Characterization of Eight Maize Varieties with a Low Glycemic Index to Support Food Security

Nur Richana, Ratnaningsih, Abdullah Bin Arif and Maulida Hayuningtyas

Indonesian Center for Agricultural Postharvest Research and Development
Jl. Tentara Pelajar 12 A Bogor
Email: r1ch4n4@yahoo.co.id

ABSTRACT. This study looking for non rice food alternative was carried out to support the food security program of Indonesia. As an agricultural country rich of genetic diversity including food crops, Indonesia has much many promising alternative sources for substitution and/or instead of rice as stapple food. One of them is maize which have many varieties for food and/or feed. Characterization of some varieties of maize is very useful to increase utilization as raw material of food. Eight varieties of maize i.e. Srikandi Putih, Anoman, Bisi 2, and local: Tretep, Kodok, Tlogomulyo, Sili and Pulut of Temanggung maize central areas were evaluated of their physical and chemical characteristics. Their physical characteristics of maize seed showed i.e.: weight of 100 grains, length, width, and height are; 19.8-33.4 g, 8-10 mm, 3-6 mm, and 7.9-11 mm respectively. Brightness level (L) maize kernels and thermal conductivity are : 88.1-93.8 and 0.256 to 0.275 (W/m.^{o}C). The chemical composition of maize grain i.e.: moisture, ash, fat, protein, and amylose contents are: 5.9-11.5, 0.4-1.7, 3.2-4.2, 6.7- 11, and 15.7 to 29.0% respectively. Analysis of levels insoluble and soluble dietary fiber corn kernels in a row are 5-6.6%, and 1.1-1.3%. The maize starch digestibility of several varieties of maize 65.4-75%. Local Sili and Anoman varieties showed highest and lowest maize starch digestibility. The results turned out to be the glycemic index of eight varieties of maize is very low 28.7-41.7, the highest is Srikandi Putih variety. However, for the highest of glycemic index is still very low compared to other food grains. Thus maize is the best diet for diabetics.

Keywords: maize, physical and chemical characters, glycemic index

Introduction

Maize grain is strategically food commodity which is potentially able to substitute or instead of rice grains as staple food of Indonesian people. Based on last five years data, Indonesian maize grains production was increased in average 11.8% a year. Maize grains production of 2006 was up to 11.61 millions tons increased 1.68 million ton or 14.5% in 2007 and increased again 16.3 million ton in 2008. In 2010 self supporting maize grains was reached and recorded 18.3 million tons of grains production. Possibilities to increase of maize production is still widely open by increasing productivity and/or extensification of maize crops, especially in outer Java island.

As sources of food, maize grains able to processes into much more valuable products i.e.; starch, vegetable oil, flour, and gritz like rice. Quality of maize processed products depend on physicall and chemical properties of grains as raw material. Several researchs result showed chemical composition of maize grains is good enough for raw material of food. This chemical composition depend on genetic, variety, and cultural practices factors of maize crops. Current food quality requirements have to refer high healthy, safety, and functionality of food. Thus foods products based on maize grains become suitable diet for diabetics and more people tend to consume recently. Low glycemic index of maize grain able to control glucose content of man blood. Based on argumentation mentioned above required characterization maize grains of several vatieties in maize centre of Temanggung, Central Java. Evaluation of maize grains characteristics included their physical and chemical properties, nutrient value, and functional food.

Materials and Methods

This study was used maize grains of 8 varieties i.e.: Anoman, Bisi 2, Srikandi and locals i.e.: Kodok, Pulut, Sili, and Tlogomulyo. Seven of them produced white colour and only Bisi 2 has yellow colour of grains. White grains more acceptable for food products because this colour similar to trygo for bakery and cookies. On the other hand white gritz like rice similar to paddy rice grains for substitution or instead truly rice as staple food.

Physical properties i.e.: number of one kg, colour (Hunter method), bulk density, specific weight, and thermal conductivity of maize grains were determined in this experiment. All of physical data statistically analysis using Duncan Multipe Range Test at 5% level of confidence.

Chemical analysis of gritz like rice was conducted on i.e.; water, protein, fat, ash, starch, fiber (AOAC method), and amylose (IRRI method) contents. Determination of starch digestibility, edible fibre, and glycemic index were also studied. Water content was determined using oven at a temperature of 105°C until constant weight of materials. The ash content was determined by AAS, heating in 500-600°C for 6 hours. Determination of fat content by Soxhlet method using hexan as a solvent. Protein content was determined by micro-Kjeldahl method. Fiber content was determined by hydrolyses of maize starch in acid solution, and then in dilute alkaline solution. Starch content was determined by washing with distilled water, and then using HCl. Cooling down this material and proceed with determination of glucose by Anthrones method. Glucose multiplied by 0.9 is a heavy starch. Changes of invert sugar in the flour was determined using DNS. Amylose content was determined by spectrophotometry using amylose derived from pure potato amylase as standard solution.

Result And Discussion

Mean weight of 100 maize grains of eight varieties recorded 19.8–33.4 g. Maize grain of local Tretep and Bisi 2 33.2 g and 33.4 g per 100 grains is the highest one, and 19.8 g per 100 grains of local Kodok is the lowest one. Recent national varieties Anoman and Srikandi Putih yielded 21.6 g weight of 100 maize grains.

Mean of length, width, and tall of maize kernel: 8-10 mm; 3-6 mm; and 8-11 mm respectively. Local Tretep yielded the largest and fat looking of maize grain: 10.06 mm length, 6 mm width, and 9 mm tall. On the other hand Srikandi Putih as national variety yielded smaller than another variety, and slim looking of maize kernel: 7.98 mm length, 2.84 width, and 9.38 mm tall. Mean level of brightness (L) is: 88.09-93.80, maize grains of Bisi 2 has the lowest brightness, and maize grains of Anoman showed the highest brightness. Mean of bulk density is : 0.659-0.806 g/ml, maize grains of Srikandi Putih and Anoman showed the lowest bulk density, and maize grains of Bisi 2 showed the highest bulk density. Mean of maize graine specific weight is 1.055-1.262 g/ml (Table 2). Thermal conductivity level is requirement for determination of temperature and drying time in order to grains postharvest processing.

Characterization of the Chemical Properties

Moisture content of materials will affect its shelf life. Higher moisture contents will increase the likeliness of damaged material and shorter shelf life. Moisture content of maize grains affected by drying process. Maximum drying process without damaging the chemical structure will produce a durable grains. Drying aims to reduce the moisture content to a certain extent such that the growth of microbes and enzyme activities which will cause damage can be inhibited. The minimum moisture content of materials where the microbes can still grow is 11-14% (Fardiaz 1989). Moisture content of maize grains on eight varieties is: 5.93-11,49% (Table 3). These levels have met the SNI standard for maize grains which is a maximum of 14%. Thus the maize grains with such moisture content is expected to have a shelf life of more than one year.

Ash content showed the mineral content of an ingredient. High levels of ashes indicates rich mineral content possessed by the ingredient, which in turn affect its nutrition value (Hood 1981). The ash content of maize grains from 8 varieties is: 0.42-1.73%. Local Sili variety has the lowest content and far lower than the other. These results fit with SNI standard for maize grains 2.0% maximum ash levels. High fat content of maize grains will shorten storage time. In addition, high fat levels can interfere gelatinization process, since fat is capable of creating complex with amylose such that it can't get out of the

Table 1. Physical properties of maize grains from eight varieties.

Varieties	Weight of 100 grains (g)	Grain dimension			Grain colour		
		Length (mm)	Width (mm)	Tall (mm)	L	a	B
Srikandi Putih	21.63 b	7.98	2.84	9.38	93.26 fg	-0.03 d	7.94 b
Anoman	21.60 b	8.66	3.06	10.51	93.80 g	0.02 d	6.62 a
Tretep	33.43 e	10.06	5.87	9.31	91.65 de	-0.81 b	10.42 d
Tlogomulyo	23.90 c	9.65	4.89	8.48	90.60 bc	0.25 e	9.02 bc
Sili	26.67 d	9.32	5.27	8.38	89.95 b	-0.78 b	10.54 d
Kodok	19.80 a	9.00	4.58	7.89	91.50 cd	-0.67 b	10.65 d
Bisi 2	33.23 e	9.60	4.99	9.75	88.09 a	-1.43 a	24.79 e
Pulut	23.67 c	8.51	3.57	9.98	92.56 ef	-0.20 c	9.09 c

Means in the same column followed by the same letter are not significantly different by 0.05 DMRT

starch granule. This problem create hydrophobic layer around the granule, due to adsorption process by the surface of granule. The layer of fat will then inhibit the binding of water by granule. This will cause the viscosity and stickiness of starch to be reduced due to the reduced amount of water available for the occurrence of the development of granule. Knowing the fat content in maize grain on a product will then helps in the determination of objectives and the creation of the product. From the results of the analysis, the fat content of maize grains is 3.21-4,24%. Maize grains of Sili local and Tretep local varieties have the lowest and the highest fat content respectively.

As raw material for a product, maize grains is expected contains high of protein. This relates to utilization for food and/or feed. Thus not to require substitution materials in its application. The results of the analysis of protein from maize grains of eight varieties is 6.74-10.96%. Highest levels of a protein is found in Pulut (10.96%), and the lowest in Srikandi Putih (6.74%).

Characterization of the Functional Properties of Starches and Fiber Seed of Corn

Starch content is an important criterion of flour quality as food and non-food products. Natural starch is a mixture of amylose which starch formula with elongated chains, and amylopectin with branching chains. Amylose and amylopectin ratio greatly affects to the processing of corn. While soluble fiber, insoluble fiber and starch digestibility also affect the functional properties of foods.

The amylose content is amounts of amylose in the starch granules. Amylose has very important role in the process of gelatinization and has a lot influence on the characteristics of the starch paste. Starch with high amylose content has hydrogen bond strength greater as the number of straight-chain in the granule, thus requiring great energy for gelatinization or boiling of maize starch.

1. Amylose

Amylose content in maize grains of eight varieties is 15.71-29.02% and the ratio of amylose / amylopectin is 0.18-0.42% (Table 4). Grains of Pulut local variety showed the lowest of amylose content, and grains of Anoman and Srikandi Putih varieties showed the highest of amylose content. The large ratios of amylose and amylopectin will produce a hard maize gritz. and the small ratios amylose and amylopectin will produce a fluffier or sticky maize gritz (waxy maize). This result showed that local maize grains is a fluffier maize suitable used for public consumption, because the amylose and amylopectin ratio is below 40%.

2. Properties of functional food of maize grains

Dietary fiber is a component of food that can not be digested by the human body. Various studies have shown that its role is very important in health care, so that is inserted into the components that have functional properties (functional food). Even the WHO in 2003 has established that dietary fiber has the ability to lose weight and obesity are associated with hormone systems in the body to digest and control hunger.

Tablel 2. Physical properties of maize grains from eight varieties.

Varieties	Bulk density (g/ml)	Specific weight (g/ml)	Thermal conductivity (w/m°c)
Srikandi Putih	0.659 a	1.055	0.263
Anoman	0.674 a	1.058	0.256
Tretep	0.799 d	1.188	0.268
Tlogomulyo	0.757 bc	1.262	0.270
Sili	0.776 c	1.205	0.275
Kodok	0.737 b	1.156	0.268
Bisi 2	0.806 d	1.012	0.273
Pulut	0.751 b	1.150	0.262

*Means in the same column followed by the same letter are not significantly different on 0.05% DMRT

Table 3. The chemical composition of maize grains from eight varieties.

Varieties	Moisture	Ash	Fat	Protein	Carbohydrate
Srikandi Putih	7.16 b	1.26 c	3.49 b	6.74 a	81.35 c
Anoman	5.93 a	1.50 cd	4.13 c	8.50 c	79.95 b
Bisi 2	11.01 c	1.24 c	3.85 b	8.95 c	74.95 a
Tretep	9.67 ab	1.32 c	4.24 c	8.87 c	75.90 a
Kodok	9.97ab	1.73 d	3.88 b	9.56 d	74.86 a
Sili	11.49 c	0.42 a	3.21 a	9.61 d	75.26 a
Tlogomulyo	9.75 ab	1.61 d	3.28 a	8.30 c	77.07 ab
Pulut	8.30 b	1.59 cd	3.78 b	10.96 e	75.37 a

* Means in the same column followed by the same letter are not significanly different on of 0.05 DMRT

Table 4. Ratio amylose, amylopectin, and functional properties of maize grains from eight varieties.

Varieties	Amylose (%)	Ratio of amylose/ amylopectin	insoluble fiber (%)	Soluble fiber (%)	Starch digestibility (%)
Srikandi Putih	29.02	0.41	6.49	1.18	68.13
Anoman	29.37	0.42	5.73	1.22	65.44
Bisi 2	26.19	0.35	6.09	1.29	68.89
Tretep	25.38	0.34	5.28	1.32	71.46
Kodok	27.67	0.38	5.02	1.12	70.46
Sili	23.84	0.31	6.06	1.09	74.95
Tlogomulyo	28.31	0.39	5.91	1.06	69.45
Pulut	15.71	0.18	6.60	1.15	72.32

Dietary fiber consist soluble and insoluble. This experiment showed insoluble dietary fiber content in maize grains is 5.02-6.60%, while soluble fiber is 1.06-1.32% (Table 4). The results indicate that maize grains contains high fiber foods and soluble fiber is also quite high, so it can be said to have the properties of functional food that is high enough. The amount of digestible fiber indicated this materials can be used as a prebiotic in the digestive tract. Fiber can hinder adhesion pathogenic microorganisms (such as *E. coli, Salmonella and Helicobacter pyroli*) in the gut wall (Sheerman 2008).

Starch digestibility is a parameter that indicates the ability of starch to be digested and absorbed in the body. When starch is digested, any type of starch will produce clusters monosaccharides, namely glucose will then be absorbed in the blood. Therefore, the body will stimulate the pancreas to produce insulin. The higher digestibility of starch cause the faster and more glucose is produced, so that the insulin needed to convert glucose into energy is also more amount. According to Englyst *et al.* (1999), Starch can be classified by their digestibility of starch into 3 groups, namely the rapid digestibility (rapidly digesting starch/RDS), the slowly digestibility (slowly digesting starch/SDS), and difficult to digest (resistant starch/RS). The number of RS is the total starch (total starch/TS) deducting the amount of RDS and SDS. While Resistant starch (RS) is defined as the fraction of resistant starch to hydrolyzed using digestive enzymes amylase and pullunase treatment in vitro (Englysh 1981). Starch digestibility is influenced by various factors, such as levels of amylose, amylopectin, protein, fat, fiber, processing and others. The digestibility of starch will vary depending on the composition of the constituent material. The digestibility of starch from maize kernels ranged from 65.44 to 74.95%, with the lowest is varieties of Anoman, and the highest is varieties of Sili. Local varieties have value relative starch digestibility higher than national superior maize varieties. These results are not much different from starch digestibility of Mamberamo rice variety reported by Widowati (2007), which reached up to 71.18%.

Table 5. The digestibility of starch and dietary fiber of maize grains fromf eight varieties.

Varieties of corn	Starch (%)	Fiber	
		Soluble (%)	Insoluble (%)
Srikandi Putih	64.92	6.72	1.26
Anoman	60.66	5.24	1.38
Bisi 2	66.68	6.82	1.42
Tretep	61.32	5.78	1.42
Kodok	61.55	5.91	1.28
Sili	63.28	6.71	1.19
Tlogomulyo	59.73	6.37	1.23
Pulut	60.46	6.32	1.36

Many fiber derived from the cell walls of various agricultural products, mainly various types of vegetables and fruits. The cell wall consists of several types of carbohydrates such as cellulose, hemicellulose, pectin, and a non-carbohydrate, such as lignin polymer.

The main function of soluble dietary fiber is decreasing rapidity of the digestion process in the intestine, providing a longer sense of fullness and slows down the appearance of blood glucose so insulin needed to transfer glucose into cells and converted into energy is less. Insoluble dietary fiber also serves to prevent the onset of various diseases, especially those related to the gastrointestinal tract, such as hemorrhoids, diverticulosis, and colon cancer. Levels of soluble dietary fiber from the eight varieties of maize kernels is 1.12-1.32%, the lowest is Kodok local variety and the highest is Tretep local variety (Table 5).

Two forms of starch in food are amylose and amylopectin. Amylose is a polymer of simple sugars that are not branched. While amylopectin is a branched polymer of simple sugars and have larger molecular size. Amylose more slowly digested than amylopectin. because amylose is a polymer of the simple sugar with a straight chain. This straight-chain amylose construct a solid bond that is not

easily tergelatinasi. Therefore. amylose is more difficult to digest than amylopectin which polymers of simple sugars. branched. and open structures. If the ratio of amylose and amylopectin is high. the digestibility of the starch will be low. This can be seen on a Srikandi putih and Anoman varieties which shows the ratio of amylose/amilopectin is high so the starch digestibility will be low (Table 4 and Table 5).

Crude fiber or soluble fiber can inhibit starch digestibility because these fibers can increase the viscosity or density of the mixture of food in the gut. it will inhibit the interaction of the enzyme with a mixture of food (starch). Based on Table 4. the levels soluble fiber of varieties Bisi 2 and local: Kodok. Sili, and Tlogomulyo show a lower value than the other varieties soluble fiber content. Varieties that have low levels of soluble fiber values will have higher digestibility starch (Table 4 and Table 5). So it can be stated that if a food has low soluble fiber content. it will be high digestibility starch.

Glycemic Index of **Corn** Gritz

With changing lifestyles and consumption patterns of society and the health paradigm from treatment to prevention, knowledge of food and nutrition is required. Changes in lifestyles and consumption patterns as the impact of the increasing in degenerative diseases, such as diabetes mellitus and hypertension.

The results showed that the rate of carbohydrate digestion in the gastrointestinal tract has a significant influence on the understanding of the role of carbohydrates in health. Each type of carbohydrate works in a different way. The glycemic index (GI) may provide clues to the physiological effects of food on blood sugar and insulin response. The glycemic index provides a more convenient and effective way to control fluctuations in blood sugar (glucose) blood. The introduction of carbohydrates based on their effect on blood glucose and insulin useful as a reference in determining the amount and type of food sources of carbohydrates which correct that will enhance and maintain health (Rimbawan and Siagian 2004). The glycemic index of diabetics allowed to choose the right type of carbohydrates to control blood sugar. By knowing the glycemic index of foods. people with diabetes can choose foods that do not raise blood sugar levels drastically so that blood sugar levels can be controlled at a safe level. Foods that have a low glycemic index helps people to control hunger. appetite and blood sugar levels. The glycemic index helps people who are trying to lose of the body weight by choosing fast food glut and durable (Miller *et al.* 1996).

Some research suggests that high GI foods cause insulin secretion in large amounts as a result of an increase in blood glucose levels are high and fast. Changes in blood glucose volunteers levels during the test GI at eight varieties of maize are presented in Table 6 and Figure 1.

Test of GI showed high increasing of glucose content in blood after 30 minutes consumed food from maize grains of eight varieties. This result is similar with experiment of Widowati *et al.* (2009). She was reported the highest increasing glucose content of blood on 30 minutes after someone consumed precooking rice of sevent varieties. Indrasari *et al.* (2008) also reported similar data after someone consumed food.

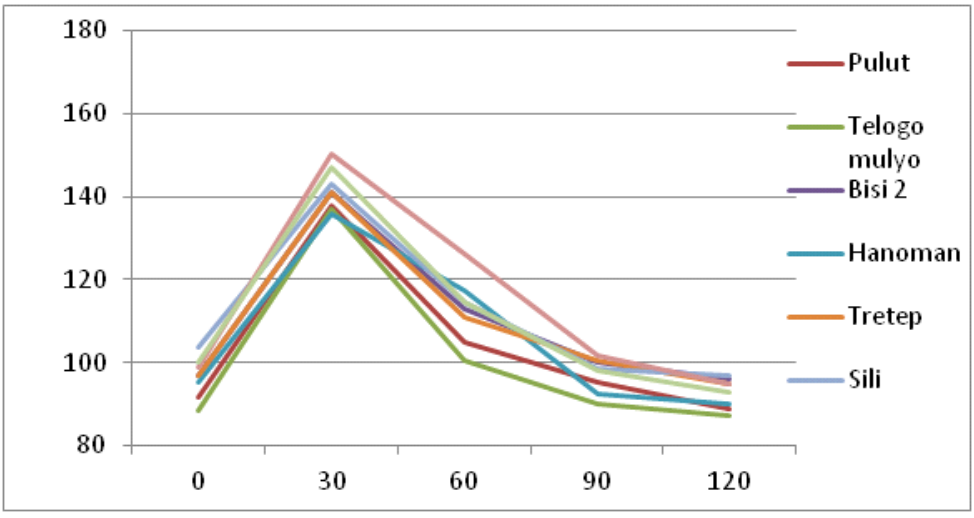

Figure 1. Fluctuation curve of glucose content in blood during GI examination of maize grains from eight varieties.

Table 6. Value and Glycemic Index (GI) categories of maize grains from eight varieties.

Varieties	IG value	Food Categories
Pulut	36.46	Low
Telogo Mulyo	33.36	Low
Bisi 2	35.43	Low
Anoman	36.40	Low
Tretep	37.50	Low
Sili	28.66	Low
Srikandi Putih	41.74	Low
Kodok	33.63	Low

Rimbawan and Siagian (2004) classified tree categories of GI i.e: low GI<55, medium GI = 55-70, and high GI>70. GI examination of maize grains from eight varieties were tested in this study showed low GI of all varieties (Table 6). Low increasing glucose content of blood was expected match with ability of insulin exretion. This kind of food suitable for diet of diabetics especially was caused by insulin deficiency both relatively and absolutely.

Conclusionse

1. Maize is source of fat, protein and carbohyrdrate for food products.
2. Digestibility of starch from maize grains of eight varieties is 59.73–66.68%. Dietary insoluble fiber content is: 5.02–6.60%
3. Glycemic index of maize grains from eight varieties is 28.66–41.74. This materials is suitable for consumption of diabetics people.

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