Original Article

Use of Jakr-Na-Rai (*Gynura divaricata*) as a Roughage Source on Growth Performance, Blood Constituent, Blood Glucose and Cholesterol Level in Growing Rabbits

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Abstract

The objective of this study was to investigate Jakr-Na-Rai (*Gynura divaricata*) as a roughage source on growth performance, blood constituent, blood glucose and cholesterol in growing rabbits. Twenty-four 7-week-old New Zealand White rabbits (12 males and 12 females) were randomly allocated into 3 groups of 8 with equal sex. The rabbits in the first group were fed on commercial feed while the rabbits in the 2nd and 3rd groups were fed the same as first group and supplemented with para grass (*Brachiaria mutica*) and Jakr-Na-Rai, respectively. The rabbits were raised in individual cages in opened house and received feed and water *ad libitum* for 4 weeks. Daily feed intake and body weight at the start and the end of the trial were recorded. Blood samples were collected for measurement of blood constituent, blood glucose and cholesterol level. Result showed that there was no significant difference in total dry matter intake, weight gain and feed conversion ratio ($p > 0.05$). Blood constituent at the beginning and the end of the experiment, except heterophil value at the start, also did not show any significant differences ($p > 0.05$). A significant difference in blood glucose was detected between the rabbits consuming Jakr-Na-Rai and para grass ($p < 0.05$) while their cholesterol levels were not significantly different ($p > 0.05$). In conclusion, Jakr-Na-Rai can potentially lower blood glucose but had no effect on blood cholesterol. Furthermore, insoluble fiber is not the active part in lowering blood glucose or blood cholesterol levels.

Keywords: cholesterol, glucose, growth, *Gynura divaricata*, insoluble fiber, rabbits

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บทคัดย่อ

การใช้จักรนารายณ์ (*Gynura divaricata*) เป็นแหล่งอาหารหยาบต่อสมรรถภาพการเจริญเติบโต ส่วนประกอบของเลือด ระดับน้ำตาลและคอเลสเตอรอลในเลือดกระต่ายระยะเจริญเติบโต

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ศึกษาการใช้จักรนารายณ์เป็นแหล่งอาหารหยาบต่อสมรรถภาพการเจริญเติบโต องค์ประกอบเม็ดเลือด ระดับน้ำตาลและคอเลสเตอรอลในเลือดกระต่ายระยะเจริญเติบโต โดยใช้กระต่ายพันธุ์นิวซีแลนด์ไวท์ อายุ 7 สัปดาห์จำนวน 24 ตัว เป็นเพศผู้ และเพศเมีย อย่างละ 12 ตัว สุ่มแบ่งออกเป็น 3 กลุ่มๆละ 8 ตัวเป็นเพศผู้และเพศเมียอย่างละครึ่ง กลุ่มที่ 1 ได้รับเฉพาะอาหารสำเร็จรูป กลุ่มที่ 2 และ 3 ได้รับอาหารสำเร็จรูป เสริมด้วยหญ้าขน และจักรนารายณ์ ตามลำดับ กระต่ายถูกเลี้ยงขังเดี่ยวในโรงเรือนเปิด ได้รับน้ำและอาหารอย่างเต็มที่ เป็นระยะเวลานาน 4 สัปดาห์ เก็บข้อมูลปริมาณอาหารที่กระต่ายกินทุกวันและชั่งน้ำหนักกระต่ายเมื่อเริ่มต้นและสิ้นสุดการทดลอง ทำการเก็บเลือดเพื่อตรวจวัดองค์ประกอบของเม็ดเลือด ระดับน้ำตาลและคอเลสเตอรอล จากการทดลองพบว่า ปริมาณอาหารที่กินทั้งหมด น้ำหนักตัวที่เพิ่มขึ้น และอัตราการเปลี่ยนอาหารเป็นน้ำหนัก ไม่มีความแตกต่างกันทางสถิติ ($p> 0.05$) องค์ประกอบของเลือดเมื่อเริ่มต้นและสิ้นสุดการทดลองยกเว้นค่าเฮเทอโรฟิลเมื่อเริ่มต้นไม่มีความแตกต่างกันทางสถิติ ($p> 0.05$) ระดับกลูโคสของกระต่ายกลุ่มที่ได้รับจักรนารายณ์และหญ้าขนมีความแตกต่างอย่างกันมีนัยสำคัญ ($p< 0.05$) ขณะที่ระดับคอเลสเตอรอลไม่มีความแตกต่างกันทางสถิติ ($p> 0.05$) สรุปได้ว่าจักรนารายณ์สามารถลดระดับน้ำตาลในเลือดกระต่ายได้แต่ไม่สามารถลดระดับคอเลสเตอรอล นอกจากนี้เยื่อใยที่ไม่ละลายน้ำไม่ได้เป็นตัวการในการลดระดับน้ำตาลในเลือดหรือระดับคอเลสเตอรอลในเลือด

คำสำคัญ: คอเลสเตอรอล กลูโคส การเจริญเติบโต *Gynura divaricata* เยื่อใยที่ไม่ละลายน้ำ กระต่าย

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Introduction

Jakr-Na-Rai *(Gynura divaricata)* is an interesting herb which originated from China and can generally be found in several parts of Asia. Its common names in Thailand are Jin-Chee-Muo-Yea, or Jakr-Na-Rai (Aritajatet al., 2008). Jakr-Na-Rai's outstanding curative effect is lowering blood glucose (Jiang et al., 2009; Liet al., 2009; Deng et al., 2011; Wu et al., 2011). Principle chemical compounds that has been reported in Jakr-Na-Rai are flavonoids, phenolics (Wan et al., 2011; Wu et al., 2011), cerebrosides (Chen et al., 2009), alkaloids (Roeder et al., 1996), polysaccharide, terpenoids, and sterols (Chen et al., 2003; Chen et al., 2009). Mode of action of lowering blood glucose is still unclear. Deng et al. (2011) suggested that the polysaccharide isolated form pieces of *G. divaricata* exerted an anti-diabetic effect partly via inhibiting the increased activities of intestinal disaccharidase in the streptozotoxin-induced diabetic rat but this effect was not shown in normal rat. Wu et al. (2011) reported that flavonoids and alkaloids in water extracted from aerial parts of *G. divaricata* (L.) DC played an important role in α-amylase and α-glycosidase inhibition *in vitro*. Li et al. (2009) demonstrated that both water extract and 95% ethanol extract of fresh stems and leaves of *G. divaricata* significantly lowered blood glucose in normal and alloxan-diabetic mice. Contradictory result was reported by Aritajatet al. (2008) that water extracted from fresh leaves of *G. divaricata* had no effect on lowering blood glucose but could reduce blood triglyceride and increase blood cholesterol in normal male rats. The inconsistent results from previous studies could be due to the differences in herbal parts, extraction methods, active ingredients, health status of experimental animals (normal vs. diabetic) and experimental setup (*in vivo vs. in vitro*). Williamson (2001) reported that using whole plant extract showed better synergistic effect than using sum of its parts, which may be due to the more completeness of the collection of its active ingredients. He proposed that because of the synergistic effect, unstable constituents, unknown active ingredient and the amount of active ingredients were the causes of unsuccessful result of using isolated or fractionated plant extract. Furthermore Gidenne and Bellier (2000), Gidenne et al. (2000) and Gidenne et al. (2004) indicated that high insoluble fiber (NDF and ADF) in

rabbit diet could decrease transit and absorption time, therefore insoluble fiber might be another factor affecting the changing in blood glucose. In addition, Patathanasopoulous and Camilleri (2010) stated that insoluble fiber had small cholesterol-lowering effect and was not related to the induction of bile acid loss. However, van Bennekum et al. (2005) demonstrated that soluble fiber could lower blood cholesterol by reducing hepatic cholesterol production in both low and high cholesterol diet. Fernandez (1995) suggested that lowering plasma cholesterol effect greatly resulted from different mechanisms that were specific to each fiber type and level. Thus, para grass which is high in insoluble fiber (DLD, 2008) was included in the present experiment to compare and contrast the effect of insoluble fiber in Jakr-Na-Rai's whole plant.

Therefore, the aim of current study was to investigate the effect of fresh whole Jakr-Na-Rai herb and insoluble fiber in para grass fed to growing rabbits on growth performance, nutrient intake, blood constituent, blood glucose and cholesterol.

Materials and Methods

Animal and Management: Twenty-four 7-week-old New Zealand White rabbits (12 males and 12 females) were randomly allocated into 3 groups of 8 with equal sex. The rabbit was individually raised in wire cage size 50x55x40 cm with feeder and nipple. Feed and water could be freely accessed in opened house with natural light. The rabbits were allowed to acclimatize to new environment for 3 days before the experiment started. The average starting body weight was 1.1±0.1 kg. The temperature and relative humidity were recorded every day at 09:00 a.m. and 3:00 p.m. by using digital thermometer (BILTEMA®). The average temperature and relative humidity for entire experimental period were 31.2±2.6^{0}C and 62±0.1%, respectively. The experimental protocol was approved by the Institutional Laboratory Animal Care and Use Committee of the Faculty of Veterinary Science, Chulalongkorn University. No. 1131058

Feed and Feeding: Feed used in this experiment comprised commercial completed rabbit feed (concentrate feed) in pellet form which was available in the market and two sources of roughage: para grass (*Brachiaria mutica*) and Jakr-Na-Rai *(Gynura divaricata*). There were three treatment groups in this experiment: 1) fed only commercial completed feed (control); 2) fed commercial completed feed supplemented with fresh para grass, and 3) fed commercial completed feed supplemented with fresh Jakr-Na-Rai. Jakr-Na-Rai was cultivated nearby the rabbit house and Para grass was naturally grown in our Veterinary training center at Nakornpathom province. Jakr-Na-Rai and para grass were cut 20 cm in length from the tip every day at 7:00 a.m. and washed with tap water before they were fed to the rabbits. Concentrate feed was always available 24 hours/day in Group 1. In the roughage groups (Groups 2 and 3), roughage was available *ad libitum* from 8:00 a.m. until 3:00 p.m. Afterward residual roughage was weighed out and commercial concentrated feed was introduced. At 8:00 a.m. of the next day residual concentrated feed of all groups were measured to calculate daily feed intake. Both commercial feed and roughage were fed in this regimen for 4 weeks long.

Data collection: Commercial completed feed, para grass and Jakr-Na-Rai were randomly collected for nutrient composition analysis. Feed intakes of concentrate and roughage were record every day. Residual roughage from each day was sun dried and kept at -20^{0}C until analyzed for residual roughage nutrients. General rabbit health status was evaluated daily basis. Stool was daily scored by visual grading system according to Russell et al. (1992) (scale 1 to 4: 1 = normal hard pellet, 2 = soft mushy stool, 3 = loose diarrhea, 4 = watery or liquid diarrhea). Body weight was measured at the start and the end of the trial. All rabbits were fasted for 12 hours (8:00 p.m. to 8:00 a.m.) prior to blood collection at the beginning and at the end of experimental period. Blood from lateral saphenous vein was kept in EDTA for blood constituent analysis (Efeoglu et al., 2004) and in heparin for cholesterol analysis (Georgiev et al. 2011). Blood droplets were immediately measured for blood glucose using digital blood glucose analyzer (Accu-Check Advantage II®) (Dondeti et al., 1995; Gupta et al., 2005).

Laboratory Analysis: Concentrated feed, para grass, Jakr-Na-Rai and residue roughage were analyzed for nutritional contents by Proximate analysis (AOAC, 1990) and Detergent analysis (van Soest et al, 1991). The residual roughage samples were pooled from 7-day collection within each replicate and then were equally pooled again within each treatment group to represent weekly residual roughage dry matter and nutrient contents. Actual weekly DM and nutrient intakes of roughage were then calculated by subtracting total DM and nutrients intake with these weekly residuals. Blood samples were analyzed for complete blood count by cell-DYN® 3700 (Shih et al., 2005) and blood cholesterol by Ilab®650 (Ypsilantis et al., 2011) at Small animal hospital, Faculty of Veterinary Science, Chulalongkorn University.

Statistical analysis: One-way Analysis of Variance (ANOVA) in completely randomized design was performed to determine treatment effects for body weight, average daily gain (ADG), feed conversion ratio (FCR), actual dry matter intake and nutrient intake. Significant differences among treatment means were compared by using Fisher's Least Significant Difference Test. Blood glucose and cholesterol differences between the beginning and the end of experiment were analyzed using Paired *t*-test. Statistical analysis was run by SPSS statistics 17.0and significant differences were considered at $p< 0.05$.

Results

Nutrient composition of commercial completed rabbit feed, para grass and Jakr-Na-Rai was presented in Table 1. Jakr-Na-Rai had the lowest crude protein and neutral detergent fiber values, but had the highest ether extract and ash. Jakr-Na-Rai's acid detergent fiber valve was in between commercial feed and para grass but its acid detergent lignin was the highest.

Growth performance: Body weight at the start and at the end of the experiment, ADG, and FCR were not significantly different (p> 0.05) among the treatment groups (Table 2). The control group had better FCR than the para grass group, but was not different to the Jakr-Na-Rai group (p= 0.051). No significant difference was detected in dry matter intake of concentrated feed (p> 0.05). For roughage, however, Jakr-Na-Rai's intake was significantly lower than para grass. Dry matter nutrient intake, crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and cellulose (ADF-ADL) showed significant difference (p< 0.05) among the treatment groups. Comparing with the control group, CP and NDF intake of Jakr-Na-Rai group did not differ while EE and ADF were different. When two sources of roughage were compared, only NDF, ADF and ADF-ADL had significant differences (Table 3).

Health status: None of the animals was suspected for any health issues. Stool characteristic scores for every group were on the normal hard pellet (score 1).

Blood constituent values: No significant difference in blood parameters both at the start and at the end of the experiment were found among the treatment groups except heterophil at starting period (Table 4). The rabbit in para grass group had lower heterophil count than the control and Jakr-Na-Rai groups (p< 0.05). However, all blood constituent values at the start and at the end were in normal reported range.

Table 1 Chemical analysis of nutrients in rabbit commercial completed feed, Para grass and Jakr-Na-Rai (g/kg DM)

Nutrients	Commercial feed	Para grass[1/]	Jakr-Na-Rai[1/]
Crude protein, CP	17.80	16.08	15.53
Ether extract, EE	2.27	2.20	3.74
Crude fiber, CF	13.17	31.44	12.73
Neutral detergent fiber, NDF	49.64	65.50	37.54
Acid detergent fiber, ADF	18.11	42.03	32.41
Acid detergent lignin, ADL	2.73	4.06	9.37

[1] Mean±SD

Table 2 Effect of Jakr-Na-Rai on growth performances (head/day)[1]

Growth Performances	Control	Para grass	Jakr-Na-Rai	P-value
Initial weight, kg	1.08±0.13	1.12±0.13	1.10±0.10	0.835
Final weight, kg	1.83±0.17	1.85±0.16	1.82±0.08	0.914
Average weight gain, g	26.79±3.88	25.98±3.45	25.62±2.75	0.738
Feed conversion ratio	3.48±0.44^{b}	4.16±0.70^{a}	3.96±0.40^{ab}	0.051

[1] Mean±SD

Table 3 Dry matter and nutrients intake per day (g/kg DM) of treatment groups[1, 2]

Intake	Control	Para grass	Jakr-Na-Rai	P-value
Total DM intake	92.24±9.95	106.65±12.88	100.79±7.08	0.34
Concentrate	92.24±9.95	93.49±12.10	92.05±6.40	0.950
Roughage	0^{c}	13.15±1.68^{a}	8.74±1.56^{b}	0.000
Nutrients intake				
CP	16.42±1.77^{b}	18.82±2.27^{a}	17.71±1.24^{ab}	0.048
EE	2.09±0.22^{b}	2.43±0.29^{a}	2.41±0.18^{a}	0.015
NDF	45.79±4.94^{b}	55.12±6.52^{a}	48.93±3.42^{b}	0.005
ADF	16.71±1.80^{c}	22.55±2.55^{a}	19.63±1.39^{b}	0.000
ADL	2.52±0.27^{b}	3.10±0.36^{a}	3.33±0.26^{a}	0.000
NDF-ADF	29.09±3.14	32.58±3.99	29.31±2.06	0.068
ADF-ADL	14.19±1.53^{c}	19.46±2.19^{a}	16.30±1.14^{b}	0.000

[1]Mean±SD

[2]a, b, c Means in a row with different superscripts are significantly different at p< 0.05

Table 4 Effect of Jakr-Na-Rai on blood constituents (fasted 12 hours) at start and the end of the experimental period [1,2]

Blood constituents		Unit	Normal range[3]	control	Para grass	Jakr-Na-Rai	P-value
Erythrocytes:	Start	x 10^6cells/µl	4.9-7.8	5.18±0.41	5.26±0.28	5.26±0.35	0.883
	Final	x 10^6cells/µl	4.9-7.8	5.42±0.32	5.54±0.52	5.48±0.25	0.826
Hemoglobin:	Start	g/dl	10-17.4	11.10±0.69	11.31±0.38	11.38±0.89	0.706
	Final	g/dl	10-17.4	11.30±0.69	11.43±0.91	11.39±0.58	0.937
Hematocrit:	Start	%	31-50	40.56±2.44	40.39±1.39	41.14±3.54	0.835
	Final	%	31-50	39.20±2.48	39.83±3.21	40.39±1.89	0.660
Platelets:	Start	x 10^3cells/µl	250-650	257.03±205.83	310.74±206.45	244.25±208.26	0.794
	Final	x 10^3cells/µl	250-650	313.33±130.92	347.19±200.45	295.02±262.77	0.876
Leukocytes :	Start	x 10^3cells/µl	5.2-12.5	3.21±2.21	2.86±1.09	2.87±1.08	0.876
	Final	x 10^3cells/µl	5.2-12.5	5.53±2.17	5.58±1.41	5.18±2.28	0.909
Heterophils:	Start	%	20-75	66.89±8.35[a]	52.84±14.36[b]	62.11±6.15[a]	0.036
	Final	%	20-75	46.54±10.42	63.49±8.95	48.63±21.76	0.066
Lymphocytes:	Start	%	30-85	17.22±7.35	31.15±19.47	22.05±6.12	0.102
	Final	%	30-85	41.04±12.14	23.79±8.49	35.11±21.05	0.845
Monocytes:	Start	%	2-10	14.40±4.59	14.89±6.71	14.23±2.13	0.961
	Final	%	2-10	11.00±4.53	10.13±2.31	11.55±3.10	0.712

[1]Mean±SD
[2]a, b Means in a row with different superscripts are significantly different at $p< 0.05$
[3]Mitchell and Tully (2009) and Banks et al. (2010)

Blood glucose and cholesterol: Blood glucose in all groups was decreased comparing between at the start and the end of the experiment; however, only the roughage groups showed significantly lower blood glucose level at the end of the experiment ($p< 0.05$). No significant differences ($p> 0.05$) in cholesterol level were found in all treatment groups (Table 5).

Table 5 Effect of Jakr-Na-Raion blood glucose and blood cholesterol (fasted 12 hours) at start and the end of the experimental period (mg/dl) [1,2]

Blood Parameters	Start	Final	P-value
Glucose			
Control	94.00±11.34	84.38±7.86	0.062
Para grass	99.38±5.04 [a]	89.50±6.00 [b]	0.005
Jakr-Na-Rai	96.63±7.15 [a]	85.55±6.58 [b]	0.039
Cholesterol			
Control	54.25±13.19	67.25±21.08	0.122
Para grass	52.25±10.14	57.88±21.94	0.526
Jakr-Na-Rai	62.63±18.21	62.50±12.14	0.986

[1] Mean±SD
[2] a, b Means in a row with different superscripts are significantly different at $p< 0.05$

Discussion

The nutrients composition of Jakr-Na-Rai based on dry matter in the present study was lower than that previously reported by Jaiboon et al. (2010) which was 176.7, 59.9, 165.3, 220.8 and 377.8 g/100g dry weight basis for CP, EE, CF, Ash and NFE, respectively; however, NDF, ADF and ADL were not reported. The differences could be due to the use of only leaves in the previous report compared with young whole plant (stem and leaves) in the current study. For the nutrient content of para grass in the present study, it was higher compared to that of a previous report in beef cattle feedstuffs by using aerial part of grass at age of 30 days (DLD, 2008). This implied that the age of para grass in the current study was older than 30 days due to the higher DM value of ADF (420.3 vs. 348 g/kg) and ADL (40.6 vs. 32 g/kg). Several reports indicated that the reduction in cellulose linearly increased mortality rate. Perez et al. (1996) examined cellulose level at 9.3, 12.5 and 15.9% in rabbit diet and found out that 9.3% fiber had the highest mortality rate regardless of the cellulose sources. In addition, Bennegadi et al. (2000) reported that decreased crude fiber in rabbit diet from 162 to 72 g/kg (air dry basis) frequently initiated digestive disorder, and increased mortality and health risk index. By comparing the fiber content of commercial completed feed used in the present study with the recommendation level (de Blas and Mateos, 2010), CP was in the recommendation range whereas CF, ADF and ADL were lower (131.7 vs 172.2, 181.3 vs 211.1, 27.3 vs 55 g/100g DM); NDF was higher (496.4 vs 377.7 g/100g DM). Although the CF level in the commercial completed feed used in this experiment was lower than the recommendation level, it had no

negative effect on rabbit health status.

Total dry matter intake was not significantly different among the treatment groups but dry matter intake of roughage was. Dry matter intake of roughage in the para grass group was higher than the Jakr-Na-Rai group because para grass was routinely fed in the colony. However, the average ADG was not significantly different among the treatment groups. The control group had better FCR compared to the para grass group while the Jakr-Na-Rai group did not differ from both the control and para grass groups. These could infer that commercial completed feed can fulfill all of rabbit's nutrient requirements especially in the aspect of fiber type and content. The increasing of NDF level in the diet from 300 to 360 g/kg adversely affected ADG, FCR and total tract apparent digestibility. This confirmed the optimum level of NDF that has been previously reported at 300 g/kg DM basis (de Blas et al., 1985; Gutierrez et al., 2002; Tao and Li, 2006). Gidenne et al. (1991) reported that high level of ADL intake reduced retention time in GI tract and consequently decreased nutrient digestibility and increased FCR. Perez et al. (1996) suggested that levels and sources of ADF-ADL could affect both growth performance and FCR and the addition of 1 unit of cellulose increased 0.1 unit of FCR. These could be used to explain the result of lower ADG and higher FCR in both roughage groups that were supplemented with Jakr-Na-Rai or para grass in present study which had higher NDF, ADF, ADL and ADF-ADL intake compared to the control group.

Red and white blood cell profiles were among the normal range and were not significantly different among the treatment groups (Mitchell and Tully, 2009; Banks et al., 2010). Blood glucose and blood cholesterol concentrations are the most important biochemical parameters in the present study, before and after feeding experiment were carefully measured after fasted for 12 hours. Harcourt-Brown (2004) and Banks et al. (2010) reported that the normal concentration ranges were 75.6-140.4 and 75-155 for blood glucose and 11.61-116.1 and 10-80 mg/dl for blood cholesterol in fasted rabbit with caecotrophy allowed. It is worth noted that the ranges are very wide because it is derived from several reports which were different in breeds, stress conditions, blood collection techniques, collection times, and analytical techniques (Harcourt-Brown, 2004). The average blood glucose and cholesterol data presented in this report could be a reference in healthy New Zealand White rabbit raising under conventional housing condition and fed *ad libitum* in tropical climate.

Before and after the treatment period, blood glucose levels were significantly different in both roughage supplemented groups ($p< 0.05$) while there was no significant difference in the control group. The percent change was highest in the Jakr-Na-Rai group (10.42%). The para grass and control groups came in second and third, respectively, which were 9.78% and 9.14%. Compared with the control group, NDF intake of the Jakr-Na-Rai group did not significantly differ but ADF and ADL intake was significantly different. Although the para grass group had higher NDF, ADF and ADF-ADL intake than the Jakr-Na-Rai group ($p< 0.05$), the change in blood glucose was lower. On the contrary, Gidenne and Bellier (2000), Gidenne et al. (2000) and Gidenne et al. (2004) indicated that the higher level of insoluble fiber intake decreased transit time and absorption time of nutrient, therefore, changes in blood glucose should be the highest. Hence, in this case, insoluble fiber had no effect on lowering blood glucose and it should be some other factors in Jakr-Na-Rai that involved which could be soluble polysaccharide, flavonoids or alkaloids. Jiang et al. (2009), Li et al. (2009) and Deng et al. (2011) reported that crude extract and active ingredient extract, soluble polysaccharide, and flavonoid from *G. divaricata* were proved to be the factors on lowering blood glucose both in normal and induced diabetic animals. Wu et al. (2011) reported that flavonoids and alkaloids in *G. divaricata* could inhibit α-glucosidase or α-amylase in digestive tract and Deng et al. (2011) reported that polysaccharide could have similar mechanism. Unfortunately, there is no literature on the active ingredients in para grass available because it is generally recognized as a feed ingredient not a herb, thus, only nutritional values have been reported. Moreover, the aim of using para grass in the present study was as an insoluble fiber source.

van Bennekum et al. (2005) demonstrated that insoluble fiber in diet could lower plasma cholesterol due to satiation and satiety effects as showed in the reduction in feed intake of high fat and high cholesterol diet in mouse and demonstrated that it was not due to the bile acid loss mechanism. Moreover, Fernandez (1995) reported that soluble fiber could lower blood cholesterol by inducing reduction in hepatic cholesterol in both low and high cholesterol diet and suggested that each fiber type and level has different mechanism on lowering plasma cholesterol. In addition to direct effect of dietary fiber on plasma cholesterol level, acetate, short chain fatty acid that is a product of fiber fermentation in rabbit intestine (Gracia et al., 2002), is mainly metabolized in liver and is one of the precursor for lipogenesis and cholesterogenesis (Vernay, 1987) and that may cause the increase of blood cholesterol. Although dietary fiber can increase or decrease plasma cholesterol via several mechanisms as previously described, in this experiment the different levels and types of fiber in each treatment group did not show any effect on blood cholesterol level.

In conclusion, this experiment indicated that supplementation of Jakr-Na-Rai as a roughage source in rabbit had no effect on growth performance and health status and it potentially could lower blood glucose. However, Jakr-Na-Rai had no effect on plasma cholesterol. Moreover, insoluble fiber was not the active part in lowering blood glucose and blood cholesterol level.

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