

PROFILE OF HEMOGLOBIN, GLUCOSE, AND TRIGLYCERIDES ON THE USE OF YACON PREBIOTIC SYRUP AS A NATURAL SUPPLEMENT

L. Yuanita^{1,✉}, N. W. Kusnanik², P. R. Wikandari¹, W. B. Sabtiawan³
and E. R. Purnama⁴

¹Department of Chemistry, Faculty of Math. Nat. Sci., Universitas Negeri Surabaya, Surabaya, Indonesia, 60231.

²Department of Sport Science, Faculty of Math. Nat. Sci., Universitas Negeri Surabaya, Surabaya, Indonesia, 60213.

³Department of Science, Faculty of Math. Nat. Sci., Universitas Negeri Surabaya, Surabaya, Indonesia, 60231.

⁴Department of Biology, Faculty of Math. Nat. Sci., Universitas Negeri Surabaya, Surabaya, Indonesia, 60231.

✉Corresponding Author: lennyuanita@unesa.ac.id

ABSTRACT

The main problem is how the effect of yacon prebiotic syrup as a natural supplement on hemoglobin, glucose, and triglycerides concentrations. A total of 24 *Rattus norvegicus* divided into T1, T2, and T3 groups, each via feeding tube received a supplement of yacon prebiotic syrup-SA with FOS levels of 5, 8, and 10% (w/w), and 6 ml of water per day for T0 (control) group. Experimental animals to be trained struggle to swim per week with a load of 20% body weight. Before and after 35-day treatment, the hemoglobin, longtime struggle, blood glucose, and triglycerides were observed. Yacon prebiotic syrup supplementation resulted in 1) increased SCFAs and colonic cecum lactate ($p < 0.05$), 2) increased hemoglobin and struggling time ($p > 0.05$), decreased glucose and triglyceride concentrations ($p < 0.05$), 3) increased FOS concentration followed by an increase in hemoglobin and struggling time, decrease blood glucose and triglycerides concentrations. It recommended the use of yacon prebiotic syrup to increase hemoglobin and regulate glucose and lipid metabolism.

Keywords: Hemoglobin, Glucose, Triglycerides, Yacon prebiotic syrup-SA.

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INTRODUCTION

Yacon (*Smallanthus sonchifolia*) is a plant classified into the sunflower family. It is identified as a native to the lower Andes Mountains in Peru and several forest regions in South America. Yacon is different from most other tuber crops, which store saccharide compounds in form of starch. Yacon stores saccharides in the form of fructooligosaccharides (FOS) of inulin-type. Their structure is described as combinations between fructose moieties linked by β -(2 \rightarrow 1)-glycosidic bonds with a terminal glucose unit. The degree of polymerization of the mixture is less than 10; inulin has a more heterogeneous DP, ranging from 3 to 60. Since yacon tubers are a rich source of FOS-inulin as soluble dietary fiber, they may potentially be used as a novel source of prebiotic components in diet supplements. According to¹, saccharides of yacon tubers composed of 74.5 mg/g sucrose, 158.3 mg/g glucose, 206.4 mg/gFOS (GF2-GF9), 350.1 mg/g fructose, and 13.5 mg/g dry weight inulin. Dominantly, 70–80 % of dry weight is formed by saccharides (mainly FOS) form.² A Report of Zevallos *et al.* as cited in³ mentioned that many variations of the FOS content of yacon tubers, 2.1- 70.8 g / 100 g dw³; while according to⁴ the tubers contain 6-12 grams FOS in 100 grams of fresh tubers. FOS is recommended as a prebiotic which is an undigested dietary fiber, as a natural sweetener that has low energy value (about 1.0–1.7 kCal/g) and maintains blood glucose (low glycemic index), preventing hypercholesterolemia. Habib *et al.* results show 1) tubers of yacon lowering triglycerides, 2) low-density lipoprotein, and 3) increasing insulin levels.⁵ Many studies have argued that FOS inulin has many similar benefits, such as maintaining normal blood glucose and reducing cholesterol

levels.⁶ FOS-inulin cannot be digested by gastric acid and digestive tract enzymes so it can reach the large intestine, where they are fermented by gut microbiota in the cecum and colon, *Bifidobacterium*, and *Lactobacillus* strains, due to the production of β -fructofuranosidase; and then stimulates its growth rapidly and selectively.⁷ The main product of anaerobic fermentation of dietary fiber by intestinal microorganisms is fatty acids with short-chain structures (SCFAs). They include butyrate, acetate, propionate, and valerate, although it is also formed from amino acid and peptide fermentation (less than 1%). The results of fermentation and increased growth of *Lactobacillus* and *Bifidobacterium* strains, will also inflict nutritional competition and suppress the growth of pathogenic bacterial strains. FOS-inulin metabolism is completely processed by the colonic microflora, primarily in the proximal colon. The end products of fermentation are SCFAs, lactate, volatile fatty acid, H_2 , CO_2 , and CH_4 . Consequently, they are lowering the luminal pH and thereby increase mineral solubility. This decrease in pH facilitates the conversion of Fe in the form of Fe(III) to Fe(II). SCFAs also increase the surface area of absorption due to the proliferation of colonic mucosal epithelial cells; thereby increasing the bioavailability of Fe. Various studies also emphasized the positive effects of FOS-inulin on iron bioavailability and hemoglobin repletion efficiency because of their fermentation products.⁸ SCFAs play a role in inhibiting the growth of pathogenic bacteria, because of colon acidification by SCFAs that support mucin production. SCFAs have various roles, maintaining blood glucose levels through increasing phospho AMPK (AMP-activated protein kinase) enzyme thereby decreasing hepatic gluconeogenesis, increasing glucose uptake through increasing peptide tyrosine (PYY) hormone activity, and GLP-1 to increasing pancreatic insulin.⁹ In adipose, increased AMPK causes increased lipoprotein lipase activity, thereby reducing lipogenesis and increasing fatty acid oxidation. SCFAs-acetate also inhibits lipogenic enzymes in the liver, namely glycerol-3-phosphate acyltransferase, an enzyme primarily involved in the de novo synthesis of lipids in the body. Phenolic compounds have a positive effect on human metabolism for maintaining the gut. Their metabolites increase the growth of beneficial microbiota and restrict pathogen bacteria proliferation. The yacon tubers contain FOS as the storage saccharides, but polyphenolic compounds have also been isolated from the tubers especially chlorogenic acid (48.5 g/g)¹⁰ and flavonoids have a phytochemical activity to increase immunity through their role as antioxidants, anti-inflammatory and anti-microbial; chlorogenic acid also has anti-hyperglycemic and hyperlipidemic functions. The polyphenol compounds can inhibit α -amylase and α -glucosidase; thus, the level of postprandial blood glucose is decreased. In addition, the compounds regulate glucose metabolism by inhibiting intestinal absorption of glucose and the release of glucose from the liver, enhancing glucose uptake by muscle cells and adipocytes, and stimulating pancreatic insulin secretion¹¹; to alter lipoprotein metabolism by decreasing plasma triglycerides and apo-B protein concentrations¹² as a constituent of very low- density lipoprotein Yacon tubers can be consumed in varied ways, as raw form, juice, syrup, jam, and dried tubers. Yacon syrup is produced to maintain levels of FOS and phenolic compounds as bioactive compounds, sensory acceptance, antioxidant properties, and as an immunostimulant, through setting the degree of acidity and processing temperature as well as the use of natural inhibitors. This product is named yacon prebiotic syrup-natural supplements.¹³ Based on the background, the research purpose was to determine the role of yacon prebiotic syrup- natural supplements on hemoglobin, glucose, and triglycerides. In vivo analysis using *Rattus norvegicus* as experimental animals.

EXPERIMENTAL

Yacon prebiotic syrup-natural supplements are made from yacon tubers from Wonosobo-Central Java through the process of using natural inhibitors and adjusting the degree of acidity and evaporation temperature to maintain bioactive levels of yacon tubers. In the use of supplements for experimental animals, the prebiotic syrup must be concentrated through freeze drying so as not to damage the components of the yacon prebiotic syrup. Yacon prebiotic syrup-natural supplements obtained have a concentration of soluble solids equal to $62 \pm 1^\circ\text{Brix}$, density is 1.304 g/ml, and pH between 5.0-5.5. Twenty-four experimental animals, *Rattus norvegicus* Wistar strain aged 8-9 weeks, healthy condition and body weight of ± 225 g maintained at the Biochemistry Laboratory, Faculty of Medicine, Airlangga University, Surabaya. This research has obtained ethical clearance approval from the Health Research Ethics Commission Faculty of Veterinary Medicine Airlangga University Surabaya, No.689-KE. Experimental

animals were divided into four groups by matching based on body weight. At the beginning of the treatment, hemoglobin, glucose, and levels were tested from the lateral tail vein. T0 (control) group received water supplements @ 6 ml, T1, T2, and T3 groups received supplements of yacon prebiotic syrup-natural supplements @ 3.5, 6, and 7 ml per day ($FOS \pm 5, 8, 10\%$) via feeding tube for 35 days. Standard feed in the form of Comfeed II consists of crude protein 19%; crude fat 5%; water content 12%; crude fiber 4.5%; ash 6.5%; calcium 0.9- 1.2%; and phosphorus 0.7-0.9%. Each animal is placed in individual cages and drinks in ad-libitum. The experimental animal's rearing room is maintained at room temperature 20–26 °C, humidity 30–70%, lighting for 12 hours of light and 12 hours of darkness, and has good airflow. Every week a swimming test is carried out in a tub measuring diameter x height = 40 x 50 cm with a load of 20% of body weight. At the end of the treatment, it was observed for a long time of struggling, the levels of blood hemoglobin, glucose, and triglycerides through intracardiac, as well as SCFAs-lactate analysis of the cecum colon of experimental animals. FOS and saccharides contents were tested using HPLC Hewlett Packard Series 1050, Zorbax 300 SB-C18 column 5 μ m, and UV detector; while chlorogenic acid was using voltammetry, solid copper amalgam as a working electrode using differential pulse voltammetry. The length of struggling was measured using a stopwatch. Blood hemoglobin using cyanmethemoglobin and digital methods (Easy Touch GCHb), blood glucose and triglycerides using accutrend plus while SCFAs and lactate cecum-colon concentration using Shimadzu gas chromatography-2010 AF, Restek Famewax column 30 m, ID 0.25 mm d 0.1 m FID detector rate 5C/minute, gas flow 1ml/minute. Data were analyzed through Kruskal Wallis and Anova one way- LSD ($\alpha = 5\%$).

RESULTS AND DISCUSSION

The stomachs of experimental animals have limitations in receiving a number of volumes of syrup supplements, so the prebiotic syrup used must be concentrated through freeze drying. Yacon prebiotic syrup-natural supplements were three times, FOS, and saccharides contents were identified. The concentration of FOS (GF4, GF3, GF2) and saccharides (sucrose, glucose, and fructose) in yacon prebiotic syrup-natural supplements are listed in Table-1.

Tabel-1: Concentration of FOS dan Saccharides of Yacon Prebiotic Syrup-Natural supplements¹⁴

| | FOS (g/L) | | | Σ FOS | Saccharides (g/L) | | | Σ Sacharrides | Chlorogenic acid (ppm) |
|------|-----------|--------|--------|--------------|-------------------|---------|---------|----------------------|------------------------|
| | GF2 | GF3 | GF4 | | Fructose | Glucose | Sucrose | | |
| | 120.128 | 64.351 | 35.596 | 220.08 | 62.066 | 41.033 | 40.117 | 143.216 | 499.676 |
| | 115.745 | 59.895 | 34.780 | 210.42 | 68.513 | 44.923 | 37.950 | 151.387 | 503.569 |
| | 157.597 | 83.682 | 46.421 | 287.70 | 62.779 | 53.921 | 45.604 | 162.304 | 536.070 |
| mean | 131.156 | 69.309 | 38.932 | 239.40 | 64.453 | 46.627 | 41.224 | 152.302 | 513.105 |

Table-1 shows that THE mean FOS and saccharides concentration was 239.4 and 152.302 grams/liter, higher than without natural inhibitors and evaporation regulation (221.30 and 140.862 grams/liter). Likewise, the average chlorogenic acid content was 513,105 ppm ($> 386,174$ ppm).¹⁴ This means that the use of natural inhibitors, pH, and temperature regulation at evaporation can maintain FOS and chlorogenic acid as bioactive content of sirup yacon prebiotic-natural supplements. Evaporation has been carried out at a temperature of 60-65°C with the pH of the syrup solution at ± 5.5 .

Blood Hemoglobin Concentration

Blood hemoglobin (Hb) concentrations were determined before and after treatment of the yacon prebiotic syrup-SA supplement as shown in Table-2.

Table-2: Differences in Blood Hb Concentration after Yacon Prebiotic Syrup-Natural Supplements (g/dl)

| No. | Treatments | | | | | | | | | | | |
|-----|------------|-------|----------|--------|-------|----------|--------|-------|----------|--------|-------|----------|
| | T0 | | | T1 | | | T2 | | | T3 | | |
| | Before | after | Δ | Before | after | Δ | Before | after | Δ | Before | after | Δ |
| 1 | 12.6 | 12.8 | 0.2 | 12.7 | 13.1 | 0.4 | 12.9 | 13.1 | 0.2 | 12.2 | 13.7 | 1.5 |
| 2 | 12.9 | 13.1 | 0.2 | 12.7 | 13.8 | 1.1 | 12.0 | 12.7 | 0.7 | 11.2 | 12.0 | 0.8 |
| 3 | 12.9 | 13.2 | 0.3 | 13.7 | 13.70 | 0 | 12.4 | 14.0 | 1.6 | 13.6 | 14.2 | 0.6 |
| 4 | 13.5 | 14.0 | 0.5 | 11.0 | 11.6 | 0.6 | 12.4 | 13.4 | 1.0 | 13.4 | 12.1 | -1.3 |

| No. | Treatments | | | | | | | | | | | |
|--------------------------------------|------------|-------|--------------------------|--------|-------|----------------------|--------|-------|-----------------------|--------|-------|-----|
| | T0 | | | T1 | | | T2 | | | T3 | | |
| | Before | after | Δ | Before | after | Δ | Before | after | Δ | Before | after | Δ |
| 5 | 13.4 | 13.6 | 0.2 | 12.7 | 12.8 | 0.1 | 14.2 | 13.8 | -0.4 | 12.8 | 14.0 | 1.2 |
| 6 | 13.8 | 13.3 | -0.5 | 12.8 | 12.7 | -0.1 | 14.2 | 13.8 | -0.4 | 14.0 | 14.3 | 0.3 |
| Mean±SD = 0.150 ±0.339 | | | Mean±SD = 0.350±0.451 | | | Mean±SD =0.450±0.799 | | | Mean±SD = 0.517±0.987 | | | |
| Chi-Square= 2.2321; p= 0.508 (>0.05) | | | | | | | | | | | | |

Table-2 shows an increase in Hb concentration sequentially from lowest to highest in the T0, T1, T2, and T3 groups. This is very possible due to the increased absorption and bioavailability of iron in the use of yacon prebiotic syrup supplements; while the iron is the main component in hemoglobin which binds to the porphyrin ring-globin and O₂. The higher the FOS concentration consumed the higher increase in hemoglobin value. According to¹⁵ the use of prebiotic FOS or fermented fiber can increase the efficiency of Hb regeneration and prevent anemia; even based on research¹⁶, it suggested that FOS can neutralize the inhibitory effect of phytic acid on Fe absorption. The increase in iron absorption is due to the stabilization of flora and ecology intestinal which increases fermenting probiotic bacteria in the colon, resulting in reducing equivalents and SCFAs which lowers the pH of the colon and cecum thereby increasing the solubility of iron. The decrease in pH will increase the reduction of iron (III) to (II) as well as the release of protein-bound iron, facilitating transfer through the enterocyte endosome membrane, and therefore increasing the bioavailability of iron. The fermented SCFAs, especially lactate and butyrate, also stimulate the proliferation of epithelial cells thereby increasing the surface area of absorption cells from the colon, especially the proximal part. Prebiotics or their fermented products also stimulate the gene expression of iron transport protein and another cellular at the brush border;¹⁷ showed that inulin fermented products activate gene-Divalent Metal Transporter 1 (DMT1) in intestinal mucosal cells. An increase in hemoglobin will also result in an increase in oxygen carried by the blood so oxidation increases and aerobic glucose catabolism increases. With high physical activity, aerobic catabolism is accompanied by anaerobic catabolism which produces lactic acid, due to insufficient oxygen supply from blood circulation so that catabolism works anaerobically. The results of the study with increasing hemoglobin levels at the end of the treatment for 35 days, the P3 group had the highest average hemoglobin and was able to survive swimming for a longer time (Table-3).

Long Time Struggling on Forced Swimming Test

Muscle fatigue in experimental animals was assessed based on the length of struggle through the forced swimming test. Experimental animals were given a load (20% body weight) tied to the tail. The length of time struggling was obtained by recording the time since a rat was submerged in water until almost drowned and showed signs of fatigue, namely weakening of movement in almost all bodies (except the nose), decreased muscle strength, reaction time, and frequency of movement. The recording is done using a stopwatch in minutes; the data on the length of time for the struggling are shown in Table-3.

Table-3: Length of Time Struggling on Yacon Prebiotic Syrup-SA Supplements (minutes)

| No | Treatments | | | |
|-------------------------------------|-------------|-------------|-------------|-------------|
| | T0 | T1 | T2 | T3 |
| 1 | 2.25 | 2.40 | 2.19 | 7.04 |
| 2 | 4.37 | 4.48 | 4.11 | 3.52 |
| 3 | 1.43 | 3.23 | 4.32 | 2.57 |
| 4 | 2.03 | 2.17 | 4.35 | 2.27 |
| 5 | 2.02 | 6.44 | 3.51 | 6.26 |
| 6 | 2.42 | 1.47 | 2.29 | 6.11 |
| Mean | 2.418±1.012 | 3.365±1.826 | 3.462±0.994 | 4.628±2.083 |
| Chi-Square= 5.527; p=0.125 (p>0.05) | | | | |

The increasing length of struggling sequentially from lowest to highest are groups T0, T1, T2, and T3. Experimental animals had a higher body resistance to the use of yacon prebiotic syrup supplements, in accordance with the increased levels of FOS and saccharides consumed. In high-intensity exercise, the energy required is greatly increased so that anaerobic metabolism occurs and one of the results is lactic acid. Lactic acid will lower the pH in the muscles and blood. A decrease in pH causes a decrease in the rate

of reaction of glycolytic enzymes, thereby reducing the ability of metabolism and ATP (adenosine triphosphate) production. ATP is the main energy source for muscle contraction, converted into adenosine diphosphate so that energy is released for contraction. Increased accumulation of lactic acid in the blood causes a decrease in ATP supply, failure of muscle contraction, and muscle fatigue.

Blood Glucose Concentration

Blood glucose concentrations were determined before and after treatment of the yacon prebiotic syrup-natural supplements as shown in Table-4.

Table-4: Differences in Blood Glucose Concentration after Yacon Prebiotic Syrup Supplements (g/dl)

| No | Treatments | | | | | | | | | | | |
|-----------------------------|------------|-----|------------------------------|-----|-----|-----------------------------|-----|-----|------------------------------|-----|-----|----|
| | T0 | | | T1 | | | T2 | | | T3 | | |
| | X | X' | Δ | X | X' | Δ | X | X' | Δ | X | X' | Δ |
| 1 | 141 | 131 | 10 | 116 | 125 | -9 | 149 | 121 | 28 | 168 | 160 | 8 |
| 2 | 122 | 131 | -9 | 82 | 93 | -11 | 138 | 112 | 26 | 158 | 114 | 44 |
| 3 | 101 | 122 | -21 | 143 | 137 | 6 | 141 | 122 | 19 | 114 | 112 | 2 |
| 4 | 96 | 112 | -16 | 154 | 145 | 9 | 146 | 135 | 11 | 152 | 119 | 33 |
| 5 | 134 | 113 | 21 | 130 | 115 | 15 | 138 | 115 | 23 | 148 | 99 | 50 |
| 6 | 101 | 130 | -29 | 134 | 110 | 24 | 82 | 104 | -22 | 133 | 111 | 22 |
| Mean±SD= | | | | | | | | | | | | |
| -7.333 ^a ±19.169 | | | 5.667 ^{abc} ±13.619 | | | 14.167 ^b ±18.713 | | | 26.500 ^{bc} ±19.305 | | | |
| F= 3.816; p=0.026 (<0.05) | | | | | | | | | | | | |

Note: X and X': before and after treatment, Δ: difference

Table-4 shows that the mean difference in the control group (T0) is negative, there are 4 out of 6 experimental animals experienced an increase in glucose levels due to treatment, while all experimental animals in the T3 group experienced a decrease in blood glucose concentration. The highest decrease in blood glucose was in the 10% FOS group (T3), followed by 8% (T2), and 5% FOS (T1). This shows that yacon prebiotic syrup-natural supplements have a significant effect on lowering blood glucose in experimental animals ($p < 0.05$). The decrease in blood glucose concentrations is the effect of the role of FOS in yacon tubers as a natural sweetener, and low glycemic index. An experiment⁵, on the use of yacon flour (340 or 6800 mg FOS/kg body weight) for 90 days in streptozotocin-induced diabetic rats, showed an increase in pancreatic cell mass and GLP-1 in the cecum, while very low-density lipoprotein and fasting plasma triacylglycerol decreased significantly.

According to^{18,19} SCFA stimulates GLP-1 secretion from enteroendocrine L cells by activating FFAR2, and indirectly regulates blood glucose levels by the proliferation of β -cell on the pancreas, increasing insulin secretion and decreasing pancreatic glucagon secretion. GLP-1 is a peptide that is easily converted into inactive by dipeptidyl peptidase IV (DPPIV); while FOS GF2, GF3, and GF4 have the potential to decrease serum DPPIV activity. The mechanism of modulation of GLP-1 production is the result of the role of FOS on L cells and DPPIV activity.²⁰ In vitro and in vivo experiments showed that SCFAs increase leptin expression via an FFAR2-dependent pathway²¹; while leptin stimulates fatty acids oxidation, uptake of glucose, and promotes the synthesis of liver glycogen.^{22,23} SCFAs, especially butyric acid, promote proglucagon expression on intestinal L cells. The high production of intestinal GLP-1 due to FOS consumption is supported by high levels of proximal colon proglucagon mRNA, which also has a physiological effect on reducing fat mass and body weight. Plant polyphenol compounds are useful for protecting body cells against free radical damage and inhibiting the relevant carbohydrate hydrolyzing enzymes.²⁴

Research has revealed, some plant extracts can decrease the activity of α -amylase and α -glucosidase and control postprandial hyperglycemia.²⁵ The *Dendrobium formosum* methanol extract (50 g/mL) inhibits (95%) of both α -glucosidase and pancreatic lipase, *Dendrobium tortile* phenolic extract also inhibits α -glucosidase.²⁶ Most of the extracts of polyphenol compounds from plants, had a significantly higher inhibitory activity against α -glucosidase than against α -amylase. It was also found that flavonoids have higher inhibitory power than other phenolic compounds on α -amylase activity.²⁷

This shows that polyphenol compounds can be used as an alternative to control postprandial hyperglycemia and reduce the risk of T2DM if these polyphenol compounds are included in the polyphenols group.

Blood Triglycerides Concentration

Before and after the treatment of yacon prebiotic syrup supplements for 35 days, the blood triglycerides of experimental animals were examined; the difference in blood triglycerides concentration of experimental animals is shown in Table-5.

Tabel-5: Differences in Blood Triglycerides Concentration after Yacon Prebiotic Syrup Supplements (g/dl)

| No | Treatments | | | | | | | | | | | |
|--|------------|-----|-----|--|-----|----|---------------------------------------|-----|----|---------------------------------------|-----|----|
| | T0 | | | T1 | | | T2 | | | T3 | | |
| | X | X' | Δ | X | X' | Δ | X | X' | Δ | X | X' | Δ |
| 1 | 116 | 99 | 17 | 127 | 105 | 22 | 175 | 148 | 27 | 108 | 86 | 22 |
| 2 | 98 | 73 | 25 | 181 | 132 | 49 | 166 | 159 | 7 | 117 | 109 | 8 |
| 3 | 114 | 122 | -8 | 108 | 102 | 6 | 105 | 90 | 15 | 116 | 93 | 23 |
| 4 | 91 | 108 | -17 | 130 | 119 | 11 | 130 | 119 | 11 | 115 | 104 | 11 |
| 5 | 128 | 156 | -28 | 118 | 111 | 7 | 105 | 99 | 6 | 148 | 110 | 38 |
| 6 | 88 | 136 | -48 | 81 | 77 | 4 | 96 | 77 | 19 | 139 | 93 | 46 |
| Mean±SD= - 9.83 ^a ±27.47 | | | | Mean±SD= 16.50 ^{ab} ±17.17 | | | Mean±SD= 14.17 ^{ab} ±7.96 | | | Mean±SD= 24.66 ^b ±14.88 | | |
| F= 3.960; p = 0.023 (<0.05) | | | | | | | | | | | | |

Note: X and X': before and after treatment, Δ: difference

Table-5 shows the mean difference in the control group is negative, indicating an increase in triglyceride levels after treatment. The highest mean difference was in the T3 group; then by T1, T2, and T0. This shows that yacon prebiotic syrup-SA supplements have a significant effect on lowering triglycerides in experimental animals ($p < 0.05$). This phenomenon is in accordance with previous studies.²⁸ Research showed the use of a diet containing 10% FOS will reduce blood lipid levels. FOS plays a role in stimulating the growth of *Bifidobacterium* and *Lactobacillus* probiotic bacteria, which functions to increase the SCFAs of the digestive tract; while SCFAs are inhibitors of hepatic and serum lipid synthesis, including fatty acids and cholesterol.²⁹ Soluble dietary fiber increases the viscosity of intestinal chyme, this promotes the excretion of bile acids through the intestine and weakens the action of lipase thereby reducing fat absorption. According to³⁰ the use of FOS was associated with decreased lipogenic enzyme activity and resulted in decreased denovo lipogenesis in the liver thereby lowering blood triglycerides. The process of induction of lipogenic enzymes through activation of fatty acid synthase mRNA transcription with increased levels of carnitine palmitoyl transferase-1 adipose mRNA during the postprandial period.³¹ The influence of various foodstuffs and hormones on lipogenic gene expression is mediated by SREBPs, USFs in the hepatocyte, and PPAR- γ in the adipocyte.

The process of making yacon prebiotic syrup-natural supplements can maintain contents of polyphenols compound (flavonoid and non-flavonoid) that it has an antioxidant activity of 52.888 % and IC₅₀: 6.383¹³, so that polyphenols can protect against oxidative stress. Polyphenol compounds can neutralize reactive oxygen species before the occurrence of oxidative damage to lipids, proteins, and DNA; as well as increase lipolysis by stimulating AMPK. Huang *et al.* explained that the AMPK signaling pathway activation in db/db mice escalated the expression of PPAR- γ and phosphorylated acetyl CoA carboxylase in the liver, lowering the levels of free fatty acids and triglycerides.³³

The activated AMPK signaling pathway can encourage the expression of hormone-sensitive lipase and adipose triglyceride lipase and then promote lipolysis. In liver tissue, AMPK inhibits gluconeogenesis through inhibition of various transcription factors such as CRTC2 and HNF4.³⁴ Various research results suggest that the hypolipidemic actions of polyphenols may initially through inhibition of pancreatic lipase, nutritional or bile acid chelation, thereby restricting the absorption of lipid.³⁵

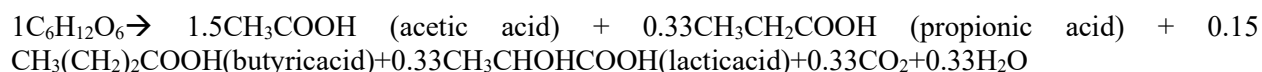
SCFAs and Lactic Acid Content of Cecum-Colon

The largest difference between glucose and triglycerides in this study was found in T3, so the SCFAs and cecum colon lactate tests of experimental animals were carried out on T0 and T3 groups. The experimental animals' cecum-colon extract solution was obtained from the isolation process of the cecum-colon, each of which was 8 ml @ ± 0.5 gram of the cecum-colon. The content of SCFAs and lactic acid were calculated based on the 0.5-gram dry weight of the cecum colon of experimental animals, in Table-6.

Table-6: Average SCFAs and Lactic Acid Content of Cecum-Colon

| Treatments | Acetate | Propionate | Butyrate | Isobutyrate | Valerate | ΣSCFAs mmol/L. (0.5g ⁻¹ dw) | Lactic acid ppm (0.5g ⁻¹ dw) |
|------------|---------|------------|----------|-------------|----------|---|--|
| T0 | 35.113 | 14.166 | 3.254 | 0 | 0 | 86.176 | 88.105 |
| | 42.991 | 17.893 | 4.788 | 0 | 0 | 58.137 | 79.502 |
| | 32.085 | 12.733 | 2.665 | 0 | 0 | 48.472 | 70.572 |
| | 38.015 | 15.539 | 3.819 | 0 | 0 | 54.466 | 61.645 |
| | 32.105 | 12.743 | 2.668 | 0 | 0 | 46.934 | 89.009 |
| | 49.164 | 20.814 | 5.990 | 0 | 0 | 57.374 | 77.175 |
| | Mean±SD | | | | | 58.593 ^a ±16.174 | 77.668 ^a ±10.471 |
| T3 | 204.223 | 130.612 | 51.177 | 6.556 | 2.113 | 523.868 | 77.726 |
| | 207.364 | 132.647 | 52.014 | 6.725 | 2.212 | 288.311 | 105.286 |
| | 114.076 | 58.822 | 21.632 | 0.620 | 0 | 232.822 | 102.880 |
| | 212.748 | 136.136 | 53.450 | 7.013 | 2.380 | 350.601 | 100.132 |
| | 174.918 | 102.414 | 39.572 | 4.225 | 0.753 | 270.812 | 108.219 |
| | 215.113 | 137.669 | 54.081 | 7.140 | 2.454 | 462.524 | 84.867 |
| | Mean±SD | | | | | 354.823 ^b ±129.672 | 96.518 ^b ±11.835 |

Table-6 shows that the SCFAs in the T0 group were very low, and no isobutyrate and valerate were detected. The yacon syrup supplement can significantly increase the concentration of SCFAs, due to the presence of FOS and inulin which are degraded by cecum-colon bacteria to form SCFAs and lactate. The high levels of SCFAs and lactate in the T3 group indicated that the FOS and inulin in the yacon prebiotic syrup could be maintained. In the cecum colon, FOS fructan compounds are fermented by several bacterial strains including *Bifidobacterium* and *Lactobacillus* which produce β-fructofuranosidase. The main production of lactic acid degrades hexoses in homofermentative conditions or hexoses will be degraded by ethanol/acetic acid, lactic acid, and CO₂d in heterofermentative conditions. SCFAs are produced from the fermentation of *Lactobacillus* and *Bifidobacterium* species about 90% are directly absorbed by the colon, and can be used as an energy source. The stoichiometry of the fermentation reaction is as follows:³⁶



The main effect of SCFAs-lactate is on acidification of the colonic environment which is detrimental to some strains of pathogenic bacteria such as bacteroidal species, clostridia, and coliforms, favoring the production of mucin, which improves mucosal morphology thereby reducing colonization and translocation of pathogenic bacteria and binding SCFAs receptor on immune cells in gut-associated lymphoid tissue. About 5-10% of the total dietary polyphenols can be absorbed in the small intestine, depending on their structure and conjugation, while the remaining polyphenols are converted into low molecular weight bioactive metabolites by enzymatic activities of gut microbiota. All of these further improve the bioavailability of polyphenols and enhance the benefits to gastrointestinal health through promote the growth of beneficial microbiota and restricting the proliferation of pathogenic bacteria. In vitro and in vivo studies have shown that the use of polyphenol compounds will increase SCFAs which selectively modulate the gut microbiota. Certain polyphenols have specific target microbiota, e.g chlorogenic acid increased the population of *Bifidobacterium* species³⁷, while catechin the growth of *E. rectal*.³⁸ Polyphenols directly or indirectly affect gastrointestinal function, reduce the growth of pathogenic bacteria, and promote the production of SCFAs by beneficial gut microbial populations. In addition, compounds of polyphenol can avoid atherosclerosis, cardiovascular diseases, and inflammation.³⁹

CONCLUSION

On the use of yacon prebiotic syrup-SA supplements for 35 days with FOS levels of 5.8 and 10%, the results were as follows: 1) increased SCFAs and colonic cecum lactate (p<0.05); 2) increased Hb concentration and struggling time (p>0.05), 3) decreased blood glucose and triglycerides concentrations (p<0.05). It is highly recommended to use the prebiotic yacon syrup to increase Hb concentration, and regulate glucose, and lipid metabolism.

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