EFFECT OF CONSUMPTION HIGH RESISTANT STARCH TYPE 3 OF
Coleus tuberosus ON GLUCOSE, LIPID, AND SHORT CHAIN FATTY ACID PROFILE IN NORMAL RATS

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# HALAMAN PENGESAHAN

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EFFECT OF CONSUMPTION HIGH RESISTANT STARCH TYPE 3 OF Coleus tuberosus ON GLUCOSE, LIPID, AND SHORT CHAIN FATTY ACID PROFILE IN NORMAL RATS

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ABSTRACT

This research was conducted to study the effect of processing methods on the starch content of resistant starch in Coleus tuberosus and influence of consumption this starch on the profile of glucose, lipids (total cholesterol, triglycerides, Low density lipoprotein, High density lipoprotein), short chain fatty acid (SCFA) and physical properties digestion in rats. The results showed that the levels of resistant starch in Coleus tuberosus by steaming-cooling: 9.5291%; boiling-cooling: 9.1235 %, and oven-cooling: 9.0306%. Steaming-cooling process can be more in control of glucose and lipid profile than boiling-cooling process and oven-cooling process. Short chain fatty acid profiles in all three processes show the greatest proportion is acetic acid, followed by acid propionate and the last is butyric acid. While the physical and chemistry properties of the digestion showed that steaming - cooling process can increase water levels and lowered pH. This study shows that Coleus tuberosus flour with the heating and cooling can be continued with increased resistant starch and provide physiological benefits to the profiles of glucose, lipids, SCFA and physical properties digestion. So the Coleus tuberosus starch with steaming - cooling process is expected to be utilized for the manufacture of functional foods for people with diabetes mellitus and hypercholesterolemia.

Keywords : Coleus tuberosus, Resistant starch, glucose, lipids, SCFA

INTRODUCTION

Diabetes mellitus is a condition of elevated blood sugar levels in chronic metabolic disorder caused by various hormonal disorders that cause a variety of
chronic complications in various target organs (Departement of health Republik Indonesia, 2007). International Diabetes Federation (IDF) in 2005 stated that in the world there are 200 million (5.1 %) people with diabetes and suspected 20 years later in 2025 will increase to 333 million (6.3 %) people. For countries like India, China, USA, Japan, Indonesia, Pakistan, Bangladesh, Italy, Russia and Brazil merupkan top 10 countries with the highest diabetes population (Departement of helath Republik Indonesia, 2007). In Diabetes Care (Wild, 2004) that perform data analysis and the WHO predicts Indonesia in 2000 is said to be 4th (8.4 million people) in 2030 will remain No. 4 in the world but with the 21.3 million with diabetes. This estimate will be true if there is no effort from all of us to prevent or at least eliminate the factors causing an explosion that amount.

Prevention alternatives that can be implemented is setting diabetics diet by consuming starchy foods that are hypoglycemic, containing or containing high amylose resistant starch (resistant gastrointestinal), and the impact on short-chain fatty acids (short chain fatty acids = SCFA) which may affect fat metabolism and prevent colon cancer.

Resistant starch (Resistant Starch / RS) is defined as starch or starch degradation products that cannot be digested by the intestines of healthy humans (Asp and Bjorck, 1992). Resistant starch, in addition to having similar benefits such as dietary fiber, also has the advantage to prevent colon cancer and diarrhea, and can improve intestinal microflora, due to high levels of short-chain fatty acids (Short-Chain Fatty Acid/SCFA) which is the main end product of the degradation of dietary fiber and resistant starch by anaerobic bacteria in the large intestine (Cummings, 1989). In recent decades, many Resistant starch studied mainly in
terms of formation and nutritional aspects. One of which can increase levels of resistant starch on starch is processing (heating and cooling of the starchy material repeatedly) (Kingman and Englyst, 1994).

Heating starch with water will result in excessive starch gelatinization experience, a process that includes hydration and dissolution of starch granules (Wursch, 1989). The process continued after the starch gelatinized, refrigeration, freezing, baking or frying will result in starch retrogradation of starch that can alter the structure leading to the formation of new crystals do not dissolve. Gelatinization and retrogradation which often occurs in starchy materials processing affects starch digestibility in the small intestine.

Black potato (Coleus tuberosus) is one of the agricultural products in Indonesia as an alternative source of carbohydrate and drugs that are expected to be a source of resistant starch through the process of heating, followed by cooling. Research is needed to determine levels of resistant starch with different processing methods, as well as its influence on lipid profile, short chain fatty acids and physical properties digestion. Based on this study is expected to be obtained by the method of making a high black potato starch resistant starch type 3 right so that it can be used as a functional food for the prevention and control of lipid profile, SCFA and physical properties as well as to encourage plantation of Coleus tuberosus in order to support food security and useful in improving public health.

METHODS

Materials
This study uses the main raw material in black potatoes get from Farmers in Clereng, Kulon Progo Yogyakarta. RS enzymes for analysis consisted of the enzyme $\alpha$ - amylase (EC 232-560-9), amyloglukosidase (EEC 232-877-2) and pullulanase (EC3.2.1.41).

Preparation of coleus tuberosus starch

Preparation stage of pre-cooked flour, treatment includes boiling (100°C for 15 min) and continued cooling (4°C for 24 hours), steaming (100°C for 15 min) and continued cooling (4°C for 24 hours), oven (100°C for 15 min) followed by cooling (4°C for 24 h) and cooling. Flour dried with dryer cabinet temperature of 50°C for 12 hours and then milled, and sieved (80 mesh).

Resistant Starch Analysis

RS levels determined enzymatically. hydrolyzed by the enzyme $\alpha$ - amylase. Amyloglukosidase enzyme is added to avoid product inhibition produced by $\alpha$ - amylase. Hydrolysis is extracted with 80% ethanol and then discarded. RS dissolved with 2 M KOH and hydrolyzed with amiloglucosidase, glucose formed was measured by the glucose oxidase method (AOAC, 1984).

Bioassay resistant starch of Coleus tuberosus

Experimental animals used were white type Wistar rats (2 months of age with an average weight of 110 g). Materials to feed the rats, including casein, sucrose, vegetable oil, cellulose, mineral mixture (AIN - 93) and vitamin mixture (AIN - 93), and glucose kit (Diagnostic bavaria Germany), cholesterol kits (Diagnostic System GmbH & DiaSys Co., Germany). Dietary treatment is made from pre-cooked Coleus tuberosus and 3 types of processing to obtain three kinds of dietary treatment, the Coleus tuberosus diet after boiling-cooling, steaming-cooling, and
oven - cooling. Making animal diet refers to a diet formula American Institute of Nutrition (AIN-93) (Reeves et al., 1993).

A total of 18 white-type Wistar rats (aged 2 months, average weight 110 g) was adapted for 7 days by placing each individual rat in a cage which is quite light, ventilation, and at room temperature. During adaptation, mice were fed a standard diet (AIN-93) and drink ad libitum. Then the rats were divided into 3 (three) groups according to treatment, each consisting of 6 rats. Dietary treatment and drinking water given ad libitum for 20 days. On day 21st performed surgery on all mice from each group to capture existing in digesta were analyzed for weight, volume, moisture content, pH and concentration short chain fatty acids (SCFA) and blood sampling for analysis of blood glucose and lipid profiles.

Blood sampling is done by conditioning the rats in the fasting state for 12 hours. Blood sampling is done through the orbital sinus (located in the eye organ) in 1 ml using a hematocrit tube and put on appendorf. The blood is then centrifuged to separate the blood serum to serum glucose levels were analyzed using the GOD-PAP method, performed analysis of total cholesterol by CHOD-PAP method (Richmond, 1973), LDL cholesterol by CHOP-PAP method (Wieland and Siedal, 1983), analysis of HDL cholesterol by CHOP-PAP method (Eckal et al., 1977), and the total triglycerides by GPO-PAP method (Mc Gowan et al., 1983).

Analysis of rat body weight

Body weight of rats determined by weighing the rats with weights. Feed intake is calculated by menguranghan amount of feeding per day is 10 grams with the rest of the feed every day.
Analysis of digesta weight and moisture content of digesta

Caecum of each rat was cut and the contents removed, the entire contents of a digesta weight. Water content measurements done by digesta samples that have been included in the homogeneous weighing bottle that has been constant and put in the oven at 105°C for 3-5 hours. Losing weight is the amount of water in the sample.

Digesta pH Analysis
digesta pH determined with a pH meter. Figures shown in the pH meter is a pH of fluid caecum.

Analysis of Short Chain Fatty Acid

Short Chain Fatty Acids extracted. 0.1 mL sample was injected on HP 5890A GC with flame ionization detector and a semi-capillary column (25mx 23 mm). Helium at a column flow rate of 12 ml / mindengan split 1 : 10 is used as a carrier gas (column temperature 125°C). The proportion of short-chain fatty acids contained in digesta with gas chromatography (GC). The principle is a solid mass in the caecum digesta were separated by centrifugation. Supernatant analyzed by GC. For the identification of each short-chain fatty acids (acetate, propionate, butyrate) by comparing the area with a standard curve. The ratio of short-chain fatty acids is calculated based on the ratio of the area of each of the short-chain fatty acids by total area.

RESULTS AND DISCUSSION

Resistant starch
Resistant starch is defined as starch can escape digestion in the small intestine and as a source of fermentation substrates for colonic microflora. An aerobic fermentation yielding short chain fatty acid (SCFA) which can be used as an additional energy to the animal (Brigitta Kleessen, 1997). As for food, Coleus tuberosus before consumption always experience processing using heat treatment. Cooling starch that has undergone can change the structure of starch gelatinization which leads to the formation of starch retrogradation. Gelatinization and retrogradation that occurs in the processing can affect the digestibility of starch in the small intestine.

Resistant starch contained in this study are classified as RS type 3 resistant starch that occurs when starch is heated and gelatinization occurs so that it becomes easier to digest, but when it is done cooling the crystalline forms of starch will happen is resistant to enzyme digest (retrograded). RS analysis result in black potatoes boiling - cooling, steaming - cooling, oven - cooling (Table 1).

Table 1. Potato black levels on the RS - cooling boiling, steaming black - cooling potatoes and black potato oven - cooling

<table>
<thead>
<tr>
<th>No.</th>
<th>Kind of starch</th>
<th>Resistant starch content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Raw Coleus tuberosus</td>
<td>7.5243± 0.2054^a</td>
</tr>
<tr>
<td>2.</td>
<td>Coleus tuberosus boiling-cooling</td>
<td>9.1235 ± 0.3680^c</td>
</tr>
<tr>
<td>3</td>
<td>Coleus tuberosus oven-cooling</td>
<td>9.0306 ± 0.9570^b</td>
</tr>
<tr>
<td>4</td>
<td>Coleus tuberosus steaming-cooling</td>
<td>9.5291 ± 0.0724^d</td>
</tr>
</tbody>
</table>

Sajilata et.al (2006) wrote that the process of boiling the potatoes, followed by cooling will increase the levels of resistant starch. The potatoes were already experiencing cooling is included in Resistant Starch 3 (RS3). Processing by
steaming, boiling and oven can increase the resistant starch. This study shows that excessive heating starch with water will result in starch gelatinization. Cooling starch which has gelatinized can alter starch structure that leads to the formation of a new crystal form of insoluble starch teretrogradasi. Gelatinization and retrogradation which often occurs in starchy materials processing affects starch digestibility in the small intestine (Englyst and Cummings, 1986). Treatment with high temperature black potatoes is expected to increase its levels of resistant starch, so it can have a beneficial physiological effect in an effort to support the development of functional foods based on local tubers.

Physiological effects of dietary fiber and resistant starch is not only caused by dietary fiber or resistant starch itself, but also by short- chain fatty acids (Short - Chain Fatty Acid / SCFA) which is the result of fermentation in the large intestine. SCFA are the major end product of the degradation of dietary fiber and resistant starch by anaerobic bacteria in the large intestine (Cummings, 1989). According to Cummings and Bingham (1987), the product of fermentation of fiber and resistant starch foods such as short- chain fatty acids and gases are CO2 , CH4 and H2. Among the resulting SCFA: acetic acid , propionic and butyric are the dominant SCFA , whereas isobutyrate, valerate and isovalerat very little contribution. Propionic acid has an important role in carbohydrate and lipid metabolism in the liver (Wolever, 1992 in Marsono , 1998), whereas butyric acid could be expected to prevent colon cancer because of its ability to suppress the growth of abnormal cells ( Kim et al , 1994 in Morita et al . , 1999).

Raw Coleus tuberosus containing resistant starch ( RS ) 7.5243 % and all the combined treatment heating and cooling will increase the resistant starch content
of potato starch black. Boiling and cooling process can raise the level of RS from 7.5243 % to 9.1235. Steaming and cooling can increase the level of RS from 7.5243 % to 9.0306 %, and the oven and cooling can increase the level of RS from 7.5243 % to 9.5291 %.

Resistant starch is produced due to processing (heating and cooling of the starchy material repeatedly) is RS - type 3. RS - 3 relating to the type of aggregate formed by heating and cooling followed by starch. Linear polymer amylose teretrogradasi faster and stronger than the branched polymer amylopectin (Schulz et al., 1993).

In the pre-cooked flour, process heating/gelatinization is carried in open containers may not have been perfect, so the results obtained when analyzed teretrogradasi starch (RS - type 3) are relatively low. But heating with cooling (in the refrigerator for 1 night) cause changes in the structure of starch which leads to the formation of a new crystal form of insoluble starch teretrogradasi (retrograded starch). So that combination treatment with the cooling process will increase the levels of flour produced RS (RS - type 3).

Evaluation of Coleus tuberosus resistant starch consumption on lipid profile of rats

This experiment using Wistar rats were fed a diet of pre-cooked Coleus tuberosus (boiling-cooling, steaming-cooling, and oven-cooling). This study aimed to determine the effect of the consumption of resistant starch potato starch rich black against physical and chemical properties of digesta and blood of rats. Analysis of physical and chemical properties of digesta include volume, weight,
moisture content, pH and the levels of short-chain fatty acids (SCFA), whereas the mice blood lipid profile analysis and blood glucose.

Volume, weight, and water content of digesta Rat based on the analysis of variance showed that treatment of black potato diet and type of processing significantly \( p \leq 0.05 \) for volume, weight, and water content of digesta rat.

Effect of dietary administration of pre-cooked potato flour black on volume, weight, and water content of digesta rats are presented in Table 2.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Digesta weight</th>
<th>Moisture content (%)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coleus tuberosus (steaming-cooling)</td>
<td>2.43±0.05</td>
<td>85.57±2.08a</td>
<td>6.31</td>
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<tr>
<td>Coleus tuberosus (boiling-cooling)</td>
<td>2.52±0.13</td>
<td>83.31±3.71b</td>
<td>6.58</td>
</tr>
<tr>
<td>Coleus tuberosus (oven-cooling)</td>
<td>2.13±0.03</td>
<td>76.20±2.64b</td>
<td>6.48</td>
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</table>

Diet steaming Coleus tuberosus has a tendency volume, weight and water content of digesta were relatively high compared to the boiling-cooling and process-cooling oven. This is due to the Coleus tuberosus with steaming-cooling process have relatively high levels of resistant starch (Table 1). These results provide information that the steaming process-cooling benefits tend to have more effective in increasing the volume, weight and water content of digesta in rats.

From the results of the study proved that the process of steaming and cooling for 30 minutes (for 24 hours) effective in producing gelatinized starch and retrogradation, which causes increased levels of resistant starch (type-3).

According Wursch (1989) in Marsono (1998), redundant heating starch with water will result in starch gelatinization experience, a process that includes hydration and dissolution of starch granules. But reheating cooling with starch
that has undergone gelatinization can alter starch structure that leads to the formation of a new crystal form of insoluble starch teretrogradasi (retrograded starch). Storage starch which has gelatinized at low temperatures will accelerate retrogradation of starch. Gelatinization and retrogradation which often occurs during the processing of starchy materials can affect the digestibility of starch in the small intestine.

Digesta water content is a reflection of the water-binding capacity (Water Holding Capacity: WHC) of dietary components, especially polysaccharides. Water binding capability of polisakaridan determined by the chemical structure of the polysaccharides, species and anatomy of the source material (Eastwood and Mitchell, 1976), but it is also influenced by the particle size and pH. The increase in the water content of digesta in the group of rats with a diet of Coleus tuberosus may be caused by high levels of RS were resistant digested by digestive enzymes. Data on water levels and digesta weight in mice fed a diet of Coleus tuberosus can give information that this material is good as a supplement to prevent constipation.

Results of previous studies show a diet high in resistant starch administration will increase the weight of digesta rats who eat (Gee et al., 1991, Morrand et al., 1992, Schulz et al., 1993, Morita et al., 1998 and 1999), increasing the water content digesta (Gee et al., 1991 and Schulz et al., 1993), and increase the amount of feces (Schulz et al., 1993).

**Short Chain Fatty Acids and pH of digesta Rat**

Based on the analysis of variance showed that the type of treatment and type of processing Coleus tuberosus significant effect (p ≤ 0.05) against the
concentration of acetic acid, propionic, butyric in digesta mice. The effect of diet on the black potato starch concentration of acetic acid, propionic, butyric, total digesta SCFA and pH in rats are presented in Table 3

<table>
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<tr>
<th>Kind of diet</th>
<th>Acetate acid (ml Mol)</th>
<th>Propionic acid (ml Mol)</th>
<th>Butyric acid (ml Mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ct (boiling-cooling)</td>
<td>67.25</td>
<td>32.39</td>
<td>12.96</td>
</tr>
<tr>
<td>Ct (oven-cooling)</td>
<td>73.41</td>
<td>30.35</td>
<td>6.29</td>
</tr>
<tr>
<td>Ct (steaming-cooling)</td>
<td>77.76</td>
<td>34.86</td>
<td>18.35</td>
</tr>
</tbody>
</table>

The results showed that the diet Coleus tuberosus steaming-cooling gives the concentration of acetate, propionate and butyrate are relatively high compared to other diets. Acetate and propionate concentrations were relatively high both for the prevention of hypercholesterolemia and diabetes. According to Cummings and Bingham (1987), the product of fermentation of fiber and resistant starch foods such as short-chain fatty acids and gases are CO2, CH4 and H2. Among the resulting SCFA, acetic acid, propionic and butyric are the dominant SCFA, whereas isobutyrate, valerate and isovalerate very little contribution.

Some research suggests propionic acid has several functions that regulate carbohydrate metabolism in the liver, as well as acetate, but has the opposite effect. Propionate can stimulate use of glucose or the potential to improve glucose metabolism in the liver (Wolever, 1992 in Marsono, 1998). By Alles et al. (1999), acetic regarded facilitate glucose uptake into cells suppress lipolysis and reduce the amount of free fatty acids in the serum, but acetate may act as a precursor for the synthesis of cholesterol, while propionate may reduce the use of acetate as a precursor of cholesterol synthesis. Acetate produced by fermentation of fiber effect on insulin sensitivity that benefit from a high-fiber diet than in glycemic control (Anderson et al., 1991).
Thus acetate and propionate have different effects on glucose and fat metabolism. Acetate could be expected to reduce glucose and cholesterol while increasing the concentration of propionic acid may increase glucose production and lower cholesterol concentration. Meanwhile, according to Cummings and Bingham (1987) butyric acid can prevent colon cancer because of its ability to suppress the growth of abnormal cells or because of its ability to inhibit carcinogenesis.

According to Morita et al. (1999), increase your intake of resistant starch is fermented also enlarge the pool SCFA in the colon that can improve the intestinal microflora and prevent colon cancer. Butyric acid is very important for colonic epithelial cells and in some circumstances has shown inhibition of neoplastic cell growth.

The main result of this fermentation are short-chain fatty acids (SCFA) are mainly composed of acetate, propionate and butyrate. High levels of short chain fatty acids will lower the pH of the digesta. So that the higher levels of resistant starch then the lower the pH of digesta rats consume.

Digesta pH decrease due to an increase in resistant starch component is not enzymatically digested along the small intestine, so it will pass through to the caecum. The result is that there is an increase in microbial activity in the caecum to produce SCFA, so it will affect the pH of the fluid. This is supported by previous studies showing that the administration of a diet rich in resistant starch lowers the pH of digesta mice compared to mice consuming a diet low in resistant starch (Gee et al., 1991).
Glucose levels

Restricting Coleus tuberosus with steaming-cooling process, boiling-cooling, and oven-cooling to controlling animal glucose profiles (Figure 1).

![Figure 1. Diet Coleus tuberosus on glucose levels](image)

This study showed that glucose levels in mice fed a diet of Coleus tuberosus steaming-cooling is lower than the diet with the boiling-cooling and oven-cooling. This is supported by the relative levels of resistant starch is high on steaming-cooling process.

According to Cumming (1987), resistant starch is a starch that is resistant to digestion by digestive enzymes in healthy individuals. Due to resistant (resistant gastrointestinal) the glucose produced is also small, so that accounts for the low postprandial response to foods containing high amylose resistant starch or included. The resistant starch have also been reported to be hypoglycemic. Resistant starch lowers the glycemic response because it is thick as well as water-soluble dietary fiber that inhibits the absorption of glucose.

Sajilata et.al (2006) stated that foods containing RS will be digested slowly, it implies to control the release of glucose. RS metabolism occurs 5-7
hours after eating, and this contrasts with the cooked starch (which is not included in the RS) can be digested quickly. 5-7 hour digestion reduces postprandial glycemia and insulemia and the potential to increase the period of satiety. Study using 10 healthy people who were given 50 g of starch-free diet RS (0 % RS) or 50 g starch containing a high RS (54 % RS) suggests that a diet with high levels of RS were significantly lower postprandial blood glucose concentration, insulin and epinephrine.

Another study, Reader and others (1997) using a commercial RS3 blood glucose was significantly lower than other simple carbohydrates (oligosaccharides and other starches). RS3 lowers postprandial blood glucose and plays a role in maintaining metabolic control in patients with type II diabetes.

**Total cholesterol levels**

Good blood cholesterol levels are below 200 mg / dL. This study shows that consumption of black potatoes with three different processes can control the levels of total cholesterol test animal. The treatment of black steaming potato diet-cooling gives the best results.
Control levels of total cholesterol is associated with higher levels of resistant starch in the feed. One mechanism of resistant starch in lowering lipid profile is resistant starch to replace the bile acid pool of Cholic acid into chenodeoxycholic acid. Chenodeoxycholic acid is an inhibitor of 3 - hydroxy - 3 - methylglutaryl ( HMG ) CoA reductase , a regulatory enzyme required for the biosynthesis of cholesterol. HMG CoA reductase activity resulted in lower production of cholesterol will decrease, and it causes serum cholesterol down. This is consistent with studies Han et al . (2003 ) showed that the consumption of adzuki ( Vigna angularis ), Kintoki ( Phaseolus vulgaris , variety), and tebou ( P. vulgaris , variety) beans can lower cholesterol levels . Mechanism of cholesterol lowering through the ability to sequester bile cholesterol , promoting its excretion into the feces . The cholesterol -lowering effect of RS may be explained by promote cecal fermentation, with the consequent production of SCFAs, especially propionate and butyrate . Short - chain fatty acids are involved in lowering cholesterol levels by counteracting the induction of hepatic cholesterol synthesis by the caused by an increase of in bile acid excretion ( Brites et al . , 2011).

**Triglyceride levels**

Blood triglyceride levels should be below 100 mg / dL . Consumption of black potatoes with three different processes that can control the triglyceride profile is still included in the normal levels . However, consumption of potatoes steaming black - cooling process is more effective in controlling triglyceride levels ( Figure 3)
These findings are consistent with research Ranhotra (1996) which proved that the consumption of feed containing resistant starch can reduce triglyceride levels by 50%. De Deckere et al (1993) suggest that the consumption of resistant starch can lower triglycerides.

**LDL (Low density lipoprotein) levels**

Blood LDL levels should be below 100 mg / dL. When LDL levels above 130 mg / dL, then it can lead to heart disease. Based on the results of the study showed that consumption of black potatoes with three different processes can control the levels of LDL within safe limits. But the steaming-cooling process provides more effective control than boiling-cooling and oven-cooling processs. Levels of resistant starch in potatoes steaming black - cooling relatively higher making one of the things that cause LDL levels can be maintained. This is because the resistant starch enhancing the hepatic LDL receptor mRNA levels. Han et al study (2005) the consumption of resistant starch may reduce LDL via enhancement of the hepatic LDL - receptor mRNA and cholesterol 7alpha -
hydroxylase mRNA levels and faecal bile acid excretion, and decrease in the hepatic HMG-CoA reductase mRNA levels. Decrease on the concentration of LDL cholesterol in rats fed resistant starch, because Coleus tuberosus has an ability to bind bile acids, increase of the intestinal contents viscosity that can inhibit various types of macronutrient absorption, including lipids, and reduced bile acid absorption from the small intestine via the enterohepatic circulation. The result of other studies conducted Finley (2007) was known that rats fed resistant starch has hepatic LDL receptor mRNA were higher when compared to the controls, so as to increase of the activity of the LDL receptor and SR-B1 in the liver. SR-B1 (scavenger receptor class B, type I) is a membrane protein present on the cells or liver tissue or the adrenal. As the LDL receptor, SR-B1 functions to capture cholesterol esters from HDL in the liver. This process can encourage the transfer of cholesterol from peripheral tissues to the liver and then excreted through the feces.

Figure 4. Coleus tuberosus consumption on levels of LDL
**High Density Lipoprotein levels**

HDL is often referred to as good cholesterol. Blood HDL levels should be above 60 mg / dL. When HDL levels below 40 mg / dL, then it can lead to heart disease.

![Graph](image)

**Figure 5. Coleus tuberosus consumption on HDL levels**

This study provides information that potato consumption in the process of steaming black - cooling has the ability to increase HDL levels higher (127.63 mg / dl) compared with the boiling - cooling (120.83 mg / dl) and oven - cooling (108.22 mg/dl). It is associated with high levels of resistant starch in potatoes steaming black - cooling higher (Table 1). This is Because resistant starch can increase of the expression of SR - B1 mRNA and decrease Concentrations of HDL cholesterol. Todesco et al . [ 1991 ] presented that when propionate was incorporated into bread , it reduced post - prandial blood glucose response in healthy subjects by 38 % . Venter et al.(1990) demonstrated a beneficial effect of propionate on man serum cholesterol, dietary propionate increased the high-density lipoprotein ( HDL ). This can occur because the content of resistant starch
can increase the number of apolipoprotein a-1. The presence of apolipoprotein a-1 will increased synthesis of HDL (Kim et al., 1998).

Conclusion

Coleus tuberosus flour based on steaming-cooling for 24 hours gave resistant starch levels higher than the boiling-cooling and oven-cooling process. Levels of resistant starch is relatively higher in the steaming-cooling process provide positive benefits to the profiles of glucose, lipids, short-chain fatty acid digestion, chemical and physical properties of experimental animals.

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References


Mathe Imre, 2008. Some Aspect of Chemical Diversity of Lamiaceae Species.


