties and sensory qualities of sago starch, we can develop food innovations that not only provide health benefits but also provide a satisfying gastronomic experience. This study aims to investigate the effect of autoclaving method on sago starch as a functional food source, with emphasis on gastronomic aspects. Through this approach, we can gain a more comprehensive understanding of the potential of sago starch in providing healthy and tasty food for consumers.

2. Literature Review

2.1. Starch

Starch is a glucose homopolymer with α-glycosidic bonds. The properties of starch depend on the length of the carbon chain, as well as the straight or branched chain of molecules. Starch consists of two fractions that can be separated by hot water, the dissolved fraction is called amylose and the undissolved fraction is called amylopectin [13]. Starch is a carbohydrate consisting of amylose and amylopectin. In its original form, starch is naturally small grains that are often called granules. Amylose is part of a straight chain that can twist and form a double tendril area. On the outer surface of single-tendriled amylose there is hydrogen bonded to O-2 and O-6 atoms. The straight chain of amylose that forms the crystal double tendril is resistant to amylase. Inter- and intra-tendril hydrogen bonding results in the formation of hydrophobic structures with low solubility. Therefore, a single tendril of amylose similar to cyclodextrin is hydrophobic on its inner surface [14]. Amylose is a fraction of motion, which means that in starch granules it is located not in one place, but depends on the type of starch. Generally, amylose is located between amylopectin molecules and randomly alternates between amorphous and crystalline regions [15]. The structure can be seen in figure 1.

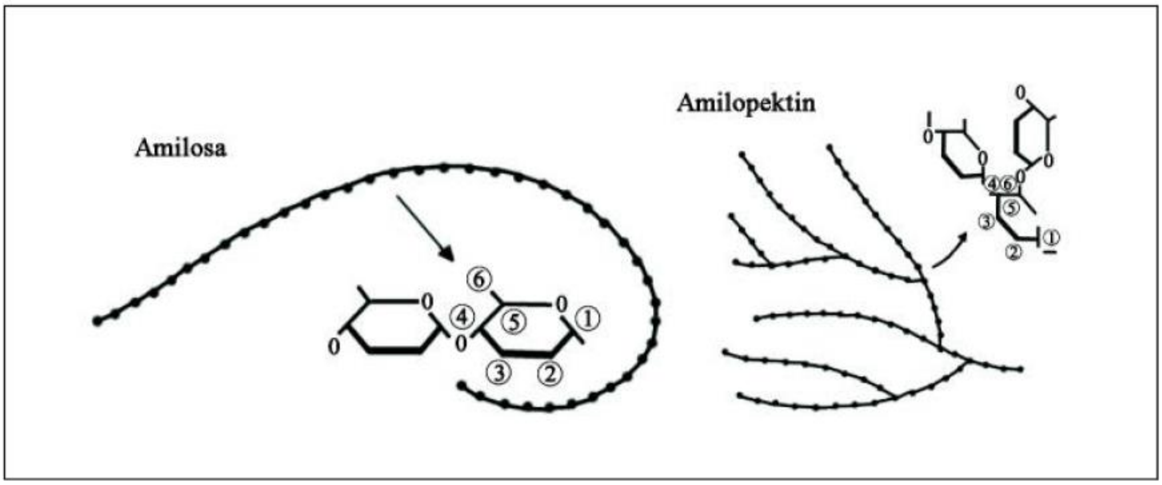

Figure 1. Amylose and amylopectin structures

When heated in water, amylopectin will form a transparent layer, which is a solution with high viscosity and in the form of layers like string strands. Amylopectin tends not to occur retrogradation and does not form gels, except at high concentrations [16].

The shape and size of the granule is characteristic of each type of starch, therefore it is used for identification [17]. In addition to granule size, other characteristics are the shape, uniformity of the granule, the location of the hilum, as well as the surface of the granule [18]. Starch is composed of at least three main components namely amylose, amylopectin and intermediate materials such as, proteins and fats [19].

Generally, starch contains 15 – 30% amylose, 70 – 85% amylopectin and 5 – 10% intermediate. The structure and type of material between each starch source differs depending on the botanical properties of the starch source. In general, it can be said that grain starch contains greater intermediate material than stem starch and tuber starch. The main source of starch in Indonesia is rice besides that several other sources of starch are found, namely; corn, potatoes, tapioca, sago, wheat, and others. The birafringence property of starch granules is the property of reflecting polarized light so that under a microscope it looks black and white. By the time the granules begin to break apart, this birefringence property will disappear.

2.2. Modified Starch

Modification is a change in the molecular structure of starch that can be done by physical, chemical (etherification, esterification, oxidation and crosslinking) and enzymatic means. Several factors are known to affect the speed of chemical reactions, including the length of time 4 Palm Starch Modification Technology reactions, pH, reactant concentration, temperature, and starch type [20]. According to [21] and [22] starch modification can improve physical and chemical characteristics, such as increasing starch stability and starch resistance to retrogradation processes with low substitution (DS) degrees (0.01-0.30) that can be applied to food. On the other hand, starch modification can not only improve the physical and chemical properties of starch but also has great potential to provide functional potential that is beneficial to health [23]. Starch modification can be done by cutting the molecular structure, rearranging the molecular structure, oxidation, or substituting chemical groups on starch molecules [24]. Some types of modified starch and their properties and uses are presented in Table 1.

Table 1. Several types of modified starch and their properties and uses for food [25]

Starch Type	Characteristic	Utilization
Pregelatinized starch	Soluble in cold water, filler material	Instant soups, instant pudding, bakery mixed sauces, frozen food
Acid hydrolysis starch	Low viscosity, high retrogradation, strong gel	Gum, Candy, liquid formulation
Dextrin	Binder, encapsulation	Candies, developers, flavors, spices, and oils
Oxidized starch	Stabilizer, adhesive, gelter, clarifier	Food formulations, gum, candy
Starch Ether	Stabilizer	Soups, puddings, frozen food
Starch Esters	Stabilizer, filler, purifier	Sweets, emulsions
Cross-reaction starch	Fillers, stabilizers, texture determinants	Pie fillers, breads, frozen foods, bakery, puddings, instant food, soups, sauces, salad dressings,

2.3. Autoclave

An autoclave is a closingable vessel, which is filled with hot steam with high pressure. The temperature inside can reach 1150C to 1250C and the vapor pressure reaches 2-4 atm [26]. The device is a double-walled steam chamber filled with air-free saturated steam and maintained at a specified temperature and pressure for a desired period of time. The time required for sterilization depends on the nature of the sterilized material, the type of container and the volume of the material. Good conditions used for sterilization are at 15 Psi and a temperature of 121 0C for 15 minutes [27]. For the use of an autoclave to be effective, water vapor must be able to penetrate every sterilized device.therefore, the autoclave must not be too full, so that moisture completely penetrates all areas [28]. Autoclaves are the most widely used method for sterilization worldwide and are considered the most powerful and cost-effective method for sterilization of medical devices [29] Autoclaving-cooling red bean flour has higher resistant starch levels than control red bean flour and cooling results. Autoclaving-cooling red bean flour is the best flour and has characteristics.

3. Method

The materials used in this study consisted of sago starch and aquades obtained from CV. Progo Mulyo, Sleman, Yogyakarta. The tools used in this study include analytical balances, cups, spatulas, 100 ml measuring cups, 500 ml beakers, autoclaves, refrigerators, thermohygrometers, ovens, grinders, and 200 mesh sieves.

This study was conducted to produce type III resistant sago starch which was carried out with three cycle variations, namely one cycle, two cycles, and three autoclaving-cooling cycles. In general, the process of making resistant sago starch is carried out in the way as shown in figure

3.1. Modification of Sago Starch by Autoclaving-Cooling Method

Sago starch is suspended in aquades with a ratio of starch and aquades, which is 1:2 (150 grams of starch in 300 ml of aquades), then heating treatment is carried out using a hirayama autoclave (121°C; 15 minutes). The paste of starch that has been autoclaved is allowed to stand at room temperature for 1 hour to prevent further gelatinization. Furthermore, the starch is retrograded by cooling in the refrigerator at 4°C for 24 hours. The autoclaving-cooling process is carried out 1 time for one cycle (T1), repeated 2 times for two cycles (T2), and repeated 3 times for three cycles (T3). Furthermore, drying using an oven (Memmert) at 50°C for 24 hours, grinding using a grinder, and sifted using a 200 mesh sieve. Then the modified starch is packaged and analyzed for its physicochemical and functional properties. The parameters observed in this stage of research include: amylose levels, starch amylography, swelling power, solubility, and resistant strach. The best results at this stage are compared with the characteristics of the physicologic and functional properties of its natural sago starch. The autoclaving-cooling cycle treatment includes:

TO: Natural starch (no cycle)
T1: One-cycle modified starch
T2: Starch Modification Two Cycles
T3: Three-cycle Modified Starch

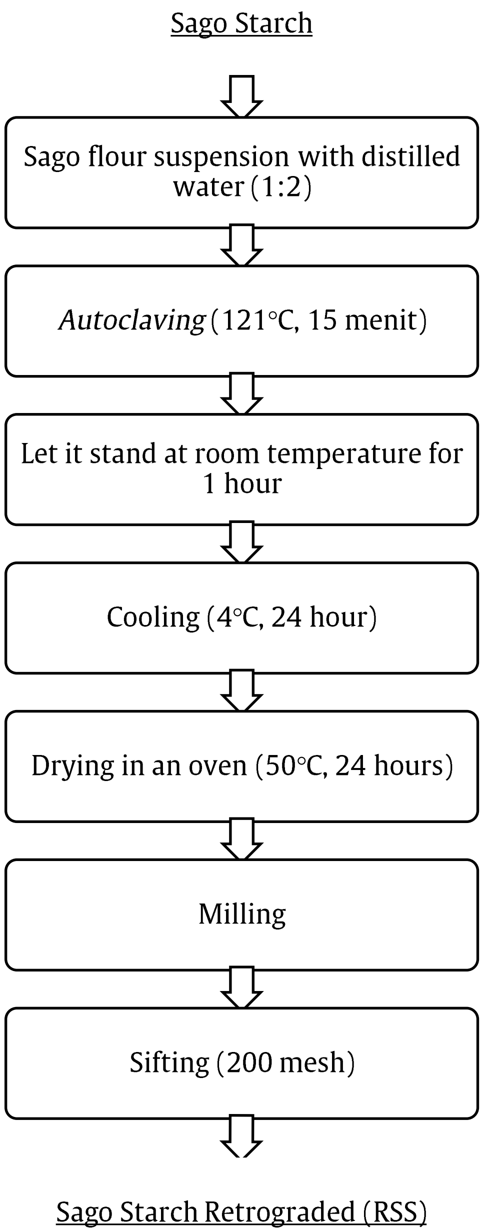

Figure 2. Scheme of making resistant sago starch

4. Results and Discussion

This study produced modified starch type 3 or RS 3. Heat treatment using autoclaving with the addition of water can lead to starch matrix expansion and gelatinization of granules [30]. The starch is cooled after autoclave treatment. During the cooling process, the dissolved starch fragments will re-form a strong layer on the surface of the granule. The reunion of amylose-amylose, amylose-amylopectin, amylopectin-amylopectin, and hard gel formation causes starch granules to be resistant to heat and resistant to enzymolysis [31]. Sago starch goes through 3 cycles of autoclaving-cooling process. Digestibility resistant starch levels can be increased through repeated autoclaving-cooling [32].

From the data from the study, it was found that the modification treatment of sago starch using autoclaving can increase the durability of starch, also known as resistant starch. The greater the number of autoclaving-cooling cycles, the higher the starch resistance. Natural sago starch levels 1.26% resistant starch and rose to 4.5 times in 3-cycle modified starch, which is up to 5.62%. Resistant starch starch modification by autoclaving-cooling can be seen in Figure 3. Resistant starch (RS) itself is divided into five groups, namely RS I, RS II, RS III, RS IV and RS V. RS III is the most resistant starch and relatively more heat resistant when compared to other types of resistant starch, especially in the form of retrograded amylose formed during cooling gelatinized starch. According to [12], heating treatment with an autoclave can reduce the digestibility of starch and increase the yield of resistant starch by up to 9%. Autoclaving method is done by suspending starch with water and then heating it with a high-temperature autoclave. After autoclaving, the starch suspension is kept at a low temperature to allow for reverse increase. To increase the content of resistant starch, the cycle can be repeated.

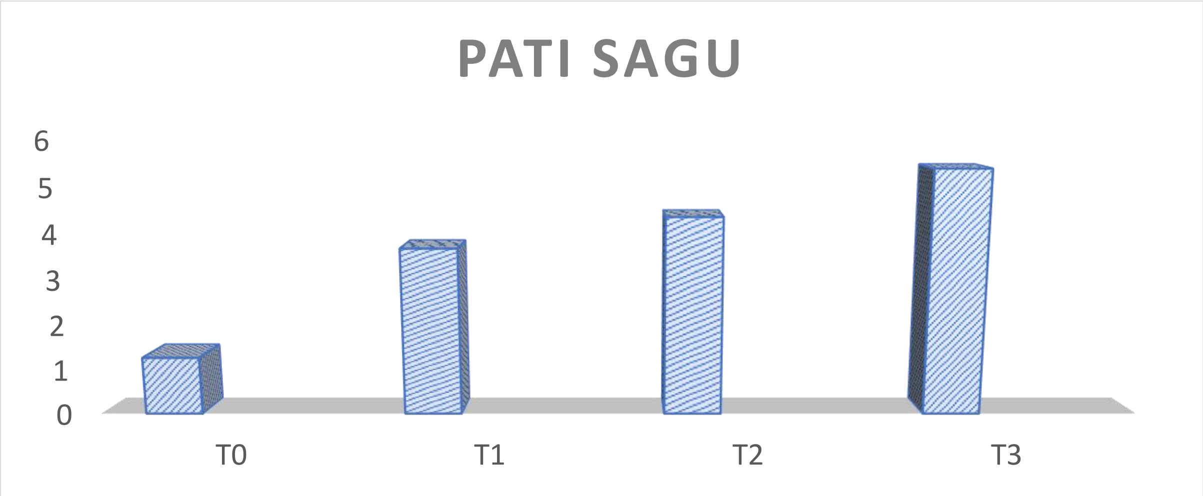

Figure 3. Modified sago starch resistant chart

Things that affect the increase in RS levels of sago starch are: (1) the ratio of amylose: amylopectin in starch, higher amylose can increase RS levels, (2) the ratio of starch: water in making RS, (3) the heating process carried out, (4) the cycle in the modification process, and (5) autoclaving temperature.

5. Conclusion

Based on the results of observations, presentation of data and discussion of data, the writer can conclude:

a. Autoclaving cooling modification treatment has an effect on increasing RS III sago starch.
b. The autoclaving-cooling process in sago starch is able to form RS III starch and increase digestibility resistant starch. Modified sago starch each in 1 cycle contains RS III of 3.67%, 2 cycles of 4.35%, then in 3 cycles 5.62% is obtained.

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