C-7

DETERMINATION OF GLYCEMIC SCORE OF PROCESSED FOOD FROM WHOLE WHEAT (*Triticum aestivum* L.) FLOUR DEWATA'S VARIETY IN TERMS OF AMYLOSE CONTENT AND STARCH DIGESTIBILITY

Febrine Pentadini*, Silvia Andini, Sri Hartini, Anik Tri Haryani

Chemistry, Science and Mathematics Department, Satya Wacana Christian University
Diponegoro street 52-60 Salatiga, Indonesia
652010002@student.uksw.edu
silvia.andini@staff.uksw.edu

ABSTRACT

Nowadays, whole wheat flour started to be like with Indonesian people. In Indonesia there is Dewata's variety of wheat. Whole wheat flour has average level of glycemic score (55-69). Dewata's whole wheat flour can be processed to be alternative food for diabetic with wet and dry processed. Amylose content and starch digestibility are related to determine glycemic score. Higher amylose content and lower starch digestibility will show low glycemic score. The goal of this research is to determine glycemic score, amylose content, and starch digestibility of processed food from whole wheat flour. The products are noodle and cookies. Amylose content be determined from gelatinization method with iod reagent and measured with spectrophotometer, and starch digestibility use enzymatic method with α-amylase enzyme. Wet and dry processed food are make from substitution of whole wheat flour to wheat flour 0%, 10%, 20%, 30%, 40% dan 50%. Amylose content for noodle is 32.2-38.48% (db) increase with substitution increase. For cookies is more constant 29.4-33.25% (db). Starch digestibility of noodle unchanged with increase of substitution, 10.92-13.15% (db) and cookies 6.67-11.32% (db). Glycemic score of noodle and cookies 20% lower than noodle and cookies without substitution. This score be obtained with incremental area under the blood glucose response curve (IAUC). The conclusion is glycemic score form processed food of whole wheat flour can be alternative food for diabetic.

INTRODUCTION

Now, whole wheat flour more famous and be liked with Indonesian people, because there are more nutrition than wheat flour. Nursantiyah's research (2009) said that wheat flour just made from endosperm component. Whole wheat flour made from bran, germ, and endosperm (Muoma, 2013). In Indonesia there are many variety of wheat that can be cultivate, one of them is Dewata's variety. Wheat Dewata's variety cultivate in Getasan, Semarang. With this cultivation, we need to develop processed food that make from whole wheat flour. Beside that, whole wheat flour has average glycemic score 55-69 (Brand-Miller dan Foster-Powell 1999). Low glycemic score foods are good for diabetic, because that food indirectly convert to blood glucose (Praptini, 2011). Processed food from whole wheat flour can be alternative food for diabetic.

Processed food from Dewata's whole wheat flour that selected are noodle and cookies. Both of them have different process. Noodle is wet processed and cookies is dry processed. Indonesian people like this food as evidence by increasing of consumption by 0,2% every year from 1990 until now (Survei Sosial Ekonomi Pertanian, 2004).

Glycemic score are influenced by amylose content and starch digestibility. Starchy foods are

rich in amylose content are associated with lower blood glucose levels and slower emptying of human gastrointestinal tract compared to those with low levels of amylose (Frei *et al*, 2003). Apart of amylose content, other starch properties such as granule size, degree of polymerization, and starch component also influence starch digestibility (Noda *et al*, 2008). Starch digestibility is parameters that show starch's ability to digest in body. Starch digestibility influenced many factor, there are amylose, amylopectin, protein, fat, fiber, and processing. This goal of this research to determine amylose content and starch digestibility from processed food of whole wheat flour and determine the glycemic score.

RESEARCH METHOD

This research is performed in Chemistry's Laboratory, Science and Mathematics Department, Satya Wacana Christian University (SWCU), Salatiga, Indonesia.

Materials and instrument

The main material is whole wheat flour Dewata's variety from Agricultural Department SWCU. Chemical reagent that used is I_2, KI, NaOH, standard glucose, ethanol, standard amylose, DNSA (dinitrosalysilic acid), $NaHPO_4$, Na_2HPO_4, standard maltose (E-Merck grade pro analysis, Germany), α-amylase enzyme (Agricultural Techonology, UGM, Indonesia), and distilled water.

The instrument are water content measurement (OHAUS, USA), incubator (WTB binder, Germany), spectrophotometer (Optizen 2120 UV, Korea), waterbath (Memmert, Germany), digital analytic balance (OHAUS, USA), glucose blood test (Easy Touch GU, Taiwan), dan glassware (pyrex, USA).

Method

Produce whole wheat wet noodle

Producing wet noodle in this research use whole wheat flour that substituted with wheat flour 10 %, 20%, 30%, 40% and 50%. As a control is wet noodle without substitution of whole wheat flour.

Table 1. Formulation of wet noodle

Material	Substitution of whole wheat flour					
	0%	10%	20%	30%	40%	50%
Wheat flour (g)	500	450	400	350	300	250
Whole wheat flour (g)	0	50	100	150	200	250
Egg	1	1	1	1	1	1
Salt (g)	3	3	3	3	3	3
Baking powder (g)	0.5	0.5	0.5	0.5	0.5	0.5

Produce whole wheat cookies

Producing cookies in this research use whole wheat flour that substituted with wheat flour 10 %, 20%, 30%, 40% and 50%. As a control is wet noodle without substitution of whole wheat flour.

Table 2. Formulation of *cookies*

Material	Substitution of whole wheat flour					
	0%	10%	20%	30%	40%	50%
Wheat flour (g)	100	90	80	70	60	50
Whole wheat flour (g)	0	10	20	30	40	50
Sugar (g)	30	30	30	30	30	30
Butter (g)	50	50	50	50	50	50

Amylose Content (Apriyantono *et al.* 1989 dalam Gustiar 2009)

Amylose standard curve

Weighed carefully 40 mg standard amylose, included to capped test tube, add 1 mL ethanol 95%

and 9 mL NaOH 1 M. The tube be heat in waterbath 95^{o}C for 10 minute. Starch gel poured carefully to 100 mL flask and add water. From this solution pipetted 1, 2, 3, 4, dan 5 mL and poured every solution to 100 mL flask. Add 0.2, 0.4, 0.6, 0.8, dan 1.0 mL acetat 1 M and 2 mL iod reagent (0.2 g I_2 and 2 g KI dissolved in 100 mL water) and add water until 100 mL. Wait for 20 minute, and measure the absorbance using spectrophotometer with wavelength 625 nm.

Sample analysis

100 mg sample entered to capped test tube. add 1 mL ethanol 95% and 9 mL NaOH 1 M. The tube be heat in waterbath 95^{o}C for 10 minute. Starch gel poured carefully to 100 mL flask and add distilated water. Pipetted 5 mL starch solution and poured to 100 mL flask. Add 1.0 mL acetat 1 M and 2 mL iod reagent and add water until 100 mL. Wait for 20 minute, and measure the absorbance using spectrophotometer with wavelength 625 nm

Starch digestibility (Muchtadi *et al.* 1992)

1 g sample entered to 250 mL erlenmeyer and add 100 mL water, cover it with aluminum foil and heated in waterbath until the temperature is 90^{o}C while stirring. Cooled the sample and pipetted 2 mL from this solution to capped test tube, add 3 mL water dan 5 mL buffer phosphat 0.1 M pH 7.0. Every sample make twice, the one as blank. Incubate the capped test tube with 37^{o}C for 15 minute. Add incubated solution with 5 mL α-amylase enzyme (1 mg/mL in buffer phosphat pH 7.0) for sample and 5 mL buffer phosphat 0.1 M pH 7.0 for blank. Incubate again for 30 minute. 1 mL result solution from incubating poured to covered test tube that contain 2 mL DNSA. Heat the solution for 12 minute in boiled water and cooled with flow water and 10 mL water. The absorbance can measure in wavelength 520 nm. Standard curve made from DNS's treatment to 0.0, 0.2, 0.4, 0.6, 0.8, and 1.0 mL standard maltose 0.5 mg/mL.

Organoleptic (Idris, 1994)

Organoleptic examination is examination of color, flavor, taste, and texture of food production. The score use line scale. The valuation will do by 30 panelist. The product that wil examination is whole wheat noodle and cookies and wheat noodle and cookies. After that use data analysis with t-Test.

Glycemic score examination (El, 1999 modificate in Gustiar, 2009)

The food that will determine the glycemic score must analyzed as proximate to determine total food that will be consumpt by panelist (contain 50 g carbohydrate). Panelists must do fasting for 10 hours. Panelists that used is 10 human that health with normal BMI (Body Mass Index). 2 hours after consumed the product, the blood will test every 30 minute to measure the glucose blood. For standard, the food product change with standard glucose. Glucose blood (every 30 minute) plotted to 2 X and Y axis. X is time and Y is glucose blood.

Data Analysis

Data will analysis with Randomized Complete Block Design (RCBD) with 6 treatment and 4 repetition. As treatment is concentration of substitution of whole wheat flour. Average of examination analyzed with Tukey HSD 5% (Steel dan Torrie, 1980).

RESULT AND DISCUSSION

Amylose Content

Starch is homopolymer form from glucose with α-glycosidic bond. Starch consist of two different polymers, there are straight compound (amylose) and branched compound (amylopectin) (Muchtadi *et al.* 2006). Amylose is sraight homopolymer α-D-glukosa that

connected by α-(1,4) glycosidic bond that soluble in boiled water. Amylose content in starch is divided into 4 level there are lowest amylose content < 10%, low amylose 10-20%, average amylose 20-24%, and high amylose > 25% (Aliawati 2003). Most of scientist claim that amylose is slower to digest (Miller *et al*. 1992; Foster-Powell *et al*. 2002; Behall and Hallfrisch 2002), because amylose is simple polymer with straight chain. This chain make bond of amylose streonger so can't gelatinization easly.

Amylose content of whole wheat noodle is 28-33% and cookies 30-34%. Amylose in cookies is higher than noodle. Although the different is not too high, that is appropriate with Carreira's research (2004) that amylose influence by gelatinization level and processed food that dry processed food has higher amylose that wet processed food. Because wet processed food has fast gelatinization process, so influence total soluable starch. It cause structure of starch gel will weakened by absorbed of water. The weak bond make water easily enter the granule so amylose will soluble in water (Suardi, 2002).

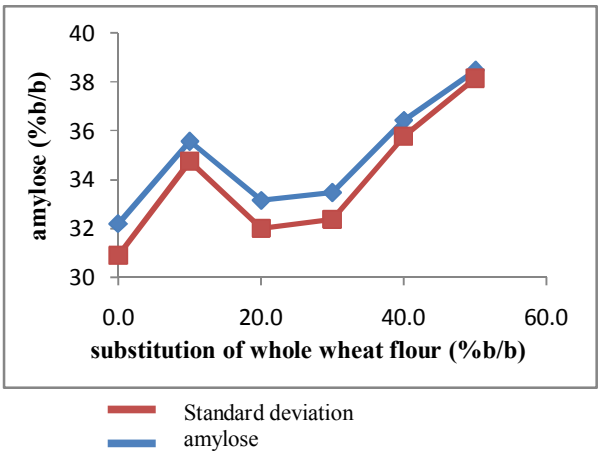

Fig 1. Relation between amylose content and substitution of whole wheat flour in noodle

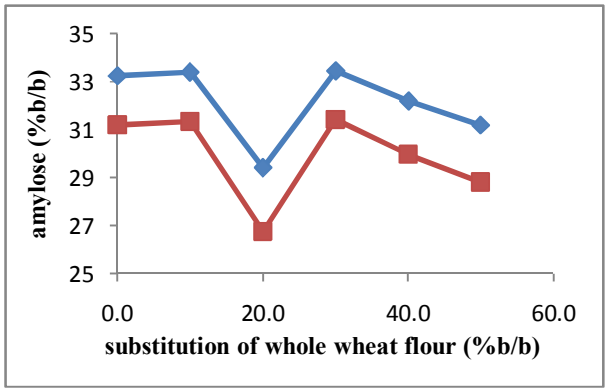

Fig 2. Relation between amylose content and substitution of whole wheat flour in cookies

Starch Digestibility

According to Willet *et al*. (2002), slow absorbed carbohydrate will produce low glucose blood and potential to manage starch digestibility that be affected by amylose composition. This measurement using enzymatic method, the enzyme is α-amylase. Using this enzyme because they can split sample through hydrolysis process to be their smaller unit, such as maltose (Gustiar, 2009). Maltose is sugar that can be absorbed in intestinal. To determine starch digestibility, do the measurement of maltose. Starch digestibility of whole wheat noodle is 10-12% (db) and cookies is 6-11% (db). More adding of whole wheat flour so the starch digestibility is lower. That is appropriate with amylose content in processed food. Amylose content and their composition is have effect to starch digestibility (Indrasari,2008).

Table 3. Comparing starch digestibility in noodle and cookies

Substitution of whole wheat flour (%)	Starch digestibility % (b/b)	
	noodle	Cookies
0	12.37±29.1066 ab	8.59±17.5145 ab
10	10.92±25.6829 a	6.67±13.5918 a
20	11.82±27.8006 a	6,69±13.6377 a
30	12.34±29.0478 ab	8.50±17.3209 ab
40	13.15±30.9360 b	7.50±15.2831 ab
50	12.38±29.1301 ab	11.32±23.0725 b

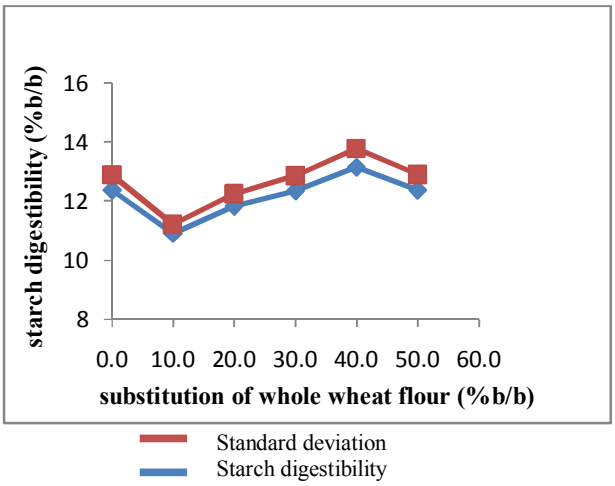

Fig 3.. Relation of between starch digestibility and substitution of whole wehat flour in noodle

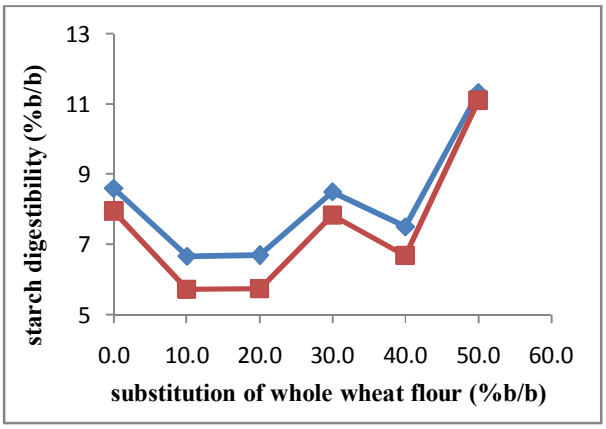

Fig 4. Relation of between starch digestibility and substitution of whole wehat flour in cookies

From this result, starch digestibility for wet processed food (noodle) is bigger than dry processed food (cookies). That is appropriate with amylose content of dry processed food is higher so the starch digestibility of cookies will be lower. Food processing is affect to starch digestibility (Noda *et al*, 2008).

Organoleptic

Table 4. Organoleptic of whole wheat noodle

Parameter	Penambahan tepung gandum utuh (%)					
	0	10	20	30	40	50
Color	4.33 ± 0.2919 c	3.83 ± 0.2869 b	3.67 ± 0.3111 b	3.17 ± 0.2658 ab	2.83 ± 0.3248 a	2.50 ± 0.4139 a
Flavor	3.10 ± 0.3583 a	3.47 ± 0.2898 a	3.63 ± 0.2856 ab	3.50 ± 0.2730 a	3.40 ± 0.2703 a	3.43 ± 0.3757 a
Texture	3.90 ± 0.3154 bc	3.83 ± 0.2955 b	3.90 ± 0.2998 bc	3.27 ± 0.3090 a	2.97 ± 0.3175 a	3.17 ± 0.4053 a
Taste	4.03 ± 0.2296 bc	3.97 ± 0.2296 bc	3,70 ± 0.2432 b	3.50 ± 0.2137 b	3.10 ± 0.3303 a	2.77 ± 0.3205 a

1 : really don't like; 2 : don't like; 3 : neutral; 4 : like; 5 : really like

Table 5. Organoleptic of whole wheat cookies

Parameter	Penambahan tepung gandum utuh (%)					
	0	10	20	30	40	50
Color	4.2000 ± 0.2842 ab	3.5333 ±0.3059 a	4.0333 ± 0.2076 ab	3.4333 ± 0.3114 a	3.0333 ± 0.2497 a	3.0333 ± 0.3600 a
Flavor	3.6333 ±0.3175 a	3.4667 ± 0.3059 a	3.8667 ± 0.3059 b	3.5000 ± 0.2471 a	3.6000 ± 0.2703 a	3.7000 ±0.3556 a
Texture	3.9333 ± 0.3242 bc	3.2667 ± 0.2762 a	4.0667 ± 0.2582 bc	3.7667 ± 0.2889 b	3.3000 ± 0.2622 a	3.7667 ± 0.3351 b
Taste	3.7667 ± 0.3492 a	3.7667 ± 0.2535 a	3.6333 ± 0.2682 a	3.7000 ± 0.3134 a	3.5000 ± 0.2547 a	3.9667 ± 0.3600 bc

1 : really don't like; 2 : don't like; 3 : neutral; 4 : like; 5 : really like

From this result, noodle that can accept with panelists is noodle with 10 and 20% substitution of wheat flour. For cookies is 20% substitution of wheat flour.

Glycemic Score

Glycemic score is leveling of food based on the effect with glucose blood. Food that can increase glucose blood faster has high glycemic score (Miller *et al*. 1992 in Rimbawan dan Siagian 2004). Glycemic score is unique nature, that's influence by their material, processing, and characteristic (composition and biochemistry nature) (Miller, 1992).

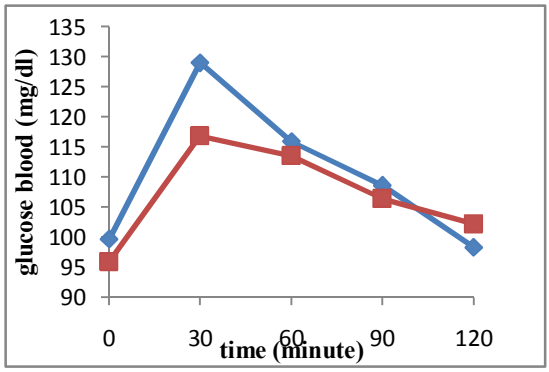

Fig 5. Glucose blood response to noodle

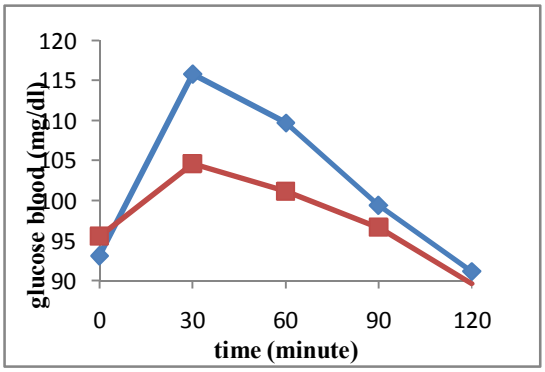

Fig 6. Glucose blood response to cookies

Table 6. Average result of glucose blood response

Sample	Time (minute)					Area under curve	IG
	0	30	60	90	120		
Glucose	102,4	152,1	131,1	108,2	94,9	29403	100
Whole wheat noodle 0%	99,7	129	115,9	108,6	98,3	20397	69,49
Whole wheat noodle 20%	95,9	116,8	113,5	106,4	102,2	19449	66,23
Whole wheat cookies 0%	93,1	115,8	109,7	99,4	91,1	15273	52,11
Whole wheat cookies 0%	95,5	104,6	101,1	96,6	89,6	14622	49,94

Comparing the area under curve from control and acceptance wet and dry processed food with glucose (standard), glycemic score can be obtained.

Glycemic score of whole wheat noodle 0% and 20% are 69.49±1.37 and 66.23±6.14. And glycemic score of whole wheat cookies 0% and 20% are 52.11±2.07 and 49.94±1.90. Glycemic score of whole wheat noodle is in average level (55-69) and cookies in low level (<55).

CONCLUSION AND SUGGESTION

Amylose content of whole wheat noodle is 32.2-28.48% and whole wheat cookies 29.4-33.25%. Starch digestibility of whole wehat noodle is 10.92-13.15% and whole wheat cookies 6.67-11.32%. Through the organoleptic whole wheat noodle and cookies that can accept is with 20% substitution. Glycemic score of whole wheat noodle is 66.23±6.14 is in average level of glycemic score and cookies 49.94±1.90 low glycemic score.

Suggestion for the next research is substitution of whole wheat be expected more than 20% so can get lower glycemis score, but must remains to be accept by people.

BIBLIOGRAPHY

Behall, K.M. and J. Hallfrisch. 2002. Plasma glucose and insulin reduction after consumption of bread varying in amylose content. Eur. J. Clin. Nutr. 56(9):913-920.

Brand-Miller J, Hayne S, Petocz P, dan Colagiuri S. 2003. Low-glycemic index diets in the management of diabetes: A meta-analysis of randomized controlled trials. Diabetes Care, 26, 2261–2267.

Carreira, M.C., F.M. Lajolo, and E.W. de Menezes. 2004. Glycemic index: effect of food storage under low temperature. Brazilian Archives of Biology and Technology 47(4):569.

Foster-Powell K dan Miller B. 1995. International tables of glicemic index. American Journal of Clinical Nutrition. 62 : 871s-893s.

Frei, M., Siddhuraju, P. and Becker, K. 2003. Studies on the in vitro starch digestibility and the glycemic index of six different indigenous rice cultivars from the Philippines. Food Chemistry 83 : 395-402.

Gustiar, Haris. 2009. Sifat Fisiko-Kimia dan Indeks Glikemik Produk *Cookies* Berbahan Baku Pati Garut (Maranta arundinacea L.) Termodifikasi. Bogor : IPB.

Idris, S. 1994. Metode Pengujian Bahan Pangan Sensoris. Fakultas Peternakan. Universitas Brawijaya. Malang.

Ludwig DS. 2000. Dietary glycemic index and obesity. *J Nutr* Supl 130: 280S- 283S

Muchtadi D, Palupi NS, dan Astawan M. 1992. Metode Kimia, Biokimia, dan Biologi dalam Evaluasi Nilai Gizi. Pusat Antar Universitas Pangan dan Gizi.IPB, Bogor.

Muoma, Ike. 2013. Whole Grain Vs Whole Wheat Vs Whole Meal Vs GranaryRefined Bread? Which is best? What to choose?. URL www.iketrainer.co.uk/articles/breads.pdf. Diakses pada 15 September 2013.

Noda, T., Takigawa, S., Matsuura-Endo, C., Suzuki, T., Hashimoto, N., Kottearachchi, N.S., Yamauchi, H. and Zaidul, I.S.M. 2008. Factors affecting the digestibility of raw and gelatinized potato starches. Food Chemistry 110 : 465-470

Nursantiyah. 2009. Gambaran Umum Industri Tepung Terigu di Indonesia dan Ketentuan Pajak Pertambahan Nilai Terkait. Jakarta : UI.

Praptini, P.E. 2011. Menu 30 Hari dan Resep untuk Diabetes. Jakarta : PT. Gramedia Pustaka Umum

Pusat Penelitian dan Pengembangan Sosial Ekonomi Pertanian. 2003. Trend Konsumsi Pangan Produk Gandum di Indonesia. Warta Penelitian dan Pengembangan Pertanian Indonesia , 25, hal. 11-12.

Ratnaningsih. 2010. Pembuatan Tepung Komposit dari Jagung, Ubikayu, Ubijalar dan Terigu (Lokal dan Impor) untuk Produk Mi. Bogor : Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian.

Rimbawan dan A. Siagian. 2004. Indeks glikemik pangan. Penebar Swadaya. Jakarta

Simanjutak, B.H. 2002. Prospek Pengembangan Gandum (*Triticum aestivum L*) di Indonesia. Salatiga : Universitas Kristen Satya Wacana.

Suardi, Suarni, A. Prabowo. 2002. Prosesing Sorgum sebagai Bahan Pangan. Sulawesi Selatan : Seminar Nasional Balai Pengkajian Pertanian