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POSTPRANDIAL GLYCEMIC RESPONSES OF YOUNG HEALTHY WOMEN TO VARIED MACRONUTRIENT COMPOSITION AND PROTEIN SOURCES IN BREAKFASTS MEALS

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ABSTRACT

BACKGROUND: Breakfast is considered to be the most important meal of the day and a healthy breakfast can help reduce the burden of many life style diseases. An increasing number of adolescent and young females are prone towards skipping breakfasts or are consuming unhealthy breakfasts which demand improved dietary strategies.

OBJECTIVES: The objectives of the current study were to design plant-based economical and locally available foods in breakfast meals and then compare their nutritional composition, sensorial attributes. satiety and postprandial glycemic regulation among young healthy females.

METHODS: The study analyzed the proximate composition, mineral composition, and overall acceptability of two conventional, one reference, and six diversified breakfast meals. One control, a reference, and three diversified breakfasts meals were studied for postprandial glycemic responses in comparison with" no breakfast". Blood glucose was tested at fasting, 30, 60, 120, 180, and 240 minutes respectively. Satiety/hunger perception was assessed throughout the study period through VAS.

RESULTS: A good number of students missed breakfast on most week days (62%). With the addition of meat, egg, mung beans, chickpea flour, and ground peanuts the mean mineral content, percent protein and percent fiber increased significantly while percent fat remained same except the one that contained groundnut stuffed bread. The perceived sensory attributes of the experimental breakfasts in comparison with the conventional and reference breakfasts were higher. Glycemic responses showed stability with the addition of proteins (irrespective of their source protein). The diversified breakfasts were reported to be effective in the stability of satiety against no breakfast.

CONCLUSION: The study concludes that the addition of protein and maintaining the overall energy nutrients balance in breakfast better regulate glycemic responses.

KEY WORDS: Breakfast, Proximate composition, Mineral composition, Postprandial blood glucose, Sensorial attribute and satiety

INTRODUCTION

The word "breakfast" can mean "to break the fast of night". It has been defined to be the first meal of the day eaten usually withing two hours of waking. It is recommended that breakfast shall meet one fourth to one-third of the day's total nutritional requirements [1]. Adolescent and young adulthood is a decisive stage of life especially for young women. Food intake patterns, dietary practices, and nutrient intake patterns being established at this stage may not only impact life time nutritional status and health but also the health and food habits of their prospective families and children they will nurture in the future [2, 3]. Dietary practices developed during young age may also play an important role in the development of obesity, eating disorders, Type 2 diabetes mellitus, polycystic ovarian syndrome, infertility, and associated risk factors for cardiometabolic disorders [4, 5]. Breakfast consumption is associated with many health benefits; intake of micronutrients, improved concentration and performance at work and in the class room, lowered cholesterol levels and reduction in fat mass during energy restriction [6- 9].

Breakfast consumption behavior among young adults have changed drastically in the last few decades. It is estimated that approximately thirty percent of adolescents skip breakfast daily while almost 60% skip it on most days of the week [10]. According to the American Heart Association around 74% of breakfast skippers did not meet their two third of the Recommended Daily allowances for vitamins and minerals as compared to 41% of those who consume breakfast [11].

Macronutrients are the major sources of energy in human diets. Macronutrient composition of breakfast meal is a key factor that need to be considered. The amount and type of carbohydrates, increased dietary proteins, and fats all have been reported to affect postprandial glucose concentration [12 ,13]. The presence of complex carbohydrates and more proteins in the breakfast have shown to increase fullness and satiety, the amount of food consumed in the next meal, and postprandial blood glucose homeostasis [14, 16]. Plant protein source in the breakfast has shown to exert less effect on appetite response however, differential impacts on postprandial glucose responses [16]. According to National Nutrition Survey, in Pakistan 36.9% of the population face food insecurity while 64% of population live in rural areas [18].

METHODS

I. PRE- STUDY SURVEY

A sample of 536 undergraduate girls aged 17-19 years were randomly selected for the purpose of getting information about their breakfast practices. A questionnaire was designed to collect information about (i) frequency of breakfast and (ii) type of breakfast usually consumed.

II. PREPARATION OF BREAKFAST MEALS

Supplies for the preparation of different breakfast meals were purchased from the local market and were prepared in the Food Lab of the Food & Nutrition Department, University of Peshawar. Meals were prepared by diversifying cereals, pulses, & some animal- based foods (Table 1). Based on initial diversification six experimental meals were selected against two conventional and one reference breakfast meals for further analyses.

Table 1: COMPOSITION OF BREAKFASTS

S. No	Breakfasts	Composition/Dry Ingredients	Total Weight (G)
1.	No breakfasts	Plain water 210 ml	210
2	Plain fried flat bread & tea	84 g wheat flour, 16 g oil, 13 g dried milk, 7 g sugar	120±1.12
3	Minced meat stuffed flat bread & Tea	20 g minced meat, 5 g herbs/spices, 60 g wheat flour, 15 g oil, 13 g dried milk, 7 g sugar	120±3.22

4	Chickpea& wheat flour bread & tea	44 g chickpea flour, 44 g wheat flour, 10 g oil, 2-3 g herbs, 13 g dried milk, 7 g sugar	120±2.02
5	Peanut mixed flat bread & tea	50 g wheat flour, 20 g peanuts, 20 g jaggery, 10 g oil, 13 g dried milk. 7 g sugar	120±2.5
6	Multigrain flat bread & tea	40 g wheat flour, 20 g chickpea flour, 20 g corn flour, 10 g jaggery, 10 g oil, 13 g dried milk, 7 g sugar	120±2.02
7	Mung beans stuffed flat bread & tea	65 g wheat flour, 15 g mung beans. 5 g herbs & spices, 15 g oil, 13 g dried milk,7 g sugar	120±1.20
8	Beef & Lentil patty, bread slices& tea	34 g minced beef, 8 g mung bean, 4 g chickpea flour, 3 g spices, 3 g oil, 50 g bread slices, 13 g dried milk, 7 g sugar	120±2.51
9	Buttered toasts & tea	82 g bread slices, 18 g butter, 13 g milk, 7 g sugar	120± 1.08
10	Reference breakfast	Egg 45-59g (without shell), 5 g oil, butter 10 g bread slices ±30-50 g, 30 g dried milk	120±3.23

III.NUTRITIONAL ANALYSES OF BREAKFAST MEALS

a). The prepared food mixes were analyzed for proximate analysis based on AOAC methods [19]. Percent carbohydrate was determined through difference from the proximate values while net energy was calculated through formula. b). Determination of zinc, copper, manganese, and iron was done through atomic absorption spectrophotometry as per AOAC procedures respectively [20].

IV. SENSORY EVALUATION OF BREAKFAST MEALS

The overall acceptability of the breakfast meals was performed through a Nine-Point Hedonic Scale [21]. A panel of 25 judges was recruited including teaching faculty and senior students of the department of Food & Nutrition sciences tested the breakfasts for different sensorial attributes.

V. DETERMINATION OF POSTPRANDIAL GLYCEMIC RESPONSES

V.1 Participants and recruitment

In this study a sample of 72 healthy female volunteers aged 18-19 years at the Fatima Jinnah Girls hostel (a female dormitory at the university of Peshawar) were recruited after procuring written consent. The study was conducted according to the Declaration of Helsinki guidelines and all the procedures were approved by the Board of Studies and Ethical Review Committee of the College of Home Economics, University of Peshawar (H. Eco/641.1). All the participants were within healthy weights and BMI range, were free from known food allergies, metabolic disease, had no near and past history of irregular menstrual cycle and heavy menstruation and none of them were under regular medication.

V.2. Screening and Anthropometric Measurements

To determine their health status heights, weights, Mid upper arm Circumference and BMI of the participants were measured as per WHO procedures [22]. Students were tested for hemoglobin (g/dL) to avoid anemic participants.

V.3. Feeding the Breakfast Meals

Based on the results of the sensory evaluation and due to shortage of time six breakfast meals were selected for further investigation. The volunteers were equally divided in to six groups each comprising of 10-12 girls. For no breakfast experiment the students were asked to join, based purely on their choice, while the effects of breakfast meals on postprandial blood glucose were tested on six separate weeks. Each breakfast was fed three times with one day in-between rest. Participants were asked not to consume any food or beverage except plain water after 10:00 p.m. night before the test day and refrain from exercise or athletics, though normal daily activities were allowed. Breakfasts were served in the Food Lab. In the morning upon arrival each participant was tested for fasting blood glucose and was then allowed to consume breakfast within 10-15 minutes. Afterwards no food and beverage were allowed except plain water ad libitum throughout the test period. The volunteers were

motivated to attend their routine classes during the test periods and they carried out their routine academic activities.

V.4. Determination of Blood Glucose

Blood glucose was determined through glucometer (Accu-chek Active Blood Glucose Meter CHS-1244). Blood was collected on a glucofilms. Blood samples were collected at fasting, and then 30, 60, 120, 180, and 240 minutes after consuming the test breakfasts.

VI. SATIETY AND HUNGER RECORD

Participants were provided with Visual Analogue Scale (VAS) and were asked to record their feelings of satiety and hunger at 30 minutes and then throughout the test period. The feelings were rated as 0= no hunger, 2= slight hunger, 4= moderate hunger, 6= strong hunger, 8= very strong hunger, and 10= strongest imaginable hunger.

VII. STATISTICAL ANALYSIS

The data collected from all the experiments were analyzed statistically by IBM SPSS version 19 for frequency, percentage, mean, & standard deviation. Difference within and among the parameters were tested through one- way ANOVA, students "t" test and coefficient of variation and association were established through Pearson Coefficient of Correlation. Statistical significance was defined as $P \leq 0.05$.

RESULTS

1. FREQUENCY AND BREAKFAST INTAKE PATTERNS

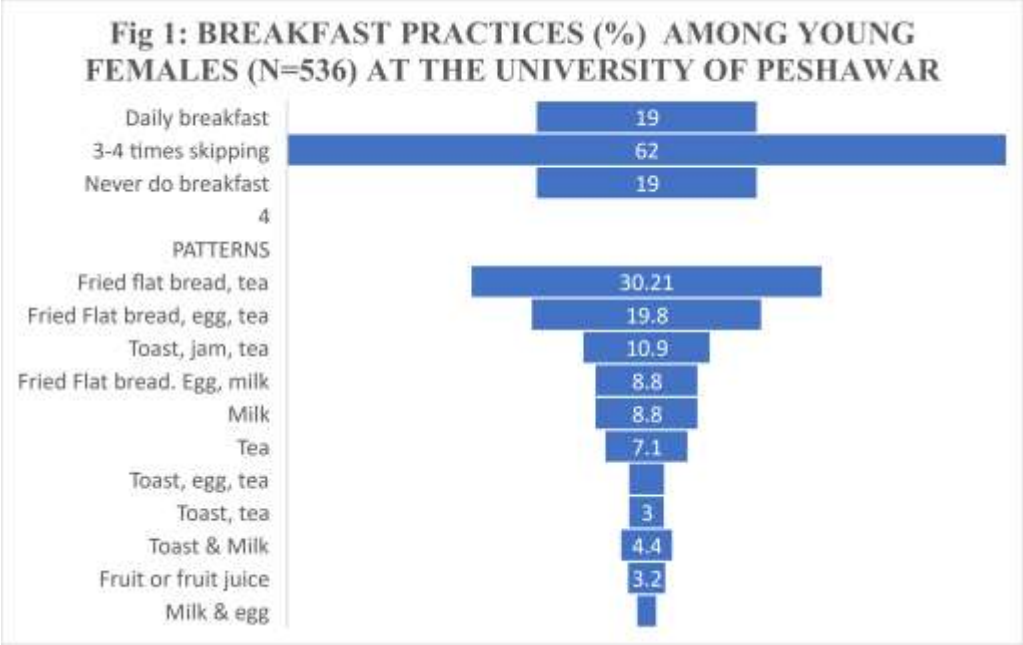

Fig 1: Breakfast intake patterns of the young females

The pre-study assessment (N=536) of the breakfast frequency per week and breakfast patterns are illustrated in Figure 1. The frequency intake per week showed breakfast skipping a usual practice in this age group. A good number of students missed breakfast on most week days (62%) while 19% were routine skippers.

Table 2: PROXIMATE COMPOSITION (g/120g DRY WEIGHT/SERVING) OF THE BREAKFAST PATTERNS

Breakfast Patterns	Protein	Fat	Carbohydrates	Fiber	Ash	Energy (Kcal)
wheat flat bread, tea	$6.40^{cd} \pm 0.2$	$22.48^{ab} \pm 21.44$	$64.42^{ab} \pm 22.0$	$1.50^{ab} \pm 1.9$	$2.6^{bc} \pm 0.8$	$516.5^{ab} \pm 10.6$

Buttered toasts, tea	$2.38^{d} \pm 0.2$	$14.41^{ab} \pm 10.14$	$76.10^{a} \pm 9.15$	$1.73^{a} \pm 1.1$	$2.4^{bc} \pm 0.1$	$526.5^{ab} \pm 55.8$
Minced meat flat bread. tea	$16.51^{b} \pm 0.4$	$13.24^{b} \pm 3.06$	$69.15^{ab} \pm 2.56$	$8.88^{d} \pm 0.2$	$1.7^{bc} \pm 1.0$	$508.5^{ab} \pm 19.0$
Chickpea (gram) & wheat flat bread, tea	$19.76^{b} \pm 1.09$	$10.76^{b} \pm 0.93$	$66.69^{ab} \pm 2.36$	$12.54^{c} \pm 0.5$	$2.4^{bc} \pm 0.2$	$470.8^{b} \pm 4.9$
Peanut mixed flat bread, tea	$18.60^{bc} \pm 1.9$	$24.33^{a} \pm 2.67$	$48.71^{ab} \pm 0.73$	$12.55^{c} \pm 0.8$	$1.9^{bc} \pm 0.2$	$529.8^{a} \pm 14.6$
Chickpea and wheat flat bread, tea	$11.49^{bc} \pm 0.9$	$11.50^{b} \pm 2.28$	$75.44^{a} \pm 4.57$	$13.45^{d} \pm 1.3$	$2.1^{bc} \pm 0.7$	$501.6^{b} \pm 3.8$
Mung bean stuffed flat bread, tea	$19.18^{b} \pm 7.4$	$13.78^{b} \pm 3.63$	$70.68^{a} \pm 2.02$	$12.15^{d} \pm 0.6$	$1.5^{c} \pm 0.8$	$501.7^{ab} \pm 23.0$
Beef patty, bread, tea	$27.86^{a} \pm 0.9$	17.90 ± 0.71	55.83 ± 1.57	$7.63^{d} \pm 0.8$	$6.4^{a} \pm 0.4$	$510.3^{ab} \pm 3.15$
Buttered toasts, fried egg, milk	$8.54^{b} \pm 8.6$	$18.15^{b} \pm 1.56$	$63.71^{ab} \pm 0.81$	$2.83^{a} \pm 1.1$	$2.9^{b} \pm 0.06$	$483.7^{b} \pm 55.3$
Coefficient of variation	23.84	45.18	12.69	7.50	21.72	8.30

** a, b, bc, cd, d: The means between rows carrying different letters are significantly different ($P \leq 0.05$)

The macronutrient composition (Table 2) has shown that the addition of meat, egg, mung beans, chickpea flour, and ground peanuts the mean percent protein (16.51 ± 0.4, 19.76b ±1.09, 18.60 ± 1.9, 11.49 ±0.9) increased significantly. With the exception of peanut, crude fat concentration of almost all the diversified breakfast remained same while crude fiber content (12.54 ± 0.5, 12.55± 0.8, 13.45 ± 1.3 and 12.15 ± 0.6) increased significantly with the addition of chickpeas, peanuts, and mung beans in these breakfasts which increased the fiber content and lowered the net energy content of the breakfasts.

Table 3: ELEMENTAL COMPOSITION (mg/120g) OF THE BREAKFAST MEALS

BREAKFAST PATTERNS	PHOSPHORUS	ZINC	IRON	COPPER	MANGANESE
wheat flat bread, tea	$645^{ab} \pm 0.2$	$7.56^{b} \pm 0.09$	6.14 ± 0.4	$2.48^{ac} \pm 0.04$	$1.58^{ab} \pm 0.05$
Buttered toasts, tea	$360^{bc} \pm 0.2$	$6.72^{e} \pm 0.2$	$5.52^{f} \pm 0.2$	$2.23^{f} \pm 0.02$	$0.6^{f} \pm 0.08$
Minced meat flat bread. tea	$369^{bc} \pm 0.08$	$8.16^{b} \pm 0.04$	$10.5^{b} \pm 0.2$	$2.61^{b} \pm 0.2$	$2.16^{ac} \pm 0.04$
Chickpea (gram) & wheat flat bread, tea	$510^{ac} \pm 0.06$	$7.68^{b} \pm 0.04$	$8.42^{ab} \pm 0.05$	$2.28^{c} \pm 0.2$	$2.13^{b} \pm 0.04$
Peanut mixed flat bread, tea	$369^{bc} \pm 0.07$	$9.96^{c} \pm 0.04$	$7.08^{d} \pm 0.05$	$3.36^{ab} \pm 0.2$	$1.78^{c} \pm 0.05$
Multigrain flat bread, tea	$480^{c} \pm 0.04$	$7.68^{b} \pm 0.07$	$8.04^{c} \pm 0.04$	$2.40^{c} \pm 0.04$	$1.89^{c} \pm 0.05$
Mung bean stuffed flat bread, tea	$450^{c} \pm 0.04$	$11.52^{ab} \pm 0.04$	$8.16^{c} \pm 0.09$	$2.88^{b} \pm 0.2$	$2.40^{a} \pm 0.02$
Beef patty, bread, tea	$705^{a} \pm 0.02$	$13.58^{a} \pm 0.07$	$18.57^{a} \pm 0.03$	$3.76^{a} \pm 0.09$	$1.28^{d} \pm 0.08$
Buttered toasts, fried egg, milk	$705^{a} \pm 0.04$	$7.80^{bc} \pm 0.1$	$6.24^{f} \pm 0.07$	$2.40^{c} \pm 0.2$	$0.44^{f} \pm 0.04$
Coefficient of variation	7.87	25.18	11.97	6.36	9.83

*a, b, bc, cd, d: The means between rows carrying different letters are significantly different ($P \leq 0.05$

The elemental composition (Table 3) showed phosphorus being significantly high in meat and egg-based breakfast. The concentrations of zinc, iron, copper, and manganese increased when animal and plant-based protein sources were added to the conventional breakfasts.

Table 4: PERCEIVED SENSORY ATTRIBUTES OF THE BREAKFAST MEALS

Breakfast Meals	**Taste/Flavor**	**Texture**	**Color**	**Overall Acceptability**
wheat flat bread, tea	$7.53^{c} \pm 3.61$	$7.33^{bc} \pm 2.08$	$7.13^{c} \pm 2.46$	$7.33^{a} \pm 6.43$
Buttered toasts, tea	$6.13^{d} \pm 3.46$	$6.1^{abc} \pm 5.31$	$6.4^{bc} \pm 4.58$	$6.0^{abc} \pm 16.26$
Minced meat flat bread. tea	$7.9^{a} \pm 1.68$	$7.5^{b} \pm 8.20$	$7.3^{a} \pm 2.52$	$7.1^{b} \pm 5.51$
Chickpea (gram) & wheat flat bread, tea	$6.7^{a} \pm 4.58$	$7.93^{b} \pm 4.16$	$7.6^{ab} \pm 3.21$	$7.55^{a} \pm 16.26$
Peanut mixed flat bread, tea	$7.06^{b} \pm 4.04$	$6.9^{ac} \pm 10.02$	$7.3^{ac} \pm 2.26$	$6.9^{ac} \pm 7.37$
Multigrain flat bread, tea	$7.2^{c} \pm 8.08$	$7.5^{b} \pm 2.00$	$7.6^{b} \pm 4.51$	$7.2^{b} \pm 4.04$
Mung bean stuffed flat bread, tea	$7.53^{c} \pm 7.37$	$7.7^{a} \pm 3.34$	$7.6^{a} \pm 3.74$	$7.6^{a} \pm 10.12$
Beef patty, bread, tea	$7.7^{b} \pm 2.00$	$7.6^{b} \pm 2.52$	$7.9^{b} \pm 3.79$	$7.73^{a} \pm 3.61$
Buttered toasts, fried egg, milk	$7.06^{cd} \pm 5.51$	$7.2^{abc} \pm 4.58$	$7.8^{b} \pm 6.43$	$7.35^{a} \pm 4.58$
Coefficient of variation	18.20	26.23	17.95	33.01

*a, b, bc, cd, d: The means between rows carrying different letters are significantly different (P≤0.05 The perceived sensory attributes of the experimental breakfasts in comparison with the conventional and reference breakfasts are presented in Table 4. All the diversified breakfasts scored higher in all the sensorial attributes taste indicating greater acceptability.

Table 5: CHARACTERISTICS OF THE PARTICIPANTS

VARIABLES	RANGE	MEAN ± SD	% OF REFERNCE VALUES
Age (Years)	18-19	18.5± 0.59	---------
Height (cm)	122.7 – 153.95	153.6 ± 5.3	162.5*
Weight (Kg)	45.45 – 63.63	54.42 ± 15.20	54.4*
MUAC (cm)	22.5 – 24.69	23.06 ± 0.59	28.14*
BMI (kg/m^2)	20.2 – 24.8	21.2 ± 9.78	Normal
Hemoglobin (g/dL)	9.59-14.03	11.7 ± 17.82	Normal

*WHO reference values [22]

Summary of the anthropometric measurements (Table 5) of the volunteers indicated the participants were in good overall health status with a mean BMI of 21.2 ± 9.78 and hemoglobin 11.7 ± 17.82 per recommended values for this age.

Table 6: GLYCEMIC INDICES OF THE YOUNG FEMALES TO DIFFERENT BREAKFAST MEALS

Test Breakfasts	**Mean Postprandial Blood Glucose Levels (Mg/dL) for the Test Breakfasts**					
	Fasting	Postprandial 30 minutes	Postprandial 60 minutes	Postprandial120 minutes	Postprandial 180 minutes	Postprandial 240 minutes
No Breakfast	79.67±8.32	81.4 ± 16.34 **(+3.77%)**	79.58 ± 5.59 **(-0.11)**	80.88 ± 4.23 **(+1.52)**	72.79* ± 5.01 **(-8.63)**	70.79*±6.02 **(-11.14)**
Wheat flat bread & tea	79.07 ± 6.09	124.3* ±14.23 **(+65.78)**	85.59* ±7.57 **(+27.33)**	87.47* ±11.24 **(+29.85)**	86.96 ± 7.31 **(+15.88)**	81.93 ± 14.22 **(+10. 84)**
Chickpea & wheat flat bread & tea	82.02 ±18.88	122.6* ± 18.62 **(+49.59)**	98.81* ± 6.23 **(+20.47)**	102.33* ±5.51 **(+24.76)**	95.67 ± 7.50 **(+4.45)**	95.62 ± 6.43 **(+4.38)**
Mung bean stuffed flat bread & tea	79.05± 6.36	119.3* ± 12.01 **(+61.12)**	101.33* ± 7.68 **(+21.98)**	100.24*±10.6 **(+13.76)**	93.50* ± 8.24 **(+12.75)**	95.13* ±8.02 **(+6.86)**
Beef Patty, bread & Tea	84.07 ± 14.8	113.9* ± 6.66 **(+52.56)**	93.83* ±5.52 **(+26.77)**	87.27* ±10.06 **(+17.82)**	85.27 ± 7.94 **(+15.12)**	86.27± 8.96 **(+2.97)**
Reference Breakfast	84.83 ± 5.80	114.13* ± 15.01 **(+52.51)**	99.03* ±18.73 **(+32.49)**	93.53* ± 8.14 **(+11.66)**	96.22*± 10.69 **(+15.22)**	90.17 ± 4.22 **(+7.13)**

*a, b, bc, cd, d: The means between rows carrying different letters are significantly different P≤0.05, Values given within the parenthesis are the mean percent difference from the fasting blood glucose

Table 7: Correlation Coefficients Of Breakfast Meals And Postprandial Blood

BREAKFAST MEALS	Nutrients Ratios g/120g serving			Pearson Correlation Coefficient Postprandial Blood Glucose (Mg/dL)			
	Protein	Fats	Carbohydrate	60 min	120 min	180 min	240 min
Wheat flat bread & tea **Nutrient Ratio**	11.4 **1: 2: 6**	22.5	64.4	-0.07ns	0.77**	0.59 ns	0.23 ns
Chickpea & wheat flat bread & tea **Nutrient Ratio**	19.8 **2: 1: 5**	12.75	66.1	0.36ns	0.81**	0.81**	0.81**
Mun bean stuffed flat bread & tea **Nutrient Ratio**	19.1 **2: 1: 4**	16.8	69.7	0.92**	0.77**	0.86**	0.56**
Beef patty, bread & Tea **Nutrient Ratio**	27.9 **2:1:3**	17.9	55.8	0.31ns	0.36ns	0.48ns	0.76**
Reference Breakfast **Nutrient Ratio**	18.5 **2:1:3**	18.1	58.8	0.52*	0.31ns	0.82**	0.57*

The post prandial glycemic responses to various breakfast meals, mean percent differences, co efficient of correlation of these breakfasts with varied ratios of proteins to fats and carbohydrates in these meals (Table 6 &7) showed a significant fall in the water only breakfast as compared to fasting

values. A continuous declines were observed in all the breakfasts after a peak highest response at 30 minutes with the highest being in the plain flat bread and tea & reference breakfast. The combination of chickpea flour with wheat bread showed the highest peak response after 30 minutes (122.6 ± 18.62) dropped at 60 minutes (98.81 ± 6.23) but then remained stable through the test period. Breakfasts that contained more proteins showed significant correlations at all intervals irrespective of their source.

Table 8: Effect Of Breakfast Meals On Postprandial On Perceived Satiety And Hunger

BREAKFAST MEALS	MEAN POSTPRANDIAL PERCEIVED HUNGER FOR BREAKFAST MEALS					
	Fasting	Postprandial 30 minutes	Postprandial 60 minutes	Postprandial 120 minutes	Postprandial 180 minutes	Postprandial 240 minutes
No Breakfast (N=11)	4.6± 0.56	3.7^{ns} ±2.1	4.6^{a} ±1.8	5.8^{ab} ±1.6	6.1^{abc} ±1.8	7.8^{**} ±4.55
Wheat flat bread & tea (N=10)	4.63 ± 1.3	0.9^{a}±3.2	2.5^{a} ±1.69	4.3^{ns} ±1.2	4.3^{ns} ±4.62	6.1^{a}±8.08
Chickpea & wheat flat bread & tea (N=10)	4.38 ±1.8	0.9^{a} ±4.36	1.9^{a} ±4.62	3.6^{a} ±5.02	4.1^{ns} ±3.33	4.7^{ns}±7.23
Mung bean stuffed flat bread & tea (N=10)	4.91 ±1.45	0.5^{a} ±3.1	2.55^{a} ±4.36	2.0^{a} ±1.98	4.5^{ns} ±1.25	4.7^{ns}± 7.07
Beef Patty, bread & Tea (N=10)	4.61 ±1.0	0.5^{a} ±9.17	2.0^{a} ±1.64	4.61^{ns} ±4.36	3.5^{ns} ±9.07	3.6^{a}±3.67
Reference Breakfast (N=12)	4.7 ±2.09	0.5^{a} ± 1.23	2.5^{a} ±4.32	2.6^{a} ±7.23	3.4^{ns} ±1.6	4.93^{ns} ±6.25

** The mean is significantly different from all the means in the same row

*a, b, bc, cd, d: The means between rows carrying different letters are significantly different (P≤0.05)

The effects of different breakfast meals on the perceived satiety and hunger during the experimental period (Table 8) showed a highly significant hunger sensations on "No breakfast" during the test period. Significant hunger sensations were also reported with wheat flat bread & tea breakfast at 240 minutes while for the rest of the breakfasts' satiety sensations remained stable.

DISCUSSION

The breakfast skipping findings of the current study are in strong agreement with many studies where adolescents skip breakfast on many week days and the general practice at this age of frequent unbalanced pattern with a focus on carbohydrate – rich and fat-rich breakfast being more common [23-26]. The addition of chickpea flour, mung beans and peanut flours to the wheat breads significantly increased the fiber, fat, and protein contents which are in agreement with the findings of many such studies [27- 28], indicating an enhancement effect on the proximate composition of the current study's results. The addition of peanut flour, chickpea flour, mung beans all exerted similar significant impacts on the elemental composition of the supplemented breakfasts emphasizing the utilization of plant-based protein rich sources also being effective way of enhancing the micronutrient content of the staple foods [29-30].

Results of the current study have shown an overall liking and acceptance for the diversified meals except for the color and texture of ground peanuts added to flat bread (paratha). Conventional paratha and tea breakfasts were the less liked breakfasts indicating the need for diversification of foods at domestic level. These results are quite promising since many of these breakfasts can be prepared well ahead, stored, kept frozen for a week and can be used as Meals Ready to Eat (MRE). These findings are also similar to other such studies [31-33].

The pre- and post- ingestion changes in the glycemic responses across four hours and changes within the specific time segments including statistical significance showed that all breakfast variations except for no breakfast induced significant postprandial glycemic responses. Peak post prandial changes were observed at 30 minutes where maximum mean values were observed. At 30 minutes the net increase for carbohydrate rich breakfast induced highest impact followed by breakfasts where the ratio of carbohydrates to fat was higher at 60 minutes. The coefficient of correlation showed positive significant correlation of protein enriched breakfasts with blood glucose at 120, 180, and 240 minutes. With this study it was attempted to make precise conclusions about the effects of different combinations of plant and animal -based proteins and it is concluded that a breakfast that contain an

overall good ratio of protein (irrespective of the source) exerted a pronounced effect on blood glucose regulation and feeling of satiation for longer hours. Proteins have higher satiety values than fats and carbohydrates rich meals supporting the findings that adding protein positively affect postprandial blood glucose homeostasis [34- 35].

CONCLUSION

The current study is concluded on the facts that breakfast intake exerts positive effects on glycemic regulation. It also emphasizes the importance of desirable distribution of macronutrients and the utilization of plant-based proteins for the population subgroups with marginalized purchasing power for animal-based protein rich foods. The preparation of locally available diversified foods that can be stored for longer periods also add advantage of the plant-based breakfasts for all age groups.

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