International Journal of Scientific Research and Management (IJSRM)
||Volume||09||Issue||09||Pages||FT-2021-110-116||2021||
Website: www.ijsrm.in ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v9i9.em01

Effect of Kithul Palm (*Caryota urens*) Fiber on Subjective Satiety and Food Intake of Normal and Overweight Women in Sri Lanka

Subashinie Samarakone, Wishmanthi Amarasinghe, Dhanesh Liyanage

Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka.

Abstract
Dietary fiber plays prominent role in satiety characteristics of meals. Kithul palm flour is a conventional food ingredient consumed in Sri Lanka, believed having superior satiety characteristics. This study aimed to find the subjective satiety characteristics of Kithul flour meal compared to soluble fiber meal (Psyllium) and low fiber meal. Three arm, single blinded, cross over placebo controlled study was designed with three isocaloric treatments (carbohydrate 55%, fat 30% and protein 15%) having same energy density (~1 kcal/g). Satiety characteristics after ingestion of treatment meal were recorded using Visual Analog Scale (VAS). The Kithul flour meal had significant reduction in hunger (P=0.0025), increment in fullness (P=0.0408), reduction in desire to eat (P<0.0001), and reduced prospective food consumption (P<0.0001) values compared to the Psyllium meal. Further, Kithul flour meal had increased fullness (P=0.0388), reduced desire to eat (P=0.0002), and reduced prospective food consumption (P<0.0001) compared to the low-fiber control meal. Kithul flour meal showed superior satiety results in overweight women compared to normal weight women.

Keywords: Kithul, Psyllium, Dietary fiber, Satiety, Women, Overweight

Introduction

The prevalence of overweight and obesity is increased drastically over the past few decades in Sri Lanka. The percentages of Sri Lankan adults in the overweight, obese categories are 37.0% and 15.8% respectively (Somasundaram et al., 2019). Female population has high prevalence of both obesity and abdominal obesity (Somasundaram et al., 2019). Obesity has many impacts, including the associations with non-communicable diseases such as cardio vascular disease and diabetes.

Dietary fibers are "plant constituents that are not enzymaticaly degraded to absorbable subunits in the stomach and small intestine" (Trowell, 1976; Cummigs and Englyst, 1987). The recommended daily intake of fiber for healthy adults is between 20 and 38 g/day, however much lower intakes of fiber have reported in worldwide (Pilch, 1987). Some epidemiological and cross studies found out that low intake of dietary fiber is associated with increased risk for obesity (Alfieri et al., 1995; Burkitt and Trowell, 1975; Van Itallie, 1978).

Obesity represents the long term result of an imbalance between energy intake and energy expenditure. There is a relationship between dietary fiber and energy control mechanisms. The ingestion of fiber has been hypothesized to suppress energy intake by inducing satiation and satiety (Blundell and Burley, 1987). Dietary fibers have a capability of regulating satiation and satiety due to their characteristic chemical and physical properties such as bulking and viscosity producing capability. The addition of fibers forms viscous colloidal dispersions and it affects to the digestion and absorption of carbohydrate and fat. Due to increasing viscosity of intestinal contents slows gastric emptying and small bowl transit, interferes with the mixing of food stuffs and digestive enzymes, disrupts micelle formation and alters diffusion and interaction of nutrients with mucosal surface (Schneeman and Tietjen, 1994).

Presently numbers of dietary fiber sources are used as dietary fiber supplements. Dietary fibers have different physiological effects and their impact on satiety and energy intake may vary due to their unique characteristics. Psyllium husk powder (*Plantago ovata*) is a rich source of soluble dietary fiber and commonly used as a dietary fiber supplement. Kithul parm (*Caryota urens*) pith, commonly known as *Kithul*

in Sri Lanka, is a traditional starch rich source (5.5 g/100 g) of dietary fiber (Rajyalakshmi and Geervani, 1994). We hypothesized that the dietary fiber in Kithul palm pith has satiety effect and reduces the postprandial energy intake. Hence, aim of this research was to find the effect of Kithul palm pith on satiety and energy intake in normal and overweight women in Sri Lanka.

Materials and Methods

Experimental Design

This study was conducted as three arm, single blinded, cross over, placebo controlled study. All subjects were given informed consent forms prior to their participation.

Subjects Recruitment Criteria

About 25 subjects were recruited through flyers placed around the Wayamba University of Sri Lanka. Eligibility of subjects was determined according to the all inclusion and exclusion criteria. Inclusion criteria were being healthy females without dietary diseases, unrestrained eaters (score ≤ 10 on the Three Factor Eating questionnaire) (Stunkard and Messick, 1985), pre-menopausal with spontaneous menstrual cycle, body mass index (BMI) between 20 to 30 kg/m^2, without depression (< 50 Zung's Depression Index) (Zung, 1965). Exclusion criteria were being pregnant or lactating, smoking, allergies or intolerances to foods consumed in the study, active modification to diet or exercise patterns to gain or lose weight in previous 60 days, unstable body weight (fluctuations of ≥ 5 kg in 60 day period) and strict to a diet plan. Standard values of BMI were used to categorize subjects into normal weight (20 > BMI < 25) and overweight groups (25 > BMI < 30). Fifteen subjects (10 normal weight and 5 over weight) completed the study were in accordance with the study protocol. Characteristics of subjects are given in Table 1.

Table 1. Subject Characteristics

	Overweight women (mean ± SD)	Normal weight women (mean ± SD)
Age (years)	22.9 ± 1.1	22.8 ± 0.8
BMI (kgm^{-2})	27.6 ± 2.2	22.9 ± 1.2
Zung's Depression Score	47.6 ± 2.6	45.9 ± 8.6
Dietary restraint value	9.6 ± 1	7.7 ± 2

Preload Preparation and Composition

Three different treatments were given in the form of breakfast muffins. Those were isocaloric treatments (~500 kcal) with 55% carbohydrates, 30% fat and 15% protein. The compositions of the three treatments are given in Table 2. Muffins were formulated fulfilling above mentioned criteria and nutrition contents were calculated with the use of USDA Food composition tables.

Table 2. Composition of Preloads

	Kithul	Psyllium	Control
Total Energy - kcal	499	502	499
Carbohydrate - g, (%kcal)	67 (54%)	64 (52%)	64 (51%)
Fat - g, (%kcal)	17 (32%)	18 (32%)	18 (32%)
Protein - g, (%kcal)	12 (10%)	15 (11%)	15 (11%)
Fiber from wheat flour - g	0	1.3	1.3
Total fiber - g	3.4	4.7	1.3
Energy density (kcal/g)	~1	~1	~1

Two of the preloads meals contained dietary fiber from Psyllium husk powder (Yerba Prima, USA) and Kithul palm pith powder at 0.94 g/100 kcal and 0.68 g/100 kcal respectively. Controlled meal had lower amounts (0.26 g/100 kcal) of dietary fiber. The energy density of each meal was ~1 kcal/g.

Muffin mixtures were prepared by adding ingredients as shown in Table 3 and following standard baking procedures. After cooling, muffins were removed from the mold and refrigerated for future use. On the study day muffins were removed from the refrigerator before each subject's visit and they were thawed in microwave oven for 2 minutes.

Table 3. Ingredients of Preloads

	Kithul	**Psyllium**	**Control**

Kithul palm pith powder	61.2	-	-
Wheat flour	-	56.1	55.0
Psyllium husk powder	-	4.1	-
Margarine	25.5	25.5	25.5
White sugar	10.2	15.4	14.5
Whole chicken egg	25.6	22.5	14.5
Vanilla	2.4	2.4	2.4
Sodium bicarbonate	1.0	1.0	1.0
Skim milk powder	20.4	14.2	15.2

Study Protocol

Subjects arrived at a time between 7.30 – 8.30 a.m. after an overnight (10-12 h) fast. There were three study visits for each subject. Subjects were participated only during follicular phase of their menstrual cycle (5 to 14 days after the start of menstrual cycle). Minimum of one week duration was kept between two visits.

Upon arrival their height, weight, waist circumference and last menstrual cycle information were recorded. Subjects were asked to mark their initial huger level on 100 mm Visual Analog Scales (VAS). Just before taking preloads, subjects were asked to mark their subjective satiety characteristics (hunger, fullness, desire to eat, and prospective food consumption) on 100 mm Visual Analog Scales (VAS). Thereafter subjects were given one of the preloads which they have consumed within 20 minutes. After consuming preloads subjects were asked to answer VAS questionnaires on above mentioned subjective satiety characteristics at 20, 40, 60, 90, 120, 150, 180, 210 and 240 minutes. At 240 minutes subjects were given a pre-weighed ad-libitum lunch (test meal) and they were asked to eat until they felt comfortably full. All the subjects were requested to record the food intake using food diaries 1 day before, remainder of the test day, one day after, and 3 days after the experiment.

Food Consumption at Test Meal

Energy intake was assessed at an ad-libitum test meal presented to subjects 240 min after the consumption of the preload. Test meal consisted with standardized vegetable fried rice. Test meal was prepared by using 90 g of raw Samba rice, 25 g of carrots, 25 g of leaks, 25 g of beans and 25 g of margarine. The rice was cooked and mixed with fried vegetables. Energy and macronutrient composition were calculated by using information provided by USDA food composition tables. Test meal contained 58.5% carbohydrates, 5.5% protein and 29% fat.

Participants received same type of test meal at each test session. The test meal was presented in excess and subjects were instructed to eat and drink until they felt comfortably full. The cooked fried rice was weighed before serving, and the amount left after the meal was subtracted from the initial weight to measure the food intake. Net weight consumed was converted into energy intake (kcal) by using calculated energy values.

Subjective Satiety Measurement by Visual Analog Scales (VAS)

Four VAS questionnaires were used to measure subjective characteristics of satiety (hunger, fullness, desire to eat, and prospective food consumption) of the preloads. VAS questionnaires consist of 100 mm lines anchored at each end with opposing statements. Participants were marked vertical line over the 100 mm horizontal line to indicate their feeling at that point of time. The VAS score was calculated by measuring the distance in millimeters from the beginning of the line to the position of the mark (from left to right).

- Hunger was assessed on a VAS asking “How hungry do you feel right now?” ranking the answer from “not at all” to “extremely”.
- Fullness was assessed on a VAS asking “How full do you feel right now?” ranking the answer from “not at all” to “extremely”.
- Desire to eat was assessed on a VAS asking “How strong is your desire to eat right now?” ranking the answer from “not at all” to “extremely”.
- Prospective consumption of food was assessed on a VAS asking “How much do you want to eat right now?” ranking the answer from “not at all” to “as much as I can”.

Participants answered those questions at 0, 20, 40, 60, 90, 120, 150, 180, 210 and 240 minutes.

Analysis of Energy Intake at Test Meal

Food records during test day was analyzed by using dietary analysis program Food Base 2000 (Brain Chemistry, UK) provided detailed nutrient information including total energy, fat, protein and fiber intake.

Statistical Analysis

Ratings for hunger, fullness, desire to eat, and prospective food consumptions were converted to normalized values. Data were statistically analyzed by using repeated measures of analysis of variance (ANOVA) using PC- SAS (Version 9.2.0, SAS Institute, Cary, NC, USA) GLM and mixed procedure with preload, time, and BMI as main factors and subjects as the blocking variables and energy intake were analyzed by one way repeated analysis of variance using Minitab (Version 15, LEAD Technologies, INC, USA). Statistical significance was determined at $P<0.05$.

Results

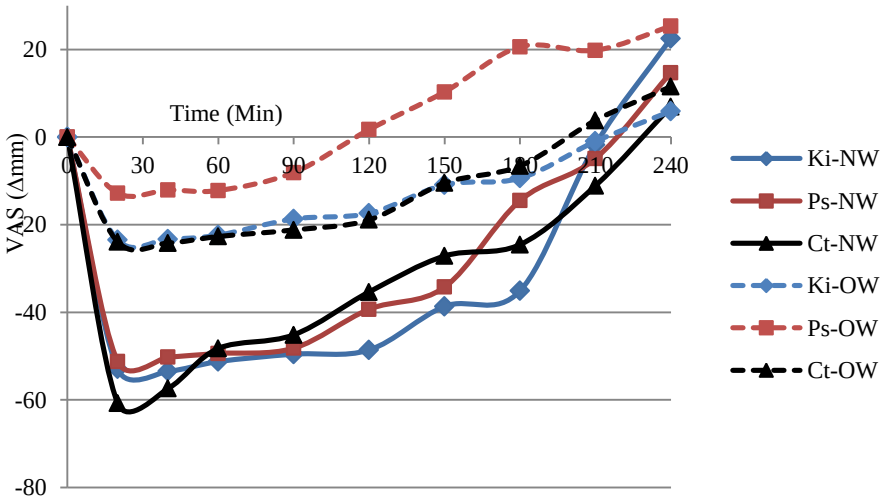
Satiety Characteristics

Irrespective of the BMI, all women showed significantly lower hunger after consuming Kithul palm flour meal ($P=0.0025$) and control meal ($P=0.0052$) compared to Psyllium meal, significantly higher fullness after consuming Kithul palm flour meal compared to Psyllium meal ($P=0.0408$) and control meal ($P=0.0388$), significantly lower desire to eat after consuming Kithul palm flour meal compared to Psyllium meal ($P<0.0001$) and control meal ($P=0.0002$), significantly lower desire to eat after consuming control meal compared to Psyllium meal ($P=0.0285$), significantly lower prospective consumption after consuming Kithul palm flour meal compared to Psyllium meal ($P<0.0001$) and control meal ($P<0.0001$).

Irrespective of meal overweight women showed significantly higher hunger ($P<0.0001$), significantly higher desire to eat ($P<0.0001$), significantly higher prospective consumption ($P<0.0001$) and significantly lower fullness ($P=0.0002$) characteristics compared to normal weight women.

Normal weight women did not show different responses to hunger ($P>0.05$) in all treatments, yet overweight women showed significantly higher hunger reduction in Kithul palm flour meal ($P=0.0021$) and control meal ($P=0.0036$) compared to Psyllium meal (Figure 1).

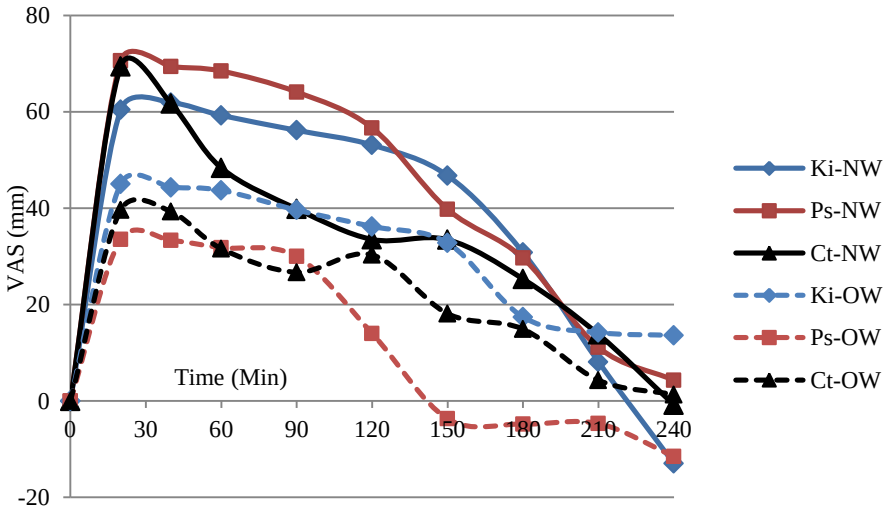
Figure 1. Variation of hunger values in normal and overweight women with different treatments



Abbreviations: Ki= Kithul; Ps= Psyllium; Ct= Control; NW= Normal weight; OW= Overweight.

Normal weight women showed significantly higher fullness after consuming Psyllium meal ($P=0.0076$) compared to control meal and, overweight women showed higher fullness after consuming Kithul palm flour meal ($P=0.0004$) compared to Psyllium meal (Figure 2).

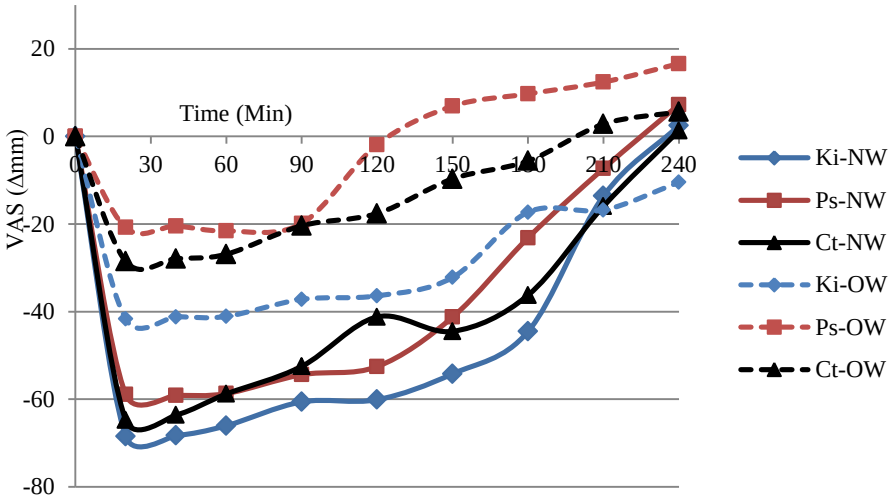
Figure 2. Variation of fullness values in normal and overweight women with different treatments



Abbreviations: Ki= Kithul; Ps= Psyllium; Ct= Control; NW= Normal weight; OW= Overweight.

Normal weight women had lower desire to eat after consuming Kithul palm flour meal (P=0.0059) compared to Psyllium meal (Figure 3). Overweight women had significantly lower desire to eat after consuming Kithul palm flour meal compared to Psyllium meal (P<0.0001) and control meal (P=0.0009), significantly lower desire to eat after consuming control meal compared to Psyllium meal (P=0.0414).

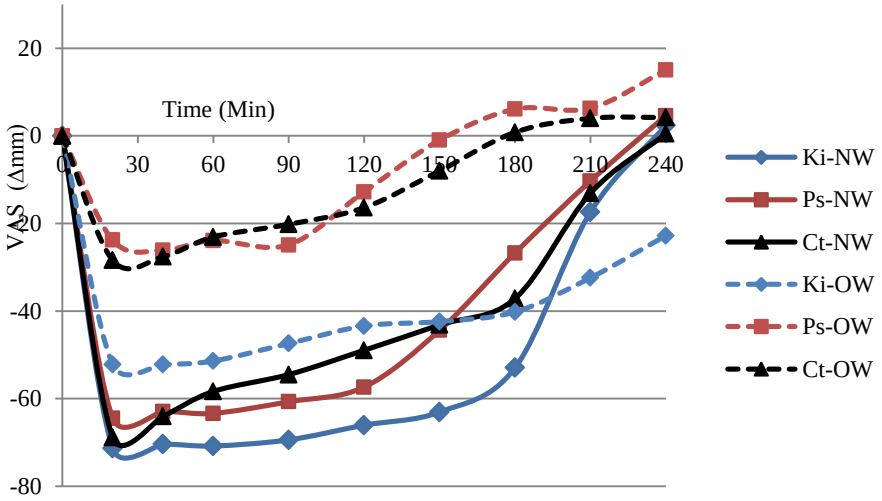
Figure 3. Variation of desire to eat values in normal and overweight women with different treatments



Abbreviations: Ki= Kithul; Ps= Psyllium; Ct= Control; NW= Normal weight; OW= Overweight.

After consuming Kithul palm flour meal both normal weight women and overweight women showed significantly lower prospective consumption compared to Psyllium meal (P=0.0019 and P<0.0001 respectively) and control (P=0.0023 and P<0.0001 respectively) meal (Figure 4).

Figure 04. Variation of prospective consumption values in normal and overweight women with different treatments



Abbreviations: Ki= Kithul; Ps= Psyllium; Ct= Control; NW= Normal weight; OW= Overweight.

Energy Intake at ad-libitum Meal

No differences were observed ($P > 0.05$) in energy intake at the ad-libitum meal after consumption of all three test meals.

Discussion

Results of this study supported the hypothesis that the dietary fiber of Kithul palm pith flour increased satiety independent to the total energy content in short term. Overall, it had an ability of reducing hunger, increasing fullness, decreasing desire to eat and prospective food consumption. Therefore Kithul palm pith flour showed positive impact on increasing satiety than Psyllium and low fiber meal (Control). Subjective satiety shown by VAS was not represented at postprandial energy intake as there were no significant differences.

Psyllium (7.4 g) was given to normal volunteers in a double-blind study, and its effects on hunger and food intake were measured (Rigaud et al., 1998). After the meal, hunger feelings and energy intake were significantly lower following the Psyllium treatment compared with the placebo. On the same study, smaller dose of Psyllium (1.7 g) has no effect on hunger showing the requirement of higher doses to be biologically active. The effects of Psyllium in the present study was not significant and it may not be a larger enough dose (3.4 g of dietary fiber from Psyllium) to be biologically active. At the same level of dietary fiber, Kithul palm pith powder (3.4 g) showed significant effect compared to same dose of Psyllium showing the biological significance at a relatively lower dose.

In a study testing subjective satiety and postprandial energy intake (Bergman et al., 1992) no significant differences were observed in satiety and energy intake at a dose of 10.8 g dietary fiber. Present study was also compatible with the finding of Bergman et al. and no differences in energy intake was shown at a dose of 3.4 g of dietary fiber.

The daily requirement of dietary fiber for women is 20 g. If someone gets their energy requirement (~ 2000 kcal) from Kithul palm pith powder that person gets 14 g per day, (0.7 g/100 kcal) which is four times higher dose compared to the present study, at such a dose reduced hunger, increased fullness, decreased desire to eat and prospective food consumption would be at higher magnitude that could cause reduced energy intake in consequent meals.

Results of the presents study showed, Kithul palm pith flour is more effective in controlling subjective satiety in overweight women than normal weight women. This may be due to the fiber properties or other bioactive compounds of Kithul palm pith flour. Kithul palm pith flour can be used as a dietary supplement to regulate the satiety of overweight women.

In the present study, low amount of dietary fiber was used (3.4 g) as those dietary fibers coming from unrefined Kithul palm pith flour. Therefore it contains other things which may negatively affect to the palatability of the product.

Particle size of Kithul palm pith powder was relatively high and it made low pleasantness in the meal. Reduction of particle size, increase of water content and fat content during the meal preparation leads to

muffin with pleasant characteristic qualities, which can be used to produce diet to control satiety and energy intake.

Conclusions

Superior subjective satiety characteristics (increased fullness, decreased desired to eat and prospective food consumption) were shown by Kithul palm starch dietary fiber even at moderate levels (0.7 g/100 kcal) of consumption.

References

1. Alfieri, M.A., Pomerleau J., Grace D.M. and Anderson, L. (1995). Fiber intake of normal weight, moderately obese and severely obese subjects. *Obesity Research*. 3(6):541-547.
2. Bergmann, J.F., Chassany O., Petit, A., Triki, R., Caulin, C. and Segrestta, J.M. (1992). Correlation between echographic gastric emptying and appetite: influence of Psyllium. *Gut.* 33(8):1042–1043.
3. Blundell, J.E. and Burley, V.J. (1987). Satiation, satiety and the action of fiber on food intake. *International Journal of Obesity*. 11(1S):9-25.
4. Burkitt, D.P. and Trowell, H.C (1975). Refined Carbohydrate Food and Disease. Pp.333-345. Academic press, London, UK.
5. Cummings, J.H. and Englyst, H.N. (1987). Fermentation in the human large intestine and the available substrates. *American Journal of Clinical Nutrition*. 45(5):1243-1255.
6. Pilch, S.M. (1987). Physiological Effects and Health Consequences of Dietary Fiber. Pp.149-157. Life Sciences Research Office, Federation of American Societies for Experimental Biology.
7. Rajyalakshmi, P. and Geervani, P. (1994). Nutritive value of the foods cultivated and consumed by the tribals of South India. *Plant Foods for Human Nutrition*. 46(1):53-61.
8. Rigaud, D., Paycha, F. Meulemans, A, and Merrouche, M. (1998). Effect of psyllium on gastric emptying, hunger feeling and food intake in normal volunteers: a double blind study. *European Journal of Clinical Nutrition*. 52(4): 239–245.
9. Schneeman, B.O. and Tietyen, J. (1994). Dietary fiber. In: Modern Nutrition in Health and Disease. Pp 89-100. 8th edition. (Shills M. E. Olson J. A. Shike M. eds.) Lea and Febiger, Philadelphia, PA.
10. Somasundaram, N., Ranathunga, I., Gunawardana, K., Ahamed, M., Ediriweera, D., Antonypillai, C.N., and Kalupahana, N. (2019). High Prevalence of Overweight/ Obesity in Urban Sri Lanka: Findings from the Colombo Urban Study. *The Journal of Diabetes Research*. 2019 Nov 22; 2019:2046428. doi: 10.1155/2019/2046428. PMID: 31886277; PMCID: PMC6893241.
11. Stunkard, A.J. and Messick, S. (1985). The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *Journal of Psychosomatic Research*. 29(1),71-83.
12. Trowell, H. (1976). Definition of dietary fiber and hypothesis that it is a protective factor in certain diseases. *American Journal of Clinical Nutrition*. 29,417–427.
13. Van Itallie, T. B. (1978). Dietary fiber and obesity. American Journal of Clinical Nutrition. 31(10),S43-S52.
14. Zung, W.W. (1965). A self-rating depression scale. *Achieves of General Psychiatry*. 12,63-70.