CHAPTER 2 – LITERATURE REVIEW

2.1 Banana

Bananas are fruits that can be obtained from tropical and subtropical areas. It is produced in large quantities and the crop have a major importance to the people in the growing area since it is part of the annual income and as a source of food . Many growing countries grows banana where Indonesia is of them.(Zhang et al., 2005)

Based on fixed number (*Angka Tetap / ATAP*), released by the Ministry of Agriculture,banana production in indonesia reaches 6.28 million tons in 2013 (Susanti, 2014).Almost all the regions in Indonesia are producers of banana since Indonesia is a tropical country with favorable climate for banana's growth (Suhartanto *et al.*, 2008).West Java, East Java, and Lampung are the three provinces with the largest banana production (Kementan, 2015)

Banana belongs to the family of Musaceae and genus of *Musa*. Almost all of the known edible-fruited cultivars arose from two diploid species, *Musa acuminata*and *Musa balbisiana*, which are native to southeast Asia. There are diploid, triploid,and tetraploid hybrids composing subspecies of *M. acuminata*, and between *M.acuminata and M. balbisiana*. Conventionally, the haploid contributions of the respective species to the cultivars are noted with the letters A and B. Cavendish subgroup banana cultivars (M. cavendishii), which are the mainstays of the export trades are pure triploid acuminata (AAA group). The two Linnaean epithets, *M. paradisiaca* and *M. sapientum*, are members of the AAB group. Plantains are generally the larger, more angular starchy fruits of hybrid triploid cultivars in the banana family (Zhang *et al.*, 2005).

2.2 Resistant Starch

2.2.1 Definition

Resistant starch" was first introduced by Englyst et al., (1982), he describes resistant starch to be a small fraction of starch that was resistant to hydrolysis by exhaustive -amylase and pullulanase treatment in vitro. In the study it shows that RS is the starch that is not hydrolyzed after120 min of incubation . However, because starch reaching the large intestine maybe more or less fermented by the gut microflora, RS is now defined as that fraction of dietary starch, which escapes digestion in the small intestine. It is measured chemically as the difference between total starch (TS) obtained from homogenized and chemically treated sample and the sum of RDS and SDS, generated from non-homogenized food samples by enzyme digestion RS = TS – (RDS + SDS) (Sajilata et al., 2006)

2.2.2 General Structure and Classification

Resistant starch are normally classified into 4 main groups which consist of RS 1 to RS 4 (Sajilata et al., 2006). In figure 2.1 it shows the classification based on Nugent (2005).

Table 2.1 Classification , description and food source of various type resistant starch

Type of RS	Description	Food sources	Resistance minimized by
RS_1	Physically protected	Whole- or partly milled grains and seeds, legumes	Milling, chewing
RS_2	Ungelatinized resistant granules with type B crystallinity, slowly hydrolyzed by α-amylase	Raw potatoes, green bananas, some legumes, high amylose corn	Food processing and cooking
RS_3	Retrograded starch	Cooked and cooled potatoes, bread, cornflakes, food products with repeated moist heat treatment	Processing conditions
RS_4	Chemically modified starches due to cross-linking with chemical reagents	Foods in which modified starches have been used (for example, breads, cakes)	Less susceptible to digestibility in vitro

- <u>Resistant starch type 1</u>

Type 1 resistant starch is found in many cereal, grains and seed. This starch is synthesized in the endosperm of cereal grains and seeds. The starch granules are surrounded by protein matrix and cell wall materials. Due to the physical structure of the starch according to O Dea et al., 1980, this hinder the digestibility of the starch and reduce the glycemic response.

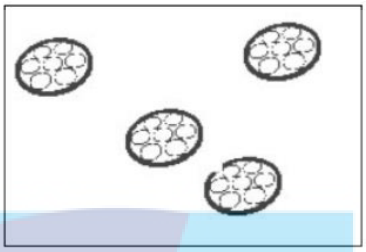

Figure 2.2 Resistant starch type 1 granules

When the kernel and seeds are process, the thick cell wall of the legume seeds and the protein matrix this will prevent water entering the starch located in the matrix . Therefore, the starch does not have adequate moisture to readily gelatinize and swell. Without proper swelling to expose the starch molecules, the starch is not ready for enzymatic hydrolysis. The cell wall material and the protein matrix also provide a physical barrier, preventing enzymes from reaching and hydrolyzing the starch. (Birt et al., 2014)

- Resistant starch type 2

Resistant starch type 2 are mostly found in raw starch granules. The starch is packed in form of a radial patterns and relatively dehydrated. With the compact structure , it limits the accessibility of the digestive enzymes and shows the characteristic for the resistant nature of RS2 such as, ungelatinized

starch. Figure 2..3 shows the RS granules, that is, raw potato, banana, and high-amylose starch (www.cerestarhealthand nutrition.com ; sajilata et al., 2006)

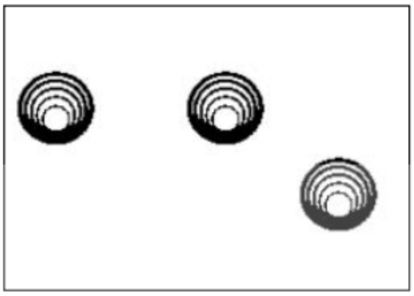

Figure 2.3 Resistant starch type 2 granules

In raw or uncooked potato starch, green banana starch,gingko starch, and high-amylose maize starch, which display the B- or C-type polymorph, are highly resistant to enzymatic hydrolysis (17) and are examples of type II resistant starch (RSII) However, after cooking, most of the starch, such as that in baked potato and cooked banana, becomes highly digestible as a result of starch gelatinization and lossof the B- and C-type crystallites. An exception is high-amylosestarch produced by mutation of the amylose-extender (ae)gene and the gene encoding starch branching-enzyme I,which has substantially longer branch chains of intermediate components and a larger proportion of amylose

Thus, this starch displays a high gelatinization temperature, above the boiling point of water. After boiling or cooking at a temperature below its gelatinization temperature, this type of starch retains its crystalline structure and remains resistant o enzymatic hydrolysis

- <u>Resistant starch type 3</u>

RS3 represents retrograded amylose starch. Because amylose molecules have linear structures, they have a great tendency to form double helices, particularly near refrigeration temperatures (4–5°C) and with adequate moisture content.

Retrograded amylose has high gelatinization temperatures, up to 170°C, and cannot be dissociated by cooking. The gelatinization temperature of retrograded amylose, however, decreases with shortening of the amylose chain length. After starchy foods are stored, particularly in a refrigerator, amylose molecules and long branch chains of amylopectin form double helices and lose their water-binding capacity. The double helices of starch molecules do not fit into the enzymatic binding site of amylase, thus they cannot be hydrolyzed by this enzyme. (Sajilata et al., 2006)

- Resistant Starch type 4

Structure of RS4 includes structures of modified starches obtained by chemical treatments like distarch phosphate ester

2.2.3 Resistant Starch as functional foods and functional ingredient

Functional foods is defined as natural and/or modified components with physiological value beyond basic nutrition, which aid in the improvement of human health (Henry, 2010). Functional ingredients can be food additives used to fortify foods or nutritional components naturally present in food. Functional foods are reported to be purchased for health issues such as weight loss, cholesterol reduction, and digestive health (Arvanitoyannis and Van Houwelingen-Koukaliaroglou, 2005).. RS is also a functional ingredient (Fuentes-Zaragoza et al., 2010) that is naturally present or incorporated into productsto make functional foods.

Commercial companies have developed functional foods with dietary fiber, but more specifically products are being formulated with RS or RS as an additive (Aigster et al., 2011). Many research studies have successfully used RS as a functional ingredient to evaluate physiological efficacy and health benefits such as lower cholesterol or improved lipid profile, modulation of glycemic and insulin response, and improved bowel health (Fuentes-Zaragoza et al., 2010); although the term ‘functional ingredient’ might not always be used.

Low fiber food enriched such as breads, muffins, and crackers with dieatary fibers have some problem in the sensory acceptance. Sensory evaluation of appearance/color, taste, and feel of high fiber fortified foods has been somewhat unfavorable. For example, fiber-fortified bread has been summarized to have a dark color, reduced loaf volume, poor mouthfeel, and flavor masking properties (Sajilata et al., 2006).

Breads formulated to be functional foods, can replace part of rapidly digestible flour with RS to improve sensory concerns. Sanz and associates (2009) replaced 15% of wheat flour with four different types of RS (2 type RS2, 2 type RS3) for final RS g (%) of muffin product to be between 8.3g (1.55% RS) and 12.5 g (1.76) as compared to the wheat control 0.65g (0.031% RS) (Sanz et al., 2009).

The appearance of RS can range from a coarse to fine powder that is white in color. RS has a bland taste, which makes it desirable as a food additive. Other desirable traits that are present in types of RS are small particle size, low water-holding capacity, viscosity, solubility, gel formation, light texture, and high gelatinization temperatures. One or more of these traits allow for successful incorporation of RS into a food product while still maintaining a fairly palatable food product, although other sensory attributes such as grittiness, chewiness, and cohesiveness have been affected by the addition of RS to bread products (Baixauli et al.,2008).

Baixauli and associates (2008) noticed an increase in grittiness, sweetness, and an overall increase in moisture as RS % increased, while springiness, chewiness, and cohesiveness decreased as RS% increased. Because of desirable physicochemical characteristics of RS, it improves sensory properties in baked goods compared to control baked goods (Maziarz et al., 2013), and in some cases, addition of RS can improve sensory properties above other dietary fibers. This allows RS to be used to increase dietary fiber in foods not typically viewed to be good sources of dietary fiber. However, RS is more commonly incorporated into baked goods to modify texture and act as a crisping agent (Sajilata et al., 2006).

With the increase of RS and its use as a functional ingredient, understanding physicochemical dynamics of RS when incorporated into food products is not only good for the improvement of human health but also has monetary importance for the food industry

2.3 Frying

Frying is one method of food processing. Deep-fat frying is one of the oldest and most one of the most common unit operation used in the preparation of foods which results in products with a unique flavor texture combination (Varela, 1988). During the process, some chemical and physical changes. For instance, due to heat, protein will start to denatured , starch will start to gelatinized and crust of the product will be formed. (Altunakar, Sahin, and Sumnu, 2004). Although there aare some changesdue to the heat applied, frying is still used in to process many foods since it give an appealing sensory appearance of golden brown and fill the taste bud due to the rheological properties present such as the crispiness and the certain taste.

2.4 Batter Coating and Battered Product

Food before process through frying are sometimes pre processed first by coating it with battered coating. When Batters covered on the surface of food products, it will form the crust during deep-fat frying. The crusts of fried products could provide golden yellow color, the crisper texture, and could act as a barrier against the loss of moisture by protecting the natural juices of foods (Dogan, Sahin, & Sumnu,2005; Mohamed, Hamid, & Hamid, 1998).

Both batter formulation (wheat flour, starch, protein, leavening, and so on) and processing methods (frying temperature, frying time, and heating method) could influence the edible quality of crusts(Salvador&Fiszman,2003)

Batter coating normally consist of wheat flour but High-protein wheat flour or vigorously mixed batters are associated with a soggy and unpleasant texture.

Therefore , starch and modified starches have been used as one of the ingredients in the batter to improve batter texture (Fiszman & Salvador, 2003and to decrease oil content of the fried and battered foods (Ahamed, Singhal,Kulkarni, & Palb, 1997). Fiszman and Salvador (2003) reported that modified starches with high amylose content had good film forming propertiesthat could help reduce oil absorption.

One of the critical sensory attributes in battered fried product is the crispiness. Crispness has been found to be positively correlated with amylose content (Altunakar,Sahin, & Sumnu, 2004; Mohamed, Hamid, & Hamid, 1998).Starch resistance to gelatinization and granule disintegration are linked to a crispier fried batter (Matsunaga et al., 2003).These authors explained that amylose contributes to crispness because it restrains the disintegration of the starch granule structure.

2.5 Oil Absorption in Fried Food

When food is processed through frying, there will be oil absorption where different food will have different absorption. According to Rossel. (1998), fish or chicken, absorbs about 15% frying oil, while breaded fish or chicken absorbs up to 20% frying oil. The amount of oil absorbed by doughnuts varies from 15-20% of their final weight. This is due to the shortening used in preparation of the dough, giving a final oil/fat content of up to 30%. Standard or traditional potato crisps absorb the highest quantity of oil, and up to 35 or 40% of the final food weight may be frying oil. Recently, low-fat crisps have been introduced, but these still contain about 20% fat.