Isolation of Oligosaccharides of Coconut Kernel and Their Effects on Serum Lipids and Glucose Concentrations of Rats

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Abstract

Coconut kernel fibre is a potential dietary fibre source which is available as by product of the virgin coconut oil production. A study was conducted to isolate insoluble fibre and to find out oligosaccharide composition and the nutritional effect of coconut kernel insoluble fibre (CKIF) on weight gain and serum lipid and glucose concentration of rats. The CKIF contained 75.6 % cell wall polysaccharides including 19 % pectin, 29.6 % hemicelluloses I, 12 % hemicelluloses II and 15 % celluloses. Mannose was present in all oligosaccharides in CKIF. Twenty-one Wistar rats (2 months old and weighing approximately 200g) were fed with a feed incorporated with CKIF. The feeding experiment continued for 90 days and blood samples (0.5 ml -1.0 ml) were drawn after keeping animals for a 12 hour fasting period. Increase of serum total cholesterol (TC) was observed during 90 days. The control feed fed group showed 68.65 mg/dl increase while 5 % CKIF and 10 % CKIF incorporated feed fed group showed 18.6 mg/dl and 14.46 mg/dl increase respectively. There was no definite pattern in change of serum HDL-C (high density lipoprotein-cholesterol) concentrations of rats. The control group showed an increasing trend of serum TAG (triacylglyceride) concentration. In contrast, CKIF incorporated feed fed groups showed non-significant decline in 60 days followed by a significant decline of serum TAG in 90 days. The serum glucose concentration of the control group increased by 40.13 mg/dl while in rats fed with 5% CKIF and 10% CKIF containing feed increased by 28.04 mg/dl and 15.52 mg/dl respectively. The study reveals that CKIF of coconut kernel is effective in decreasing serum levels of total cholesterol, TAG and glucose in rats. Therefore, it can be used as potential food grade fibre.

Keywords: *Hemicellulose, Coconut kernel, Insoluble fibre, Lipid profile, Glucose concentration*

Introduction

By-products obtained from manufacturing of plant based foods: cereal, fruits, vegetables are sources of abundant dietary fibre. These fibre-rich by-products can be added to fortify foods to increase the fibre content of food products. The fibre in food may also serve as functional ingredients to improve physical and structural properties of hydration, oil holding capacity, viscosity, texture, sensory characteristics and shelf life (Elleuch *et al.*, 2011). The plant cell walls are the fibre rich components of the plants. Plant cell walls (PCWs) have been isolated as a group of cell walls (dietary

fibre, neutral detergent fibre, acid detergent fibre, water insoluble fibre, water soluble fibre, alcohol soluble fibre, alcohol insoluble fibre) or pectin, hemicelluloses and celluloses (Abdul-Hamid and Luan, 2000; Sindurani and Rajmohan, 2000; Saffiatu *et al.*, 1985; Mohamadzadesh *et al.*, 2010).

The importance of dietary fibre in reducing risk of obesity and in factors responsible for cardiovascular diseases have been studied widely (Trinidad *et al.*, 2006; Sindurani and Rajmohan, 1998). Dietary fibre rich diets have been shown to lower the risks of diseases associated with obesity, diverticula and coronary heart diseases and diabetes mellitus.

Coconut (*Cocos nucifera*) is an edible oil rich fruit crop which is grown in countries with tropical climate. Coconut kernel is widely used for manufacture of coconut oil. Virgin coconut oil is a product obtained from expelling the oil in controlled condition leading the edible by product called coconut residue flour which has a potential to be a rich source of food grade fibre (Yalegama, 2012). The raw from of coconut kernel fibre has been studied for its health effects in the recent past (Yalegama, 2012; Trinidad *et al.*, 2006) while Sindurani and Rajmohan (1998) studied neutral detergent fibre of coconut kernel which is a purified form of raw kernel fibre of the coconut kernel. The residue obtained from virgin coconut oil expelling (VOR) is a convenient form of the by-product which can be utilized for isolation of food grade fibre of coconut kernel. In the present study we isolated insoluble fibre from coconut kernel (CKIF) using chemical methods. The structural components of the CKIF was determined and the effect of feeding the isolated fibre on serum lipids and glucose concentrations of rats as well as on the weight were studied for a period of 90 days.

Material and Methods

Insoluble fibre of coconut kernel (CKIF)

Defatted VOR was soaked in 500ml of 0.1N NaOH (1: 5, w/v) and the contents were stirred for two hours. Then the insoluble residue was collected by filtration through double layers of linen cloth. The residue was washed with distilled water until washings were neutral to phenolphthalein. To the residue, 500 ml of 70% aqueous ethanol was added and heated to 80 °C while mixing. The temperature was maintained at 80 °C for 30 minutes. The insoluble material in hot aqueous ethanol was collected by filtration through a double layer of linen cloth. The residue remaining after the above procedure was dried at 60 °C.

Isolation of oligosaccharides of CKIF

Insoluble fibre of coconut kernel was separated into pectin, Hemicelluloses I, Hemicelluloses II, Hemicelluloses III and celluloses using methods used by Del Rosario *et al.*, (1972) with modifications.

Isolation of pectin

Five grams of CKIF were transferred to 100 ml of 0.5% Ammonium oxalate-oxalic acid (prepared by dissolving 0.5g ammonium oxalate and 0.5g oxalic acid in 100 ml of water). The extraction was carried out for 24 hours with stirring at 90 °C under reflux. The supernatant was separated by centrifugation (5000 rpm) and the solid part was re-extracted for 24 hours using the same procedure. The supernatants were combined followed by addition of 4 volumes of ethanol (96%) slowly with gentle stirring. The pectin was precipitated out by standing at 4 °C overnight. The

pectin was collected by centrifugation at 5000 rpm for 30 minutes. The pellet was freeze dried to a constant weight and the percentage yield was recorded.

Isolation of hemicelluloses

Hemicelluloses fraction I

The residue obtained after separation of pectin was placed in a conical flask and 400 ml of 4% NaOH was added. Liquid paraffin (1/2 cm thickness) was added and the contents were shaken for 18 hours at room temperature. The supernatant was separated from the insoluble matter by centrifugation at 11,000 rpm, and was neutralized with hydrochloric acid. Four volumes of alcohol (96%) were added to the neutralized supernatant and left overnight to precipitate hemicelluloses fraction I (HC I). The precipitate was separated by centrifugation at 11,000 rpm and washed with 96% ethanol followed by acetone. The precipitate was freeze dried and the percentage yield of hemicelluloses fraction I (HCI) was recorded. The same procedure as in the isolation of HC I was followed using 10 % NaOH and 17.5 % NaOH to isolate HCII and HCIII respectively. The insoluble material was the cellulose content of coconut kernel.

Derivatization of alditol acetates of neutral sugars in cell wall polysaccharides

Fibre isolations (0.1 g) were hydrolysed using 2M TFA (Trifluroacetic acid) at 100 °C for 14 - 18 hours. The hydrolysate was filtered through Whatman 42 filter paper. Excess acid in the filtrate was removed by vacuum evaporation followed by co-evaporation with water to remove all the traces of acids. The hydrolyzate containing monosaccharides were converted to alditol acetates.

Determination of monosaccharide composition of the oligosaccharides

Standard sugars: Glucose, arabinose, xylose, mannose and galactose and rhamnose (5-10 mg) or monosaccharide samples were dissolved in 1-2 ml of distilled water. One drop of conc. ammonia was added. Then 50 - 10 mg of Sodium borohydride ($NaBH_4$) was added. The contents were stirred for two hours. Then excess $NaBH_4$ was destroyed with a few drops of 50% acetic acid until effervescence stopped. The content was deionized using a column of IR – 120 (H^+) resin. The elute was evaporated to dryness and co-evaporated with methanol (3x5 ml of 50% aqueous methanol) to remove borate. The alditols were dried in vacuum (2-3 h) and was dissolved in pyridine-acetic anhydride 1:1 (2-4 ml). The contents were heated on a steam bath for 45-60 minutes (the solution became clear). The excess pyridine – acetic anhydride was removed by successive evaporation (5x5 ml of water) with water. The alditol acetates (which was synthesized) was dissolved in water (5ml) and transferred to a 50 ml separating funnel. Chloroform (5ml) was added and alditol acetates were extracted into chloroform. The alditol acetates in chloroform were concentrated by vacuum evaporation. Alditol acetates were analysed using Gas Chromatograph (Agilent 4890D, Agilent technologies (Pvt) Ltd., USA) using capillary column DB 23, 30 m x 0.32 mm x 0.25 µm film thickness maintained at 200 °C using flame ionization detector at 260 °C.

Preparation of rats feed

Basal rats feed

The basal rats feed was prepared according to the protocol of Medical Research Institute of Sri Lanka.

The ingredients were thoroughly mixed with water and were extruded to form pellets. The pellets were dried at 70 °C in a hot air oven and stored at ambient condition (28 ± 2 °C).

Preparation of control and experimental rats feeds

The feed for the control group was prepared by mixing 80% of the basal feed and 20% of egg yolk powder to make the feed hypercholesteromic. The test feeds were prepared by incorporating different percentages of IF to the control feed as given in the Table 1.

Table1. Preparation basal and experimental rats feed of 1 kg

Ingredients	Control	5.0 % CKIF	10.0 % CKIF
Basal rats feed	800 g	750 g	700 g
Egg yolk powder	200 g	200 g	200 g
CKIF	-	50 g	100 g

Estimation of nutritional effects of experimental feed incorporated with CKIF

Male Wister rats of 8 weeks old and weighing approximately 200 g were procured from Medical Research Institute, Colombo. The rats were kept at 25 ± 2 °C. The rats were fed with basal feed for a period of one week for familiarization of the feed. The initial weights of rats were taken. The basal fasting blood samples (before starting the test feed) were drawn from the rats after a 14 hour fasting period. The rats were grouped randomly into 3 groups of 7 rats per group. The rats were anesthetized by keeping in a sealed glass container saturated with chloroform. After the rat was anesthetized the tail was warmed at 40 °C (using water bath) for 90 seconds. The blood samples of 0.5 ml to 1 ml were drawn from the coccygeal vein of the Wistar rats as per the protocol of Medical Research Institute of Sri Lanka. The initial blood samples were drawn before the commencement of the test feed. Blood samples were collected at monthly intervals after the commencement of the experimental feed. The blood samples were transferred to 1.5 ml eppendorf tubes and centrifuged for 10 minutes at 5800 g to separate serum. The serum was used for determination of serum TC, HDL-C, TAG and glucose concentrations of the rats using Randox enzymatic assay kits.

Results and Discussion

Structure of oligosaccharides CKIF

Insoluble fibre of coconut kernel consisted of hemicelluloses groups as major oligosaccharide. Total hemicelluloses are 42.6 % while pectin is 19%. Results in Table 2 shows that major hemicelluloses fraction is extracted with 4% NaOH which can be considered as loosely bound hemicelluloses. The hemicelluloses extracted by 10 % NaOH are bound to polysaccharides stronger

compared to the hemicelluloses extracted with 4 % NaOH. However, when the concentration of NaOH is increased to 17.5 % hemicelluloses could not be isolated in considerable amount. This suggests that it contains much less strongly bound hemicelluloses. Non extractable portion is considered as celluloses. According to the Table 2 CKIF contains 15.0 % celluloses. CKIF contains 60.6 % much valued oligosaccharides. Therefore, CKIF can be used as a functional food.

Table 2. Composition of coconut kernel insoluble fibre

Extraction	Fraction	Yield percentage
0.5 % ammonium oxalate – oxalic acid	Pectin	19.0
4 % NaOH	Hemicelluloses I	29.6
10 % NaOH	Hemicelluloses II	12.0
17.5 % NaOH	Hemicelluloses III	Trace
Non extractable matter	Celluloses	15.0
Total cell wall polysaccharides		75.6

Monosaccharide compositions of the hemicelluloses of CKIF are given in Table 3. The pectin rich fraction of the CKIF contains rhamnose and arabinose in low concentration while mannose and galactose are in comparatively higher concentrations. Similar results were reported by Sengkhamparn *et al.* (2009) for pectin rich fraction from okra.

Table 3. Neutral sugars in sequentially extracted fractions

Neutral sugar	Fraction			
	Pectin	HCI	HCII	Cellulose (as NaOH insoluble)
Rhamnose	6.14 %	13.29 %	37.12 %	22.5 %
Arabinose	3.31 %	4.49 %	3.35 %	ND
Xylose	ND	22.89 %	ND	ND
Mannose	61.72 %	50.98 %	27.15 %	23.95 %
galactose	28.71 %	5.90 %	5.76 %	16.35 %
glucose	ND	3.34 %	ND	37.05 %

ND – not detected

Pectin from okra obtained as hot buffer soluble matter showed that it contained rhamnose (26%), galactose (34%) and glucose (1%). The pectic substances obtained from unripe mango contained rhamnose, arabinose, xylose, mannose, galactose and glucose. The same neutral sugars were present in the ripe mango. Hilz *et al.,* (2006) reported that rhamnogalactouronan is present in all pectic substances. Therefore, coconut kernel pectin may also have similar rhamnogalactouronic acid structure. Arabinogalactan side chains and mannose can link to main carbohydrate chains. The HCI contains almost all the neutral monosaccharides. The major monosaccharide is mannose followed by xylose, rhamnose, galactose, arabinose and glucose. Reports of Balasubramanium (1976) showed that coconut kernel contains galactomannan. This report supports the presence of galactomannan in CKIF. Further, the monosaccharide composition of HCII also shows possible presence of galactomannan structure of HCII as it contains mannose and galactose. However, rhamnose is the major monosaccharide in HCII. Although it is expected to be 100 % glucose in celluloses portion it contains other monosaccharides (Table 3). The possible reason is that incomplete extraction of hemicelluloses in earlier steps, Therefore, final insoluble part contains non extractable components. from pectin HCI, HCII and HCIII.

Proximate composition of the test feeds

The proximate compositions of the Control and experimental feed are given in Table 4.

Table 4. Proximate composition of the control and test feeds

Feed	Moisture %	Ash %	Fat %	Protein%	Crude fibre %	Carbohydrates %
Control	4.80	5.20	15.66	22.85	3.14	48.35
5 % Insoluble fibre	6.39*	4.14	15.19	22.22	4.65*	47.41
10 % Insoluble fibre	2.63*	5.38	13.42*	24.85*	5.61*	48.11

Values are means of triplicate determinations. Superscript * indicates significant difference compared with the control diet at $p < 0.05$ level using paired t-test.

Table 4 shows significant changes in proximate composition except the ash content and carbohydrates content of the three feed samples due to substitution of CKIF (5 % and 10 %) to the control feed. Moisture content of 10 % insoluble fibre added feed was significantly lower than the control and 5 % CKIF incorporated feed. Fat content of the test diets was not significantly different with the addition of 5 % CKIF. CKIF contains less than 1 % fat and thus replacing 10 % of control feed with CKIF causes significant decrease in fat content. The protein contents of the samples were not significantly affected due to the addition 5 % of CKIF. However, the addition of 10 % CKIF increased the protein content significantly. The fibre incorporated feed samples showed significantly higher crude fibre content than the control. Carbohydrate content did not significantly differ with the incorporation of CKIF to the control feed.

Effect of CKIF on weight gain of rats

The gain in body weight of rats fed with CKIF is shown in Figure 1. The weight gain of the

rats increased significantly during 90 days of feeding. This shows that the feeds have growth improvement effect. The weight gain of rats fed with diet incorporated with insoluble fibre did not differ significantly at 30 and 90 days compared to the control feed fed group. The results further showed that addition of CKIF increased the weight gain at 60 and 90 days. However, the weight gain of rats fed with 10 % CKIF fed group showed significantly lower weight gain in 60 days. Addition of 5 % CKIF to the feed is not sufficient to show a significant effect. Previous studies have shown that weight gain of rats fed with different types of fibre incorporated diets did not differ significantly. Sindurani and Rajmohan (1998) did not observe a significant difference of weight gain when the diet was substituted with neutral detergent fibre of coconut kernel (an insoluble fibre) for a period of 8 weeks. Leontowicz *et al.*, (2001) did not observe a significant difference in body weight gain and food intake between rats given diets rich in apple pomace fibre compared to a diet without fibre. The results of the present study agree with Sindurani and Rajmohan (1998) and Leontowicz *et al.*, (2001) where the weight gains of rats fed with CKIF did not differ significantly at 30 and 90 days.

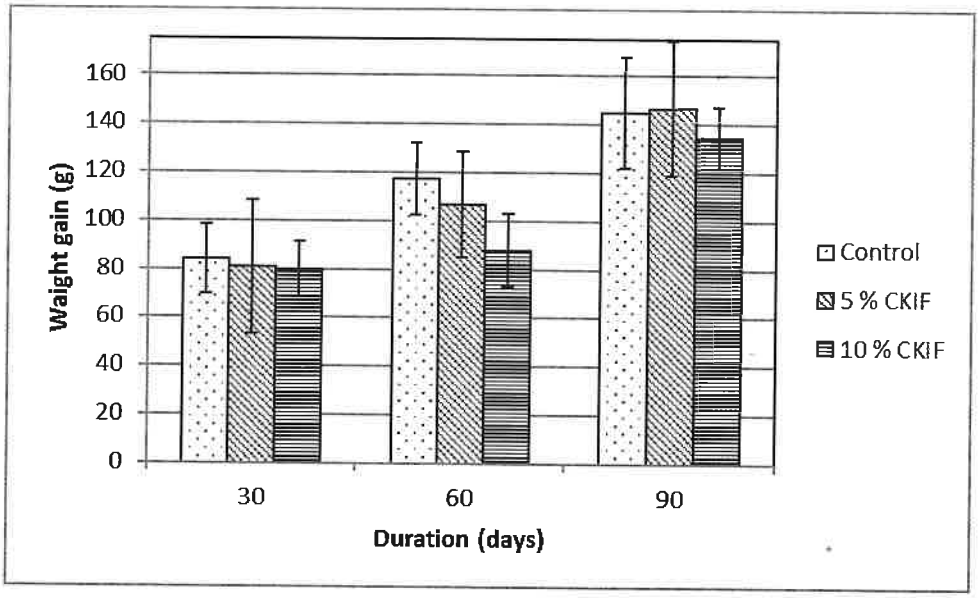

Figure 1. Weight gain of rats at monthly intervals

In contrast, Rashad and Moharib (2003) reported that rats fed with diets incorporated with turnip, sugar beet, cabbage and fenugreek green leaves fibre showed significant decrease in weight gain compared to the fibre free group for a period of 8 weeks. However, coconut insoluble fibre used in this study was capable of controlling increase of weight gain by substituting at 10 % level.

The effect of CKIF on serum lipids and glucose concentrations of rats

Serum TC, HDL-C, TAG and glucose concentrations of rats fed with cholesterol enriched feed (control) and feeds containing 5 % CKIF and 10 % CKIF were determined for a period of 90 days.

Table 5 shows the change of total serum cholesterol (TC). HDL-C, TAG and glucose concentrations of rats fed with a feed containing different amounts of CKIF at 30, 60 and 90 days interval with respect to the base line.

The serum TC of all the rats increased with time significantly (Table 5). The group fed with control feed showed significant increase of serum TC at the end of 30, 60 and 90 days compared to the initial serum total concentrations of the rats. The 5 % CKIF and 10 % CKIF incorporated feed fed groups also showed a similar increase of serum total cholesterol concentrations. The 5 % CKIF and 10 % CKIF showed higher increase of serum total cholesterol concentrations at the end of 60 days while the control feed fed group showed lower increase. On the whole the increase of serum TC of CKIF fed groups showed lower increase at the end of 90 days. The control feed fed group showed 68.65 mg/dl increase while the 5 % CKIF fed group showed 18.6 mg/dl and 14.46 mg/dl which are significant compared to the initial serum TC concentrations.

The results show that addition of CKIF (at 5 % and 10 %) to the hypercholesterolemic feed significantly hinders the increase in serum TC compared to rats consuming a similar feed without fibre. Leontowicz *et al.* (2001) observed that TC concentrations of rats fed with hypercholesteromic feed enriched with 10 % apple pomace (AP) reduced by 18.4 % compared to the rats consuming the same diet without fibre in 40 days. However, feed incorporated with 32 % oat bran and 32.5 % oat bran concentrate did not show a significant effect on serum total concentrations of hamsters (Rieckhoff *et al.*, 1999) in 35 days. Similarly, Fukushima *et al.*, (2001) reported that the serum TC concentrations of rats did not changed when the rats were fed with cholesterol free diet incorporated with cellulose powder (CP) and fungal based fibres such as *maitake* fibre, *shiitake* fibre, *enokitake* fibre in 50 g/kg for 4 weeks.In contrast Rashad and Moharib (2003) reported that the serum TC concentration of rats, fed with Turnip and sugar beet fibre incorporated (at 10%) diet, significantly lowered compared to that of control feed fed rats in 35 days. The crude by product from virgin coconut oil production did not show a significant reduction of total cholesterol concentrations during 120 days when incorporated to the feed at 10 and 20 % levels compared to the group fed without fibre in the basal feed (Yalegama, 2012). However, CKIF obtained from same crude fiber improved the effect on total cholesterol when added in lower amounts compared to the crude VOR. The crude VOR contains fat, protein and sugars as residual matter. The residual matter present in VOR is removed in preparation of CKIF. Therefore, the effect of raw VOR as fibre can be improved by concentrating the different types of fibre in the coconut kernel.

Changes of serum HDL-C concentrations of rats fed with different amounts of CKIF are shown in Table 5. The results show that serum HDL-C concentrations of rats fed with control feed fed rats reduced significantly at 60 days. However, with increase incorporation, significant drop in HDL-C occurred early (within 30 days). At 90 days the serum HDL-C concentrations of rats consuming control feed and CKIF had non-significant increasing trend compared to the basal value.

Table 5. Change of serum lipids and glucose concentrations of rats fed with hypercholesterolemic feed incorporated with coconut kernel insoluble fibre

Treatment	Change of serum TC concentrations compared to initial value (mg/dl)			Change of serum HDL-C concentrations compared to initial value (mg/dl)			Change of serum TAG concentrations compared to initial values (mg/dl)			Change of serum glucose concentrations compared to initial values (mg/dl)		
	30 days	**60 days**	**90 days**	**30 days**	**60 days**	**90 days**	**30 days**	**60 days**	**90 days**	**30 days**	**60 days**	**90 days**
Control	11.79*	17.67*	68.65*	7.25	-12.7*	2.54	-97.04*	-86.1*	-19.1	-0.4	3.81	40.13*
5 % CKIF	12.61*	35.56*	18.6*	-8.8	-15.84*	3.26	-91.08*	-4.78	-89.52*	18.75	41.64*	28.04*
10 % CKIF	21.18	41.66*	14.46*	-20.51*	-10.54	-2.1	-66.44*	-16.95	-103.17*	28.27	25.46	15.52

*indicates change is significant at $p<0.05$ compared to basal value

Non-significant alterations in serum HDL-C concentrations were observed by several previous studies. Rieckhoff *et al.*, (1999), found hamsters fed with oat bran concentrate (32%) and oat fibre concentrate (32.5%) incorporated feed did not show significant variation in HDL-C concentrations. Fukushima *et al.*, (2001) reported that the rats fed with fungal based fibres: *maitake* fibre and *shiitake* fibre (50 g/Kg each) containing diet had no significant differences in the HDL-C concentrations during 4 weeks' period where as *enokitake* fibre fed groups showed a significant decline compared to the rat fed with control.

HDL-C is the major carrier of cholesterol in rats and therefore its variation will be reflected in the changes occurring with respect to TC. The serum HDL-C was in increasing trend at the end of 90 days. Therefore, long term feeding of CKIF was effective in elevating the serum HDL-C of rats despite inconsistent variation in between. The increase of HDL-C is favorable since it is cardio protective.

Serum TAG concentrations of rats fed with CKIF containing feed

The serum TAG concentrations of rats fed with control and experimental feeds declined in 30 days significantly (Table 5). The highest decline was observed from the group fed with the control feed at 30 days. However, the serum TAG concentrations of rats in all groups showed an increase. The control group showed significant decline of serum TAG in 60 days and non-significant decline in 90 days. Therefore, the control group shows an increasing trend of serum TAG concentration. In contrast, fibre incorporated feed fed groups showed non-significant decline in 60 days followed by a significant decline in 90 days. Therefore, fibre caused to hinder the increase of serum TAG concentrations of rats in 90 days. When the incorporation is increased from 5 % to 10 % stronger effect was observed.

Previous studies have shown that insoluble fibres contribute to significant lowering of serum TAG concentrations. Among them, Leontowicz *et al.* (2001) showed that serum TAG concentrations of rats fed with cholesterol enriched 10 % AP reduced by 14.8 % compared to cholesterol enriched basal diets fed without fibre in 40 days. The present study showed significant reduction of serum TAG concentration of rats fed with 5 % CKIF and 10 % CKIF containing diets compared to the basal feed fed group at 30 and 90 days. Rashad and Moharib (2003) observed significantly lower serum TAG concentrations in rats fed with four diets containing 10 % Turnip, 10 % sugar beet, 10 % cabbage and 10 % fenugreek green fibre concentrates compared to a fibre free diet for 56 days. Therefore, these studies confirm the potential of insoluble fibres (CKIF, vegetable fibre concentrates and AP) to reduce TAG concentrations of the rats. However, the study of Rieckhoff *et al.* (1999) showed that oat fibre concentrate fed hamsters did not show significant change in serum TAG concentrations after 5 weeks of feeding. The CKIF in present study showed similar results in 60 days of feeding.

In the control group, the serum glucose concentration increased by 40.13 mg/dl while in rats fed with 5 % CKIF and 10 % CKIF containing feed increased by 28.04 mg/dl and 15.52 mg/dl respectively. The increase shown by the CKIF incorporated feed fed groups are less compared to the increase shown by the control group. This shows that addition of CKIF to hypercholesterolemic rat diet hinders the elevation in serum glucose concentration at 90 days.

Insoluble fibre rich diets resulted in the reduction of serum glucose concentrations of rats. Sindurani and Rajmohan (2000) showed that the blood glucose concentrations of male albino

rats (Sprague- Dawley strain) consuming feeds incorporated with 5 %, 15 % and 30 % of NDF obtained from coconut kernel were lower than the glucose concentrations in the control group. The percentage reduction was directly proportional to the amount of the fibre added. Moharib and Batran (2008) showed that there was a significant reduction in plasma glucose concentrations of rats (male albino) fed with 50 mg/kg, 100 mg/kg, 150 mg/kg and 200 mg/kg of dietary fibre obtained from Egyptian grape leaves. The grape leaves fiber was administered orally. However the decline in glucose concentrations in groups administered with 100 mg/kg and 200 mg/kg was highly significant ($P<0.01$). They observed a gradual decrease in glucose concentrations.

Conclusion

The coconut kernel insoluble fibre obtained from residue of virgin coconut oil production contains 60.9 % hemicelluloses. The CKIF has the capacity to lower serum total cholesterol, serum triglycerides and serum glucose of rats. The coconut kernel insoluble fibre at 10 % incorporation to the feed was more effective for hindering the increase of serum TC, TAG and glucose concentration of rats. The increase of serum TC and TAG concentrations at 60 days is observed. Therefore, insoluble fibre of coconut kernel can be incorporated in food preparation to increase dietary fibre intake.

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