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Original article

Acute effect of pulses based functional muffins on food intake, postprandial glucose and appetite regulation in healthy females

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Summary. *Background/Aims:* The core intention of recent exploration was to investigate the impact of pulse based dietary intervention (muffins) on blood Glucose (BG) & average appetite before and after an ad libitum pizza meal and on food intake (FI). *Methods:* Purposely, a crossover, repeated measure design was adapted by involving 12 healthy females (18–30 years old: with a normal BMI 20–24·9 kg/m^2) randomly provided 4 treatments (isovolumetric and isocaloric): T_1 (control: muffin without pulses), T_2 (Lentil based muffins prepared by pulses floor replacement @ 20% with conventional floor), T_3 (Mung bean based muffins prepared by pulses flour replacement @ 20% with conventional floor) and T_4 (Combination of Lentil+Mung bean based muffins prepared by pulses floor replacement @ 10+10%, respectively with conventional floor), followed by a provision of pizza meal after the 120minutes. BG and average appetite was measured at 0, 15, 30, 45, 60, 90 and 120 minutes for pre meal and 140 and 170 minutes for post meal. Whereas, food intake was measured at a pizza meal (140 minutes). *Results:* The pulses based muffins caused reduced food intake ($p<0.0001$) at later pizza meal, in this context, mung bean based muffins imparted more pronounced impact then the rest of the treatments. Likewise trend was observed for post treatment period (0–120minutes), significant ($p<0.0001$) decline in BG and average appetite by all treatments, however again T_2 exhibited better response then the rest. The order of effectiveness to tackle BG and average appetite for pre and post meal period $T_2>T_3>T_1>T_0$. *Conclusion:* Conclusively, the type of pulses has stronger influence on short term glucose, average appetite and reduce food intake after subsequent meal might be due to difference in their protein contents. The pulses with higher protein exhibited better glycemic control. Moreover, pulses based functional foods should be developed to tackle the glycemic responses owing to their appetite and food intake lowering perspective.

Key words: postprandial blood glucose, pulses based dietary intervention

Introduction

Metabolic syndrome is considered as havoc for developing economies and Pakistan is no more acceptation. In Pakistan obesity, diabetes and hypertension are leading cause of death and morbidity. According to an estimate, 42% deaths are accounts for chronic diseases in Pakistan with alarminutesg increase in diabetes and obesity. Despites all efforts, it seems increasing with every passing day. Currently, we are expected in 4th place in terms of diabetes and 9th in obesity. Scientists have identified the numerous factors for their onset, however, reliance on monotonous diet, excessive consumption of caloric dense foods and lack of active lifestyle are considered as major contributors. Amongst the different strategies, dietary interventions are imperative approach to tackle the ever-escalating threats for metabolic syndrome. In dietary regimen

plant based bioactive molecules has the stimulated effect to control different glitches through regulation of body weight, appetite and glucose homeostasis.

Satiation and satiety are the phenomenon associated with the fullness sensation. However, there is basic difference among these in terms of time and outcome. Satiation is defined restriction within meal owing to the fullness onset. Thus, it can be plausible in controlling hunger and energy intake in natural way. Whereas, satiety is the sensation after fullness that can delay the desire for the consumption of 2nd meal can play vital role for maintaining balance in energy intake and utilization. The food that produced higher/early satiations and satiety is instrumental for controlling metabolic syndromes like diabetes and obesity (1-3). Basically, satiation and satiety are directly proportional with sensory properties of any meal and may also be affected by the nutritional composition of that food (4). Feeling of fullness during and after meal is a complex phenomenon that correlate with the gastric sensation, gastric emptying rate and various gastrointestinal hormones, with special reference to active ghrelin, cholecystokinin (CCK), dipeptide peptidase (PYY) and glucagon like peptide-1 (GLP-1), key components in satiety and postprandial glucose management (5, 6)

In this milieu, pulses are the promising candidates with potential to earlier onset of both these thus mange low food intake and increase energy expenditure. Short-term studies have shown that pulses, when consumed alone, are high satiety low glycemic foods that have the ability to lower the BG response to a later meal (7-9).

Recent human trials revealed the effectiveness of pulses intake is directly associated to reduce hunger and increased satiety 2–4 h after pulse consumption when meals were controlled for energy. Satiety refers to the processes that decrease hunger after an eating occasion has ended and will mirror the amount of food consumed (10). Moreover, scientists were of the view that delayed carbohydrate oxidation associated with the diet high in unavailable carbohydrate resulted in less hunger. Whereas nutritional properties also indicate that affluent source of pulse grains are strongly related with positive effect of postprandial glucose, appetite and satiety which are key factors in the fight against diabetes and obesity. Postprandial glucose (PG) provides insights into the adequacy of insulin secretion, the degree of insulin sensitivity and the activation of glucose homeostatic system. Additionally, studies explained that the addition of pulses flour in bakery items is efficiently control the hunger, satiety and appetite thus helpful to attenuate the metabolic syndrome. There are consolidated evidences that advocating an inverse association between enhanced protein consumption and reduced risks for metabolic syndromes. The 20% protein increment may cause decline on elevated weight and blood glucose by lowering the fat and promoting the lean body mass. Furthermore, the high protein diets are also managed the glycemic responses by modulating energy metabolism and appetitive signaling leading to reduced energy intake (11). Being a rich source of proteins, pulses have credential to be incorporated as a part of dietary interventions against diabetes and obesity owing to their lower food intake and glycemic management perspectives (12). Numerous previous investigations have divulged the positive impact of pulses based interventions on glycemic response by modulating the appetite, food intake and satiety (13, 14). The outcomes of most of studies have showed the inverse association between pulses consumption and blood glucose level however, none of the studies have elaborated the comparative analysis of pulses in alone or in combination in different products. In recent experiment two type of pulses were utilized *i.e* .Mung bean (*Vignaradiata*) and lentils (*Lens culinaris*). Mung bean (*Vignaradiata*), belonging to the (*Fabaceae*) legume family which containing several phytonutrients and antioxidants. While lentils (*Lens culinaris*) belonging to (*Fabaceae)* legume family other name is masoor which containing bioactive molecules with unique nutraceutical potential (15).

The prime mandate of current investigation was to carried out the comparative assessment of Mung bean (*Vignaradiata*), lentils (*Lens culinaris*) and combination (Mung+Lentil) based dietary intervention (muffins) for satiating and glycemic modulating perspectives. Purposely, a crossover double blind randomized design was adapted by providing pulses based intervention randomly to healthy young women alongside control. The selection of muffin as a vehicle is based upon the popularity of bakery items among the consumers of all ages and their easy availability.

Materials and Methods

Treatment Preparation

Initially, nine kinds of treatments (functional muffins) alongside control were prepared by using mung bean and lentil flour @10, 20 & 30% as flour replacement for Lentils and Mung Bean & 5+5, 10+10 & 15+15% for their combination. Moreover, the consumer acceptability of developed functional muffins (data not included) was assessed and on the bases of results 03 treatments alongside control was selected to be further utilized in efficacy trial (Table 1).

Study Protocol

Subjects

In present study, 12 healthy females age 18–30 years old with a normal BMI (20–24·9 kg/m^2) were recruited via advertisements within the Government College University Faisalabad vicinity through university websites, notice boards, on social media and as well as communicated verbally. Subjects were excluded if they involved in diabetes mellitus, have any metabolic disorders, on dieting, taking medicines, frequent breakfast skipper, allergy from pulses and participated in any other nutritional studies. At the time of in person screening at department, females with score of >11 on Eating Habits Questionnaire were considered as following diet restraints (16). Before the initiation of study, the protocol was presented to University Human Resource Committee and got approval (Protocol No- GCHRE-45286) and further communicated to subjects before taking their written willingness regarding the trial participation.

Table 1: Treatments utilized in short term human intervention trail

Treatments	Description
T_0	Control
T_1	20% from Mung Bean
T_2	20 % from Lentils
T_3	Selected from combination of both 10% Mung bean±10%Lentils

Study Design

Healthy young females (n=12) were already determined through power analysis attend four sessions randomly on a weekly basis during which they were received four treatments T_1, T_2, T_3 and control muffins in random order. They were fully informed and briefed about the purpose of study and signed the consent forms. The procedures adopted for the study were approved by the Scrutiny committee of Institute of Home and Food Science, Government College University, Faisalabad (GCUF).

Research participants visited the Nutrition lab. Institute of Home and Food Sciences GCUF, during four weekly sessions with one week gap to washout the effect of previous treatment. The subjects arrived in the experiment room after twelve hours overnight fast on the day of session. Water was allowed up to1 hour before the onset of each session. To minimize the variability within subjects each participant was scheduled to arrive at the same time and on the same day of the week for each treatment, and was instructed to maintain the same dietary and exercise patterns, the evening before each session. To ensure that instructions were followed fully, participants were provided visual analog scale questionnaires assessing their 'Sleep Habits', 'Stress Factors', 'Food Intake and Activity Level', and 'Feelings of Fatigue' to fill in upon their arrival to the department. Those whose answers on the questionnaire indicated feelings of illness, fatigue or stress were asked to reschedule.

Treatments were provided in random order once per week, over a period of 4 weeks. Following the completion of baseline measurements, each participant was instructed to consume the treatment within 15 minutes at a random order. The order of treatments was randomized using randomization block design, which was generated with a random generator script in SAS version 9.2. Participants were blinded to the treatment. Pleasantness, taste and texture of treatments were assessed and compared using 'Palatability' visual analog scale. After consumption of the treatments, subjects were asked to be seated for the whole duration of experimental session, and were permitted to read, do homework or listen to music.

Food intake of 12 participants was measured at an ad libitum pizza meal, served 120 minutes after

consumption of the treatments as described previously. Three varieties (Chicken Fajita, Deluxe and B. B. Q) of Al- Maida pizza Garden (Koh-e-Noor city, FSD, Pakistan) were offered to participants, according to their preference at screening, one variety i.e, Chicken Fajita was selected and was provided at all four sessions. The treatments were prepared 4 h before the session and stored in ambient storage conditions. Nutritional information of treatments and meal (pizza) is expressed in Table 2.

Protocol

The participants were instructed to 10–12 h overnight fast and were asked to complete a sleep habits performa, stress factors questionnaire and an Activity Questionnaire. If they report significant deviations from their usual patterns, they were asked to reschedule. Then the sample for Blood Glucose (BG) , alongside Visual analogous Scale (VAS) were taken; afterwards they were given assign treatment. Baseline blood samples were obtained by finger prick by a Monojector Lancet Device (Sherwood Medical), and BG concentrations measure by using a glucose meter (Accu-Chek Performa). The second drop was placed on the testing strip after wiping off the first drop of blood due to contamination with alcohol and interstitial fluid. Each participant was provided with the same glucometer to use throughout the study to reduce intra-subject variation. After baseline measurements for BG, participants were giving 20 minutes to consume a fixed-size muffin with 250 ml of filtered water. BG, VAS was measured at 15, 30, 45, 60, 90 and 120 minutes. Following the same procedures all the participants were treated and data were piled up accordingly. Afterwards, participants were provided with ad libitum pizza meal alongside 500 mL filtered water. The participant then requested to consume pizza meal up to fullness within 20 minutes. Afterwards, The Blood glucose concentrations and appetite scores were measured at 140 & 170 minutes. The food and caloric intake was measured through measurement of pizza weight before and after eating session.

Statistical analysis

Statistical program Statistix 8.1 was utilized to analyze the data collected from this study. To assess the effect of variables, i.e. time, treatment, their interaction on BG concentrations and appetite scores (VAS) two-way analysis of variance (ANOVA) was conducted. One-way ANOVA following Tukey's post hoc test was also conducted at each time point, where the interactions between both independent variables were found significant. Incremental area under the curve (iAUC) for BG and average appetite scores were also estimated through the trapezoid method. One-way ANOVA was conducted using Statistix 8.1software to assess the effect of treatments on iAUC for BG and appe-

Table 2. Nutritional composition of treatments and pizza meal

Treatments	Volume (g)	Energy (kcal)	Protein (g)	Fiber (g)	Available Carbohydrate (g)	Lipid Fat (g)
T_0	100 g	350	10.8	0.8	75	1.4
T_2	100 g	350	22.5	3.5	60.3	1.4
T_1	100 g	349	24.8	3.6	56.1	1.1
T_3	100 g	345	23.7	3.5	58.2	1.3
Pizza meal (per 1 slice)	100 g	210	12.0	1.0	30.0	5.0

[a]Nutrient content of Muffin and pizza as provided by the manufacturer on the food label.
[b]Amounts given for treatments are as per 40 g (1 serving size).
[c]Composition of pizza meal is as per 1 slice, i.e. 100g.

tite scores. Additionally, associations between dependent variables, i.e. food intake, BG and appetite were analyzed through Pearson's correlation coefficients. All the analyses were concluded with statistical significance with p value <0.05.

Results

Blood glucose (BG)

During post-treatment period (0–30minutes) blood glucose (BG) concentration were significantly affected by time (p<0.0001) and treatment (p<0.0001). Following control treatment mean for post treatment BG concentrations (0-120 minutes) was highest as measured up to all further treatments. However, amongst all treatments functional muffin with mung bean flour caused utmost decline in glucose during post treatment period (0-120 minutes). BG concentrations ascended immediately after treatment utilization at 0, 15 & 30 minutes and then decline to base line at 120 minutes, with the maximum restraint by muffins without pulses as compared to all others (Fig 1).

Similarly, BG concentrations during post-meal blood glucose (140–170minutes) were also affected by time (p< 0.000) and treatment (p< 0.000). In comparison to control treatment all treatments exhibited diminutesishing effect on BG concentrations instantaneously after treatment consumption (140 minutes). So that, functional muffin with mung bean flour had more enunciate effect on BG concentration as compared to other treatments. Additionally, cumulative BG concentrations of all the treatments (0-170 minutes) were also lesser than control treatment.

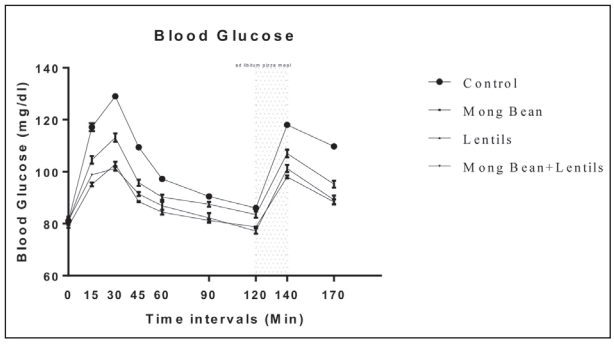

Figure 1. Effect of Treatments on Blood Glucose (mg/dL) over time (0-170 minutes).
Mean with different suerscripts are significantly different from each other (one factor anova followed Tuckey Kramer Post hoc test, P<0.05)

At peak time (30minutes) maximum BG concentration was observed in subjects consuming muffins without pulses however, the less increase in BG concentration was recorded for subjects consuming other treatments. In this context, minimum increase was reveled for mung bean added muffins. Likewise, the cumulative post meal means for BG (0-170) of all the treatments showed the similar trend; maximum BG in control muffin (118.00mg/dL) and minimum (98.00mg/dL) in functional muffin with mung bean flour. Likewise, the values of cumulative BG concentrations (0-170 minutes) were also showed lower results in trial groups in comparison to control group (Table 3).

Average Appetite

Time (p < 0.000) and treatment (p < 0.000) imparted significant effect on post treatment average appetite score. After the consumption of treatment (15 minutes) average appetite values were immediately declined for all treatments however mung bean muffins caused maximum suppression as compared to all others (Figure 2). Similar trend was recorded for whole post meal period (0-120 minutes). Likewise, during the post-meal phase (140-170 minutes) average appetite was also affected by time (p<0.0000) and treatment (p<0.000). The results showed that all treatments had declined effect on average appetite instantaneously after treatment consumption (140 minutes) as compared to control however, it is worth noted that the mung bean based muffin caused maximum decline. With the intention that, functional muffin with mung bean flour had more articulate effect on average appetite as compared to other treatments. In addition, cumulative values of average appetite after all the treatments (0-170 minutes) were also lesser than control treatment (p < 0.0032) as reflected by table 3. At the early stage of present study, in each session hunger was greatest at baseline before consumption of any treatment. Consequently, the consumption of treatment desire to eat was declined. Highly reduced after 15 minutes of consumption and progressively start to increase till 120 minutes. However, muffin with mung bean flour (T_2) caused minimum enhancement in desire to eat as compared to other trial treatments (lentils flour T_3 and

Table 3. Mean values for blood glucose, Appetite during pre-meal, peak time rise and pre-meal incremental area under the curve (iAUC) values for all biomarkers

Biomarkers	Control (Muffins without pulses)	Functional muffin with mong bean flour	Functional muffin with lentils flour	Functional Muffin with Mong Bean+ Lentils flour	*P-value*
Blood glucose (mg/dL)					
Post-treatment [1] (0-120minutes)	101.47±9.64a	86.34±4.39c	96.35±7.22b	87.8±3.34c	0.0053
Peak time rise [2] (30 minutes)	129.0±1.01a	102.83±2.30c	113.16±2.56b	101.33±1.85c	0.0221
Post Meal (140-170minutes) [3]	118.00±9.21a	98.00±4.52c	107.00±3.96ab	101.20±1.89b	0.0011
Cumulative (0-170minutes) [4]	109.73±6.96a	92.17±3.89d	100.1±4.19b	94.5±6.74c	0.0001
Post-treatment iAUC [5] (mmol*minutes/l)	2496±16.01a	1586.5±16.01c	1853.5±4.6bb	1534.08±6.c	0.0003
Average appetite Score (mm)					
Post-treatment (0-120minutes)	63.22±2.93a	58.95±1.66d	61.34±.2.56b	59.72±1.30c	0.0041
Post-treatment iAUC[4] (mmol*minutes/l)	79.52±16.32d	167.91±16.01a	101.2.62±4.63b	145.36±6.31c	0.0000
Post Meal (140-170minutes)	25.00±1.20a	18.00±1.06d	21.00±0.96b	19.00±2.34c	0.0000
Cumulative (0-170minutes)	44.11±1.21a	38.47±0.56c	41.17±1.52ab	39.36±0.24b	0.0032

[a]Control=Muffins without pulses flour, muffins with Mong bean (Total 20g Protein), Muffins with lentils (Total 20g Protein), Muffins with mong bean+ lentils (Total 20g Protein), [b] Mean values ± SE (n=12) within a row, with unlike superscript letters, were significantly different from each other (P<0.05, two-way ANOVA, Tukey–Kramer post hoc test). [1]Post-treatment values are means of all observations before the test meal: 0, 15, 30, 60, 90 and 120 minutes (blood glucose).[2] Peak time rise values are means of all observations at the peak glucose rise time i.e. 30 minutes.[3] Post-meal values are means of all observations (absolute values) after the test meal: 140, 155 & 170minutes. Cummulative values are means all observations within 0-170 minutes[4]. Post-treatment incremental areas under the curve (iAUC) values are means of the iAUC during 0-120 minutes.

combination of both lentils ± mung bean T_4). In all the sessions of current study, feeling of fullness at baseline with no consumption was least. However, after the consumption of each treatment there were highly significant results over time. Therefore, maximum level of fullness showed by treatment with mung bean flour (T_2) throughout the measured points with comparison to following treatments (lentils flour T_3 and combination of both lentils ± mung bean T_4) at 120 minutes. Whereas all the treatments were indicated significantly differences than control (treatment without pulses).

Food intake(FI)

Statistical analysis for food intake (kcal) demonstrated significant imapct of treatments (p<0.0000) on FI (kcal) for post-meal given after 120 minutes. The current study illustrated that FI after consuminutesg experimental treatments were lower as comapred to control traetment. However, in comparison with experimental treatments, the treatment of functional muffin with mung bean flour showed lesser amount of FI (kcal). The recorded food intake (kcal) for all the treatments were as follows T_1 (400±12.32), T_2 (355±8.9), T_3 (376±19.69) and T_4(370±12.78) respectively (Fig 5).

Discussion

The outcomes of current exploration expounded that pulses based muffins provision proved effectual for

controlling short term food intake, satiety as well as glycemic responses to a post-meal given at 120 minutes. It is worth noted that in all the experimental treatments the specific functional muffin with mong bean flour showed more prononced effect in diminutesshing BG response during peak time (30 minutes) and post-treatment (0-120 minutes) period. Moreover, the interpretations also cleared that, functional muffin with mong bean flour had more pronounced effect on average appetite compared to other treatments before and after the post-meal. Even though, both functional muffin with lentils and mung bean + lentils also exhibited considerable effects in decreasing the post-glycemic response, average appetite and food intake of pizza meal, however, functional muffin with mong bean flour showed the better control on glycemic response and satiety than that of other experimental treatments alongside control.

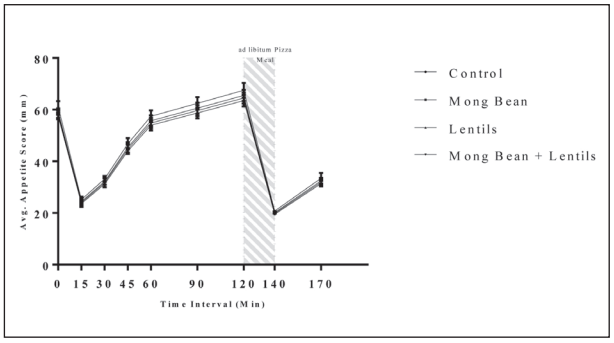

Figure 2. Effect of treatments on average appetite score (mm) over time (0–170minutes). Means with different superscripts are significantly different at each measured time (one-way ANOVA, Tukey–Kramer post hoc test, p<0.05).

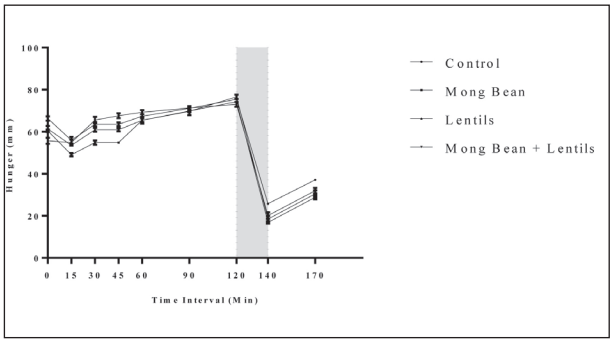

Figure 3. Effect of treatments on hunger score (mm) over time (0–170minutes). Means with different superscripts are significantly different at each measured time (one-way ANOVA, Tukey–Kramer post hoc test, p<0.05).

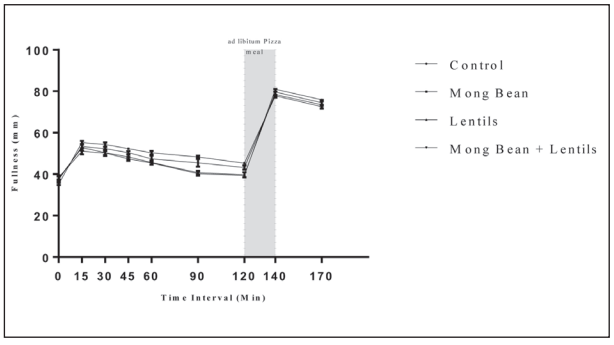

Figure 4. Effect of treatments on fullness score (mm) over time (0–170minutes). Means with different superscripts are significantly different at each measured time (one-way ANOVA, Tukey–Kramer post hoc test, p<0.05).

The result of present investigation is in harmony with the earlier finding of (17) formulated a pulse based intervention against glycemic abnormalities and observed improvements in glycemic responses. They inferred regular intake of pulses may contribute to lowering of the plasma glucose & cholesterol level owing to its fiber and protein contents thus suitable to manage component of metabolic syndromes. The glycemic management perspective of current study might be ascribed to pulses perspective to reduce food intake, regulating appetite and satiety cascade.

Moreover, (13) they carried out a double-blind cross over human trial to validate the effect of predetermined volume feeding of pulses meal on appetite and blood glucose (BG) and food intake. The results indicated that all the treatments caused immediate decline in BG. They were of the view that the type of pulses, the

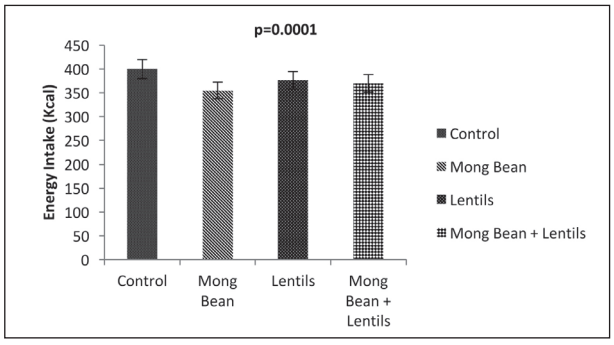

Figure 5. Effect of Treatments on Food intake (Kcal) at ad libitum pizza meal (120 minutes following the treatments). Mean with different suerscripts are significantly different from each other (one factor anova followed Tuckey Kramer Post hoc test, P<0.05) All values are mean±SEM (n=12)

nutritional composition of pulses and the duration and combination of meal may have influence on the BG and average appetite suppressing perspective of pulses.

The more pronounced effect of mung bean in present exploration in comparison with other treatments is might be due to type of pulses as each pulse has different kind of nutritional buildup that may contribute towards its therapeutic potential. This concept is further verified by the previous exploration of (14) were investigating the effect of processing conditions, recipe of dishes, and effect of variety on short-term acute BG, average appetite and food intake by involving the healthy young men and observed that the glycemic responses affected by type of pulses not the processing condition. They envisaged that subjective appetite and FI was determined primarily by energy content and was little influenced by composition, processing, recipe, or variety. Pulses nutritional profile might play important role in this context. pulses are chiefly loaded with fiber and proteins contents and have a low glycemic index (GI) which makes them a priceless source of energy for diabetic people (18, 19).

Pulses have ability to delayed gastric emptying and slower delivery of nutrients in small intestine which ultimately results in reduced blood glucose levels (20). The therapeutic worth of pulses may be elucidated by different mechanisms. Among these, innate resistance to digestion of key components bioactive compounds affecting digestion and satiety signals, and the low energy density of dietary pulses. In turn, these are related to the content and composition of constituents including carbohydrates (e.g., fiber, starches, and oligosaccharides), protein, and phytochemicals are the leading ones (18, 21).

Another possible explanation of better results regarding mung bean is further explicated through the findings (22) stated that the protein-specific appetite will stimulate the drive for increased food intake when the protein density of the diet is limited but will reduce intake of diets with higher protein density. Secondly, the effect of proteins on peripheral hormonal signals and central targets that impudence energy intake. The proteins are considered effective to enhance or halt the expression for these hormones thus have influence upon food intake and appetite control owing to higher protein contents of mung bean better results were evident.

Ghrelin is a hormone that increases the hunger and food intake. There are consolidated evidences that advocating the impact of protein on ghrelin (23). Likewise, high protein foods like pulses have ability to modulate the expression for the Peptide YY (PYY) and glucagon-like peptide 1 (GLP-1) which were controlling the satiety and food intake (24). There is also evidence of a dose-response relation between protein quantity and the magnitude of PYY and GLP-1 responses (21). Moreover, (25) also observed 31% increase in satiety by high protein meal consumption (Pulses) regard less of Age, gender, BMI and analysis sensitivity. Reduced food intake by high protein diet in present study are in corroborated with the earlier findings of (22) investigated the impact of high protein meals on food intake and average appetite. Purposely, they were conducted a randomized crossover study by producing04 diets with 5, 10, 15 and 20% of proteins. They inferred that the protein level has impact on food intake. However, beyond 20% addition no further reduction was observed. Later (12) also conducted the similar type of experiment to elucidate the satiety improvement and glycemic responses management perspective of pulses. They were served lentil, chickpeas, navy beans and yellow peas with tomato sauce and pasta. They observed better lower FI with lentils as compared to others. Moreover, lentil also exhibited better glycemic control as compared to others will least BG concentration at the termination of study. They narrated that pulses consumption is helpful to tackle the complications in high glycemic state.

Conclusion

The outcomes indicate that the pulses consumption caused significant impact on the components of metabolic syndromes. The postive impact of pulses based dietary intervention in current study can be associated with their higher protein and fiber contents that caused short term acte effect on postprandial blood glucose, appetite and food intake. In the nutt shell, pulse consumption may be helpful to effectively increase pulse intake in individual diets and on a population-wide basis. Moreover, longterm studies should be planed to enahnce the meticulousness regarding the

issue alongside the studies regarding the mechanistic concerns of pulses and their nutrients upon component of glycemia control to disclsed the associated mechanistic concerns.

Authors' contributions

The contribution of each author for this manuscript was as follows, MUA & AI, designed the experimental plan. SN conducted the analysis. UN, MSA, AA, FS, MI drafted the manuscript. It is also confirmed that all the authors read and approved the final manuscript.

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