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PROBING THE NUTRITIONAL QUALITY OF READY-TO-USE THERAPEUTIC FOODS DEVELOPED FROM LOCALLY GROWN PEANUT, CHICKPEA AND MUNGBEAN FOR TACKLING MALNUTRITION

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Malnutrition is a widely prevalent in its various forms in Pakistani. Among the vulnerable segments of population, the children are adversely affected from protein energy malnutrition (PEM) and micronutrient deficiencies leading to higher morbidity and mortality. Amongst globally practiced malnutrition tackling strategies, use of locally developed ready-to-use therapeutic foods (RUTF) is gaining popularity due to cost-effectiveness, efficacy, convenience, and wider acceptability among the malnourished children. The objective of the current study was development of RUTF formulations using locally grown legumes *i.e.* peanut, chickpea and mungbean followed by its nutritional quality and hedonic acceptance. After conducting some preliminary trials, fourteen formulations of RUTF were developed by mixing chickpea, mung bean and peanut alone as well as in various combinations along with other ingredients. After optimization, the calorific value of developed formulations was ranged from 502-535 Kcal/100 g which is within the standard specification reported by WHO and health department in Pakistan. The chemical composition of the RUTF showed varied ranges of moisture content (2.68-5.33%), crude protein (12.87-15.02%), crude fat (23.21-44.56%), crude fiber (1.10-1.97%), ash (1.66-2.29%), nitrogen free extract (34.65-55.21%), minerals (mg/100 g) like Na (15.0-24.0), Ca (81.60-139.0), P (320.4-362.0), K (705.0-1246), Fe (2.6-6.1), Mg (125.6-189.0) and Zn (1.80-3.4). The results of sensory evaluation showed variations in sensory scores with respect to appearance (6.16-7.89), flavor (6.12-7.96), texture (5.80-7.48), mouthfeel (6.20-7.68), smoothness (5.68-7.69), and over all acceptability (5.88-7.78). Overall, 100% chickpea-based RUTF got maximum appreciation from the panelist as apparent from the higher scores for appearance (7.89), flavor (7.96), texture (7.48), mouthfeel (7.68), smoothness (7.69), and over all acceptability (7.78) followed by RUTF prepared with 80% chickpea and 20% mung bean and RUTF containing 40% chickpea and 60% mung bean. It is concluded from the current study that RUTF can successfully be manufactured using locally available ingredients with added benefits of cost effectiveness, better acceptability, and availability.

Keywords: Malnutrition, protein energy malnutrition, ready-to-use therapeutic food, mungbean, chickpeas, proximate analysis, mineral analysis.

INTRODUCTION

Malnutrition is a main nutritional dilemma particularly in the developing countries where food insecurity is widely prevalent alongwith escalating population. It has greatly hampered the physical and cognitive performance of human capital leading to low productivity. Consequently, residents are unable to maintain sufficient efficiency vital for growth, development, physical work, and recovery from infections (Saunders, 2015).The primary cause of malnutrition in Pakistani children is poor quality of their diets and less availability of supplementary foods. Malnutrition encompasses both over- and under-nutrition and is the outcome of imbalance in energy or nutrient intake of an individual over a prolonged period. Under-nutrition, mainly present in developing nations, is further characterized by range of clinical disorders such as marasmus (energy deficiency), kwashiorkor (severe deficiency of protein), marasmic-kwashiorkor (deficiency of both energy and protein), retarded growth (height for age is low), wasting (less weight for height) and numerous micronutrient deficiencies (UNICEF, 2013).

According to the Global Hunger Index (2018), Pakistan ranks at 106th position among 119 nations based on percentage of undernourished individuals (20.5%), rate of stunting (45%), wasting (10.5%) and rate of under-five mortality (7.9%). Among the kids and young children, more than half of the mortality and morbidity is attributed to malnutrition. There is high prevalence of underweight (28.9%), retarded growth (40.2%) and wasting (17.7%) in the children. Moreover, 14.4% of non-pregnant women and 16.1% lactating mothers are malnourished (GOP, 2018). Pakistan with an estimated population of 212.82 million is the sixth most populated country in the world. Pakistan has plunged into a critical state

of child malnutrition due to devastating floods, economic insecurity, and political turmoil. The population is suffering from double burden of diseases. Agriculture is the backbone of the economy as approximately 38.49% population is directly or indirectly linked with this profession for their livelihood. Being agro-based economy, a wide variety of legumes and pulses like chickpea, mungbean, lentil, mash, and peanuts are produced in different areas of the country (GOP, 2018). However, the nutritional value of these crops is linked with the bioavailability of specific amino acids in the diets. Mung beans and chickpea are considered important sources of protein with less anti-nutritional factors and higher bioavailability (Papalamprou *et al*., 2010).

Chickpea (*Cicer arietinum* L.*)* is one of the chiefly consumed ingredients globally in different food products. India is the global market leader by contributing 66% of the total production. The rest of sizable markets include Pakistan, Turkey and Australia. Due to high nutrient value, chickpea demand is rising day-by-day (Frias *et al*.,2000). Besides better palatability and digestibility, it also provides good amounts of carbohydrates, proteins, vitamins, and minerals calcium, phosphorous, copper, potassium, and zinc. *Besan* (chickpea flour) is a major ingredient used in various cuisine and supplement for weaning foods and snack products (Frias *et al.,* 2000). Mung bean (*Vigna radiata)* is a tropical legume, abundantly produced in South-Asian countries (Hussain and Burhanddin, 2011). It is produced as dry-beans or fresh sprouts and has an edge over other legumes due to its very short growth duration and ability to fit in widely diverse cropping systems (AVRDC, 2006). Mung bean is also considered a significant source of carbohydrates and protein along with bioactive phytochemicals and digestible fiber (Dongyan *et al*., 2014). The protein content in mung beans is around 20 to 24% (Branch and Maria, 2017). Being prime ingredient with respect to protein, it can be used along with cereals to enhance the quality of meal (Wang *et al*., 2004).

Global communities are striving hard to tackle malnutrition through different approaches such as health programs, school nutrition, food multi-mixes, composite flour technology, food fortification, diet diversification and utilization of ready-to-use therapeutic foods (RUTF). RUTF is, a semi-soft energy- and nutrient-dense food provided to infants without further preparation and cooking (Dubey and Bhattacharya, 2011). Typically, it's a peanut and milk-based paste that provides ~520-550 Kcal/100 grams energy with certain quantities of micronutrients (Kapil, 2009).RUTF are designed specially to cure moderately acute malnutrition in young children, toddlers as it is the first choice of international agencies (Eklund and Girma, 2008).In Pakistan, Integrated Reproductive Newborn & Child Health & Nutrition Program (IRMNCH) procure Plumpy'nut based RUTF through UNICEF from "Nutriset, France", which also has some acceptability issues. Peanut is ranked as 3rd allergen after milk and eggs. In this context, the use of peanut can be a severe threat for peanut allergen individuals and those with compromised immune system (Du Toit *et al*., 2015). In 2015, only 20% of the malnourished children received RUTF in low middle-income countries (LMI) like Pakistan, India, and Bangladesh (UNICEF, 2016). The high cost of RUTF further put pressure on country's lingering economy (Kapil, 2009). RUTF is usually stigmatized as an imported commodity developed with expensive ingredients, and this is referred to a barrier in its adoption worldwide. It is the need of time to formulate RUTF with indigenously produced ingredients and manufactured by the local people. In the long run, the usage of traditional ingredients is constructive due sustainability, wider availability, cost-effectiveness, and consumer adoptability (Mannar and Sankar, 2004). This study has been designed to develop ready to-use therapeutic foods (RUTF) from locally grown pulses for the treatment of malnourished children and assesment of their consumer acceptability through sensory evaluation by the panelists.

MATERIALS AND METHODS

***Procurement of Raw Materials*:** Mung bean (*Vigna Radiatus*) and chickpea (*Cicer arietinum*) were procured from Ayub Agriculture Research Institute (AARI), Faisalabad whereas peanut (*Arachis hypogaea*) was obtained from Barani Agriculture Research Institute (BARI), Chakwal. Powdered sugar, sunflower oil, skim milk powder and packaging materials were purchased from METRO Pakistan (Pvt.) Limited, Faisalabad. The vitamin/mineral pre-mix was provided by the Fortitech Inc., Schenectady, New York, (USA). All chemicals (analytical) were purchased from Merck, Germany and Sigma-Aldrich, Japan.

***Preparation of Raw Materials*:** Peanut was manually de-hulled to obtain peanut kernels followed by roasting and grinding into fine peanut flour. Likewise, mung bean and chickpea were ground into whole meal. All powdered samples were sieved for uniform size and kept in airtight plastic bottles at room temperature for further analysis and usage in study.

Analysis of Raw Materials

***Proximate composition*:** Powdered sample were examined for moisture content, crude protein, crude fat, crude fiber, total ash, and nitrogen free extract (NFE) according to their respective protocols and procedures (AACC, 2000).

***Mineral contents*:** Chickpea, mung bean and peanut flours were examined for minerals such as Na, Ca, P, K, Fe, Mg and Zn after wet digestion of samples using Atomic Absorption Spectrophotometer (Varian AA240, Australia) and Flame Photometer (Sherwood Scientific Ltd., Cambridge, UK), according to the procedures described in AOAC (2016). Dried sample (0.5 g) along with 5mL $HCLO_4$ and 10 mL of HNO_3 in digestion flask was heated on hot plate until the contents became clear. This digested sample was then shifted to volumetric flask (100 mL), to prepare volume by using double distilled water followed by filtration. The standard curves

were obtained for each element. Afterward, samples of unknown strength were run for each mineral. Mineral contents were then examined by comparing the standard curves made for each element.

***Development of Ready-to-Use Therapeutic Food (RUTF*)**: Fourteen RUTF formulations were prepared by following the modified methods of Manary *et al.* (2004) and Ciliberto *et al*. (2005). For the purpose, the powdered ingredients like peanut, chickpea and mung bean were blended in different proportions (Table 1; Fig. 1) and transferred in Laboratory Planetary Bakery Mixer (A-200, Hobart, USA) along with weighed amounts of sugar and skim milk powder as per RUTF specifications (Table 2).

Table 1. RUTF formulations used in study.

Treatments*	Peanut (%)	Chickpea (%)	Mungbean (%)
T_0	100	-	-
T_1	80	20	-
T_2	60	40	
T_3	40	60	-
T_4	20	80	-
T_5	-	100	-
T_6	80	-	20
T_7	60	-	40
T_8	40	-	60
T_9	20		80
T_{10}	-	-	100
T_{11}	-	20	80
T_{12}	-	40	60
T_{13}		60	40
T_{14}	-	80	20

*Micronutrients were added in all formulations according to standard for RUTF. T_0=RUTF with 100% peanut act as control; T_1=RUTF with 80% peanut and 20% chickpea; T_2=RUTF with 60% peanut and 40% chickpea; T_3=RUTF with 40% peanut and 60% chickpea; T_4=RUTF with 20% peanut and 80% chickpea; T_5=RUTF with 100% chickpea; T_6=RUTF with 80% peanut and 20% mung bean; T_7=RUTF with 60% peanut and 40% mung bean; T_8=RUTF with 40% peanut and 60% mung bean; T_9=RUTF with 20% peanut and 80 % mung bean; T_{10}=RUTF with 100% mung bean; T_{11}=RUTF with 20% chickpea and 80% mung bean; T_{12}=RUTF with 40% chickpea and 60% mung bean; T_{13}=RUTF with 60% chickpea and 40% mung bean; T_{14}=RUTF with 80% chickpea and 20% mung bean

Table 2. Standard specifications of RUTF formulation.

Ingredients	Weight (g)
Defatted peanuts/ chickpeas/ mungbean	50 (as per treatment plan)
Sugar	13.4
Oil	25
Powdered milk	10
Vitamin and mineral pre-mix	1.6

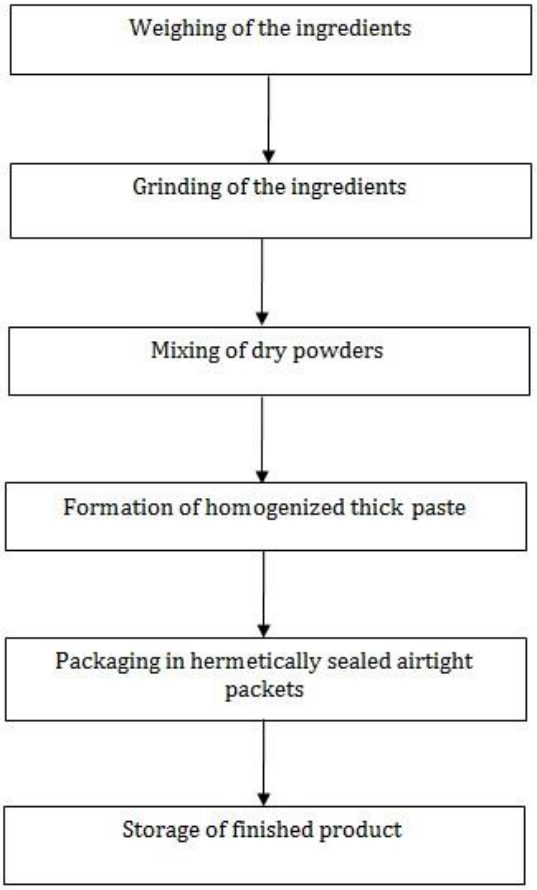


Figure 1. Flow diagram of ready-to-use therapeutic food (RUTF) production

The vitamins and mineral pre-mix were added as per WHO requirements in all formulations. Afterwards, edible oil was included, and the blend was stirred vigorously for 6-7 minutes till a homogenized, semi-soft paste with thick consistency was obtained. After confirmation that the mixture is homogenized properly and will not be separated during storage, RUTF sachets (Weighing ~100g) were sealed using Vacuum Sealer (PFS-200, Impulse Sealer, Pakistan), labeled and stored at ambient temperature in cardboard boxes.

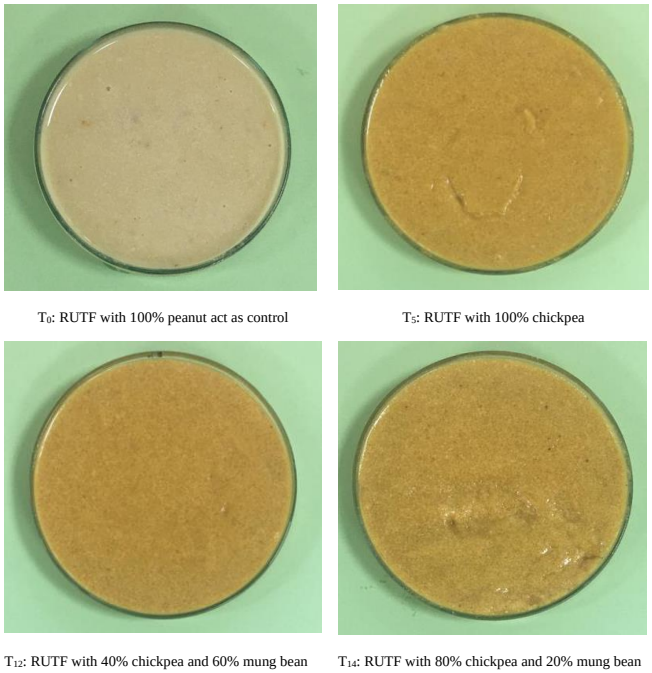
Analysis of Ready-to-Use Therapeutic Food (RUTF)

Chemical composition: RUTF formulations were analyzed for moisture, crude fat, crude protein, ash content, crude fiber, and nitrogen free extract (NFE) following the protocols of AACC (2000). Likewise, specified mineral in RUTF was determined by following the method of AOAC (2016).

***Sensory evaluation*:** The sensory evaluation was performed using 9-point Hedonic Score System to rate the newly formed products from 1 (extremely disliked) to 9 (extremely liked) for characteristics like appearance, flavor, texture, mouthfeel, smoothness and overall acceptability (Meilgaard *et al.*, 2007).

The judges were given RUTF in petri dishes with the request of rating each sample by allocating specific scores. The panelists were given plain crackers and water to rinse their mouth and neutralize taste buds prior to next evaluation. Furthermore, names of panelists were concealed to retain confidentiality.

***Selection of Best Samples*:** Based on consumer acceptance and better nutritional quality, three best RUTF formulations *i.e.*, T_5 (RUTF with 100% chickpea), T_{12} (RUTF with 40% chickpea and 60% mung bean) and T_{14} (RUTF with 80% chickpea and 20% mung bean) along with control (T_0 = RUTF with 100% peanut) were selected for further use in efficacy trial (Fig. 2).



T_0: RUTF with 100% peanut act as control

T_5: RUTF with 100% chickpea

T_{12}: RUTF with 40% chickpea and 60% mung bean

T_{14}: RUTF with 80% chickpea and 20% mung bean

Figure 2. Physical appearance of ready-to-use therapeutic foods (RUTFs)

***Statistical Analysis*:** All the proximate and mineral analyses were repeated thrice, and data collected were subjected to statistical analysis for determining the level of significance (Steel *et al*., 1997). One-way ANOVA under CRD was used in characterization of raw materials studies as per the guidelines explained by Montgomery (2008). Mean values and graphs were computed from excel 2013 and variation among treatment was computed through Statistix 8.1.

RESULTS

***Chemical Analysis of Raw Materials*:** Means for the proximate composition of ingredients used in RUTF are given in Table 3. The highest value for moisture (9.8±0.45%) was seen in chickpea followed by mung bean (6.8±0.29%) and peanut (4.5±0.18%) whilst the lower moisture (0.4±0.02%) in was noted in table sugar. The results revealed the highest crude protein content (25.20±1.13%) in milk followed by peanut (25.00±1.03%) and mung bean (22.5±0.99%) whilst the lowest protein was found in chickpea flour (20.50±0.9%). Crude fat content showed the lowest value in mung bean (1.4±0.061%) followed by chickpea (3.80±0.17%) while oil exhibited the highest crude fat content (100.00±0.00%). Crude fiber was maximum in chickpea (3.90±0.18%) and mung bean (3.50±0.154%), whereas the lowest was noticed in peanut (2.50±0.10%). Proximate analysis revealed milk as ingredient having maximum total ash content (5.90±0.27%). The nitrogen free extract (NFE) in sucrose, mung bean, chickpea, and peanut were 99.50±0.02, 62.4± 1.654, 59.10±1.88 and 21.40±3.22%, respectively.

The results of mineral analysis of raw materials are presented in Table 4. It is evident from results that highest content of sodium (130±5.85 mg/100 g) was present in milk followed by chickpea (24±1.10 mg/100 g) and peanut (18±0.74 mg/100 g) and mung bean (15±0.66 mg/100 g). The highest potassium content (1246±54.82 mg/100 g) was in mung bean followed by chickpea (875±40.25 mg/100 g), and peanut (705±28.91 mg/100 g). The calcium was maximum (938±42.21mg/100 g) in milk and mung bean (133±5.85 mg/100 g). Likewise, phosphorous was maximum (739±33.26 mg/100 g) in milk whereas the lowest value (0.003±0.001mg/100 g) was noticed in sugar. The potassium content was found in maximum quantity (1246±54.82 mg/100 g) in mung bean followed by 875±40.25 mg/100 g in chickpea, 705±28.91mg/100 g in peanut. The highest amount of iron (26±1.07 mg/100 g) was

Table 3. Means for proximate composition (%) of raw materials used in ready-to-use therapeutic foods.

Raw materials	Proximate composition (%)					
	Moisture	**Crude protein**	**Crude fat**	**Crude fiber**	**Total ash**	**NFE**
Peanut	4.5±0.18	25.00±1.03	44.1±1.81	2.50±0.10	2.50±0.10	21.40±3.22
Chickpeas	9.8±0.45	20.50±0.94	3.80±0.17	3.90±0.18	2.90±0.13	59.10±1.88
Mung bean	6.8±0.29	22.5±0.99	1.4±0.061	3.50±0.15	3.40±0.14	62.40±1.65
Milk	3.7±0.17	25.20±1.13	25.1±1.13	ND	5.90±0.27	40.10±2.70
Oil	ND	ND	100.00±0.00	ND	ND	0.00±0.00
Sucrose	0.4±0.02	ND	ND	ND	0.10±0.00	99.50±0.02

Means±S.D; NFE=Nitrogen Free Extract; ND = Not determined

Table 4. Means for mineral contents of raw materials used to make ready-to-use therapeutic foods.

Raw materials	Mineral contents (mg/100g)						
	Sodium	**Calcium**	**Phosphorous**	**Potassium**	**Iron**	**Magnesium**	**Zinc**
Peanut	18±0.74	70±2.87	362±14.84	705±28.91	26±1.07	168±6.89	1.8±0.07
Chickpeas	24±1.10	128.±5.89	330±15.18	875±40.25	5.8±0.27	115±5.29	3.4±0.16
Mung bean	15±0.66	133±5.85	315±13.86	1246±54.82	6.1±0.26	189±8.316	2.7±0.118
Milk	130±5.85	938±42.21	739±33.26	382±17.19	0.60±0.03	110±4.95	3.3±0.15
Oil	ND	1.03±0.10	0.09±0.06	ND	ND	ND	ND
Sugar	ND	0.004±0.002	0.003±0.001	ND	0.003±0.001	ND	ND

Means± S.D; ND=Not detected

Table 5. Means for the proximate analysis per 100 grams of the ready-to-use therapeutic foods.

Treatments	Moisture	Crude protein	Crude fat	Crude fiber	Total ash	NFE
T_0 (Control)	2.68±0.11^{h}	15.02±0.57^{a}	44.56±1.88^{a}	1.25±0.05^{de}	1.83±0.07^{fg}	34.65±2.67^{f}
T_1	3.21±0.15^{fgh}	14.64±0.72^{abc}	40.50±1.75^{ab}	1.39±0.06^{cd}	1.88±0.04^{efg}	38.33±2.65^{ef}
T_2	4.72±0.21^{abc}	14.05±0.57^{abc}	36.49±1.65^{bc}	1.53±0.07^{bc}	1.92±0.08^{d-g}	41.28±2.58^{def}
T_3	5.25±0.26^{a}	13.74±0.68^{abc}	32.47±1.59^{cd}	1.22±0.06^{de}	1.96±0.10^{c-f}	45.36±2.68^{cde}
T_4	4.43±0.19^{bcd}	13.25±0.58^{abc}	28.44±1.22^{de}	1.81±0.08^{a}	2.00±0.13^{b-f}	50.07±2.15^{abc}
T_5	5.33±0.22^{a}	12.87±0.56^{c}	24.41±1.03^{efg}	1.97±0.09^{a}	2.04±0.18^{a-f}	53.41±1.93^{ab}
T_6	2.91±0.13^{gh}	14.80±0.68^{ab}	40.29±1.81^{b}	1.35±0.06^{cd}	1.93±0.15^{c-g}	38.72±2.76^{ef}
T_7	3.14±0.22^{fgh}	14.52±0.70^{abc}	36.02±1.73^{c}	1.44±0.03^{cd}	2.02±0.10^{a-f}	42.85±2.70^{de}
T_8	3.36±0.23^{fg}	14.27±0.67^{abc}	31.75±1.49^{d}	1.10±0.05^{e}	1.66±0.14^{g}	47.43±2.50^{bcd}
T_9	3.57±0.15^{efg}	13.60±0.49^{abc}	27.48±1.10^{ef}	1.81±0.07^{a}	2.20±0.07^{abc}	51.34±1.90^{abc}
T_{10}	3 .00±0.10^{def}	13.74±0.53^{abc}	23.21±0.91^{g}	1.76±0.16^{ab}	2.29±0.12^{a}	55.21±1.71^{a}
T_{11}	4.13±0.18^{cde}	13.87±0.51^{abc}	23.45±1.03^{fg}	1.95±0.07^{a}	2.24±0.21^{ab}	54.36±1.82^{ab}
T_{12}	4.52±0.37^{bc}	13.36±0.70^{abc}	23.69±1.14^{fg}	1.83±0.10^{a}	2.19±0.11^{a-d}	54.40±2.33^{ab}
T_{13}	4.73±0.22^{abc}	13.21±0.61^{abc}	23.93±1.10^{fg}	1.87±0.09^{a}	2.14±0.17^{a-e}	54.12±2.11^{ab}
T_{14}	5.03±0.35^{ab}	12.94±0.65^{bc}	24.17±1.21^{fg}	1.91±0.10^{a}	2.09±0.22^{a-f}	53.86±2.41^{ab}

Means ± S.D Means carrying same letters in a column differed non-significantly (p> 0.05)

T_0=RUTF with 100% peanut act as control; T_1=RUTF with 80% peanut and 20% chickpea; T_2=RUTF with 60% peanut and 40% chickpea; T_3=RUTF with 40% peanut and 60% chickpea; T_4=RUTF with 20% peanut and 80% chickpea; T_5=RUTF with 100% chickpea; T_6=RUTF with 80% peanut and 20% mung bean; T_7=RUTF with 60% peanut and 40% mung bean; T_8=RUTF with 40% peanut and 60% mung bean; T_9=RUTF with 20% peanut and 80 % mung bean; T_{10}=RUTF with 100% mung bean; T_{11}=RUTF with 20% chickpea and 80% mung bean; T_{12}=RUTF with 40% chickpea and 60% mung bean; T_{13}=RUTF with 60% chickpea and 40% mung bean; T_{14}=RUTF with 80% chickpea and 20% mung bean

reported in peanut whereas the lowest levels (0.003±0.001mg/100 g) were in sucrose. The magnesium was present in highest amount (189±8.31mg/100 g) in mung bean and peanut (168±6.89 mg/100 g). The highest zinc content was in chickpea (3.40±0.16 mg/100 g), powdered milk (3.30±0.15 mg/100 g) and mung bean (2.7±0.1188 mg/100 g).

Chemical Analysis of Ready-to-Use Therapeutic Foods

***Proximate analysis*:** Mean squares for the proximate composition of ready-to-use therapeutic foods (RUTF) containing peanut, chickpeas and mung bean showed significant differences among the treatments regarding moisture, crude protein, crude fat, crude fiber, ash, and nitrogen free extract. Means for moisture content exhibited the maximum content of moisture (5.33±0.22) in T_5 (RUTF developed with 100% chickpea) and RUTF developed with 40% peanut and 60% chickpeas (5.25±0.26%) whilst the minimum value 2.68±0.11% was found in RUTF formulated with 100% peanut (Table 5). Among the RUTF developed with peanut and chickpea, moisture content was increased from 2.68±0.11 to 4.43±0.19% with progressive decrease in peanut levels. Similarly, RUTF developed with peanut and mung bean proved the same increasing trend of moisture 2.91±0.13 to 3.57±0.15% by the addition of mung bean flour. Overall, moisture was ranged from 2.68 to 5.33% among all the treatments. It is clear from the results obtained from treatments containing higher levels chickpea and mung bean exhibited higher levels of moisture content in RUTF formulations mainly attributed to their initial higher moisture contents.

Means for the crude protein of RUTF showed significant differences among all the formulations. The lowest protein value (12.87±0.56%) was found in RUTF formed with 100% chickpea followed by 12.94±0.65% in RUTF containing 80% chickpeas and 20% mung bean whereas the highest value (15.02±0.57%) was noted in T_0 (RUTF developed with 100% peanut). Among the RUTF having peanut and chickpea, the

maximum value (14.64±0.72%) was observed in T_1 (RUTF developed with 80% peanut and 20% chickpea) and minimum (13.25±0.58%) in T_4 (20% peanut and 80% chickpea).

Similarly, peanut and mung bean based RUTF formulations explicit maximum crude protein (14.80±0.68%) in T_6 (RUTF developed with 80% peanut and 20% mung bean flour) and minimum (13.60±0.49%) in T_9 (RUTF developed with 20% peanut and 80% mung bean). It is apparent from the results that RUTF formulation with higher concentration of peanut was comparatively rich in protein owing to initial higher protein levels in peanut. However, among the chickpea and mung bean based RUTF, the lowest protein (12.94±0.65%) was noticed in T_{14} (RUTF with 80% chickpea flour and 20% mung bean) whilst the highest value (13.87±0.51) was noted in T_{11} (20% chickpea and 80% mung bean). Overall, range of crude protein in RUTF treatments was 12.87 to 15.02%, respectively.

Means for the crude fat content of RUTF (Table 5) showed maximum fat concentration (44.56 ±1.88%) in T_0 (RTUF prepared with 100% peanut). Among the peanut and chickpea based RUTF, the results showed maximum value (40.50±1.75) in T_1 (RUTF with 80% peanut and 20% chickpea) whereas minimum crude fat (28.44± 1.22%) was found in T_4 (RUTF developed with 20% peanut and 80% chickpea). Similarly, peanut and mung bean based RUTF revealed maximum fat (40.29±1.81) in T_6 (RUTF with 80% peanut and 20% mung bean) and the lowest (27.48 ±1.10) in T_9 (RUTF developed with 20% peanut and 80% mung bean). This RUTF formulation with elevated share of peanut exhibited comparatively high fat content mainly contributed by peanut. In the chickpea and mung bean based RUTF, the minimum value of crude fat (23.45 ± 1.03) was noted in T_{11} (RUTF with 20% chickpea and 80% mung bean) whereas high crude fat (23.69± 1.14) was found in T_{12} (RUTF containing 40% chickpea and 60% mung bean).

Means for the crude fiber of developed RUTF exhibited significant differences amongst all the formulations (Table 5). Crude fiber content of RUTF developed with peanut and chickpea was ranged from 1.39 ±0.06 to 1.81±0.08% with the highest concentration in RUTF having 20% peanut and 80% chickpea. On the other hand, in peanut and mung bean based RUTF, maximum crude fiber (1.97±0.09%) was in T_4 (RUTF prepared with 20% peanut and 80% chickpea) and minimum (1.10±0.05%) in T_8 (RUTF prepared with 40% peanut and 60% mung bean). Similarly, chickpea and mung bean based RUTF showed content of crude fiber ranged from 1.83±0.10 to 1.95±0.07%. The formulations showed non-significant differences among this trait.

Means of total ash in RUTF of peanut and chickpea combination showed the lowest ash (1.88 ±0.04%) in the RUTF developed with 20% peanut and 80% chickpea whereas the highest concentration (2.00± 0.13%) was found in RUTF containing 80% peanut and 20% chickpea. On the other hand, blends of peanut and mung bean based RUTF showed maximum value (2.20 ±0.07%) in RUTF developed with 20% peanut and 80% mung bean with minimum value (1.66 ±0.14%) in RUTF containing 40% peanut and 60% mung bean. Similarly, chickpea and mung bean based RUTF showed minimum ash content (2.09 ±0.22%) in RUTF with 80% chickpea and 20% mung bean and maximum (2.19 ±0.11%) in RUTF prepared from 40% chickpea 60% mung bean.

Mean values for nitrogen free extract of RUTF with peanut and chickpea combination showed the lowest NFE (38.33 ±2.65%) in the RUTF developed with 80% peanut and 20% chickpea whereas the highest (50.07± 2.15%) in RUTF containing 20% peanut and 80% chickpea. Likewise, amalgamations of peanut and mung bean based RUTF showed maximum NFE (51.34 ±1.90%) in RUTF developed with 20% peanut and 80% mung bean whereas minimum value (38.72 ±2.76) in RUTF developed with 80% peanut and 20% mung bean. The chickpea and mung bean based RUTF showed minimum NFE (54.12± 2.11%) in RUTF prepared with 60% chickpea and 40% mung bean. Overall NFE contents of RUTF were ranged from 34.65 to 55.21%, respectively.

***Minerals analysis*:** Mean squares for mineral analysis of RUTF showed variations in different treatments with respect to sodium, calcium, phosphorus, potassium, iron, and magnesium and zinc contents (Table 6). Means of minerals concentration in RUTF are given in Table 4.6. The highest sodium content (24±0.98 mg/100 g) was seen in T_5 (RUTF made from 100% chickpea only) followed by 22.2±0.95 mg/100 g in T_{14} (RUTF with 80% chickpea and 20% mung bean) and T_{12} (21.6±1.058 mg/100 g)whereas the lowest sodium content (16.2±0.94 mg/100 g)was found in T_4 (RUTF with 20% peanut and 80% chickpea). Overall, sodium content varied from 16.2 to 24 mg/100 g in all samples.

Means for calcium content of RUTF formulations (Table 6) explored the highest value (139±5.76 mg/100 g) in T_{12} (RUTF with 40% chickpea and 60% mung bean) followed by 133±5.45 mg/100 g in RUTF with 100% mung bean. However, the lowest calcium content (70±2.87) was found in T_1 (RUTF with 80% peanut and 20% chickpea) followed by 81.6±3.75 mg/100 g in T_0 (RUTF prepared with 100% peanut), respectively. Overall, it was ranged from 70 to 139 mg/100 g among all treatments.

Means for phosphorous (P) content of different treatments showed the highest phosphorous quantities (362±14.84) in T_0 (RUTF having 100% peanut) followed by 355.6±16.35 mg/100 g in RUTF prepared with 100% chickpea whereas RUTF with 40% chickpea and 60% mung bean (T_{12}) showed the lowest P contents (315±12.91). Overall, range of phosphorous content was 320.4 to 362 mg/100 g among all the food samples.

Means for potassium (K) content of different treatments exposed the highest value (1246±51.08 mg/100 g) in T_{10} (RUTF with 100% mung bean) followed by T_{14}

Table 6. Means for mineral contents (mg/100g) of ready-to-use therapeutic foods.

Treatments	Sodium	Calcium	Phosphorous	Potassium	Iron	Magnesium	Zinc
T_0	18±0.73d^{efg}	81.6±3.75^{fg}	362.0±14.84^{a}	705.0±28.90^{i}	2.60±0.10^{g}	168.0±6.88^{a-d}	2.44±0.10^{cde}
T_1	19.2±0.88^{cde}	70.0±2.87^{g}	330.0±13.53^{ab}	807.0±39.54^{f-i}	3.24±0.14^{fg}	157.4±7.24^{c-f}	1.92±0.07^{g}
T_2	20.1±0.89^{bcd}	93.2±4.10^{ef}	349.2±15.36^{ab}	773.0±34.01^{ghi}	3.88±0.17^{ef}	146.8±6.45^{d-g}	2.12±0.09^{efg}
T_3	18.6±0.81^{def}	104.8±5.13^{de}	342.8±16.79^{ab}	739.0±33.99^{hi}	4.52±0.22^{de}	136.2±6.67^{fgh}	2.76±0.13^{bc}
T_4	16.2±0.94^{ab}	116.4±5.00^{bcd}	336.4±14.46^{ab}	841.0±36.16^{efgh}	5.16±0.29^{cd}	125.6±5.40^{gh}	2.09±0.12^{ab}
T_5	24±0.98^{a}	128.0±5.24^{ab}	355.6±16.35^{ab}	875.0±35.87^{efg}	6.10±0.25^{a}	189.0±7.74^{a}	3.40±0.13^{a}
T_6	17.4±0.80^{e-h}	82.6±3.79^{fg}	320.4±13.94^{ab}	813.2±37.40^{f-i}	3.30±0.15^{f}	172.2±7.92^{abc}	1.98±0.81^{fg}
T_7	16.0±0.73^{e-h}	95.2±4.18^{ef}	343.2±15.10^{ab}	921.4±40.54^{def}	4.00±0.17^{e}	115.0±4.71^{h}	2.16±0.09^{ef}
T_8	16.5±0.79^{fgh}	107.8±5.28^{cde}	333.8±16.35^{ab}	1029.6±50.45^{cd}	4.70±0.20^{d3}	181.6±8.84^{ab}	2.34±0.11^{de}
T_9	15.6±0.67^{gh}	120.4±5.17^{abc}	352.6±16.21^{ab}	1137.8±48.92^{abc}	5.40±0.21^{bc}	184.8±7.94^{a}	2.52±0.10^{cd}
T_{10}	15±0.61^{h}	134±5.45^{a}	326.0±14.12^{ab}	1246.0±51.08^{a}	5.80±0.23^{abc}	176.4±7.76^{abc}	3.08±0.13^{a}
T_{11}	16.8±0.77^{e-h}	130±6.07^{a}	324.0±14.62^{ab}	949.2±40.81^{de}	5.86±0.25^{ab}	174.2±8.01^{abc}	1.80±0.09^{fg}
T_{12}	21.6±1.05^{abc}	139±5.76^{ab}	315.0±12.91^{b}	1097.6±48.29^{bc}	5.98±0.26^{ab}	159.4±7.01^{b-e}	2.16±0.05^{ef}
T_{13}	20.4±0.99^{bcd}	125±6.37^{ab}	329.0±15.87^{ab}	1023.4±50.14^{cd}	5.92±0.29^{ab}	144.6±7.08^{efg}	2.34±0.11^{de}
T_{14}	22.8±0.98^{ab}	129±5.54^{ab}	327.0±14.06^{ab}	1171.8±53.90^{ab}	6.04±0.27^{ab}	129.8±5.58^{gh}	2.52±0.10^{cd}

Means ± S.D Means carrying same letters in a column differed non-significantly (p> 0.05)

T_0=RUTF with 100% peanut act as control; T_1=RUTF with 80% peanut and 20% chickpea; T_2=RUTF with 60% peanut and 40% chickpea; T_3=RUTF with 40% peanut and 60% chickpea; T_4=RUTF with 20% peanut and 80% chickpea; T_5=RUTF with 100% chickpea; T_6=RUTF with 80% peanut and 20% mung bean; T_7=RUTF with 60% peanut and 40% mung bean; T_8=RUTF with 40% peanut and 60% mung bean; T_9=RUTF with 20% peanut and 80 % mung bean; T_{10}=RUTF with 100% mung bean; T_{11}=RUTF with 20% chickpea and 80% mung bean; T_{12}=RUTF with 40% chickpea and 60% mung bean; T_{13}=RUTF with 60% chickpea and 40% mung bean; T_{14}=RUTF with 80% chickpea and 20% mung bean

(1171.8±53.90) and T_9 (1137.8±48.92) whereas lowest potassium content (7 05±28.90 mg/100 g) was found in T_0 (RUTF prepared with 100% peanut). Overall, potassium in all RUTF samples was ranged from 705 to 1246 mg/100 g.

Means for iron content of different treatments varied significantly see (Table 6). The highest value of iron (6.1±0.25 mg/100 g) was seen in T_5 (RUTF prepared with 100% chickpea) followed by 6.04±0.27 and 5.98±0.26 mg/100g in RUTF containing 80% chickpea and 20% mung bean(T_{14}) and RUTF prepared with 40% chickpea and 60% mung bean (T_{12}), respectively whereas the lowest value of iron (2.6±0.10 mg/100 g) was noticed in T_0 (RUTF prepared with 100% peanut). Overall, range of iron content was 2.6 to 6.1 mg/100 g among all the food samples.

Means for magnesium concentration of RUTF formulations depicted the highest value (189±7.74 mg/100 g)in RUTF prepared with 100% chickpea (T_5) and RUTF prepared with RUTF with 20% peanut and 80 % mung bean (184.8±7.94 mg/100g) followed by T_8 (RUTF with 40% peanut and 60% mung bean) the whereas lowest levels (125.6±5.40 mg/100 g) were reported in T_4 (RUTF with 20% peanut and 80% chickpea) followed by 129.8±5.58 mg/100 g in T_{14} (RUTF with 80% chickpea and 20% mung bean). Overall, magnesium content was 125 to 189 mg/100 g in all RUTF formulations.

Means for zinc (Zn) in different treatments of RUTF are given in Table 4.6. It is clear from the results that highest Zn (3.4±0.13 mg/100 g) was seen in T_5 (RUTF prepared with 100% chickpea) followed by T_3 (2.76±0.13) while the lowest zinc content (1.80±0.09 mg/100 g) was found in T_{11} (RUTF prepared with 20% chickpea and 80% mung bean). Overall, zinc content of RUTF was ranged 1.80 to 3.4 mg/100 g.

***Sensory evaluation*:** The means for all sensory traits are presented in Table 7. Means for the appearance showed maximum likeness (7.89±0.918) for RUTF containing 100% chickpea followed by RUTF developed with 80% chickpea and 20% mung bean (7.80±0.500) and 40% chickpea and 60% mung bean (7.56±0.712) whereas the lowest value (6.16±1.201) for appearance was noted in RUTF prepared with 100% mung bean and RUTF developed with 60% chickpea and 40% mung bean (6.29±0.779). Means for flavor showed that T5 (RUTF containing 100% chickpea) was more appreciated (7.96±0.866) followed by RUTF with 80% chickpea and 20% mung bean (7.80±0.918) and 40% chickpea and 60% mung bean (7.76±1.172) whereas the lowest value was seen in RUTF prepared with 100% mung bean (6.12±0.881). Flavor score for the peanut, chickpea, mung bean-based formulations was ranged from 6.12 ±0.94 to 7.96±0.86 showing their acceptability.

Means for texture showed that panelists ranked T5 (RUTF containing 100% chickpea) at the top (7.48±0.823) followed by RUTF developed with 80% chickpea and 20% mung bean (7.40± 1.294) and RUTF with 40% chickpea and 60% mung bean (7.36±0.707) due to smooth texture whereas the lowest score was assigned to RUTF prepared with 100% mung bean (5.80±1.258) and RUTF with 60% chickpea and 40% mung bean (6.56±1.044).Means values for mouthfeel of RUTF exhibited significant differences amongst the formulations.

Table 7. Means for the sensory evaluation of ready-to-use therapeutic foods.

Treatments	Appearance	Flavor	Texture	Mouthfeel	Smoothness	Overall acceptability
T_0	6.76±0.87^{cde}	6.32±0.62^{de}	7.08±0.70^{ab}	7.12±1.13^{a-d}	6.96±1.45^{abc}	6.77±0.41^{def}
T_1	7.32±0.74^{a-d}	7.28±0.61^{abc}	7.02±0.95^{ab}	6.76±0.66^{b-e}	6.72±1.30^{abc}	7.13±0.68^{a-e}
T_2	6.84±0.55^{b-e}	6.56±0.87^{cde}	7.26±0.76^{ab}	6.86±1.01^{b-e}	7.32±0.85^{ab}	7.08±0.66^{a-e}
T_3	7.14±1.19^{a-d}	6.88±0.44^{bcd}	6.84±0.74^{ab}	7.16±0.68^{a-d}	7.45±0.77^{abc}	7.18±0.45^{abc}
T_4	7.64±1.15^{ab}	6.52±0.65^{cde}	7.24±0.72^{ab}	6.40±1.083^{f}	7.16±1.28^{abc}	7.28±0.75^{a-d}
T_5	7.89±0.91^{a-d}	7.96±0.86^{a}	7.48±0.82^{a}	7.68±0.85^{a}	7.69±1.11^{ab}	7.78±0.81^{a}
T_6	7.40±0.86^{a-d}	7.24±0.72^{abc}	7.12±0.60^{ab}	7.36±0.81^{abc}	7.32±0.90^{ab}	7.34±0.57^{a-d}
T_7	7.57±1.03^{ab}	7.27±0.73^{a}	7.05±0.86^{ab}	6.44±0.58^{de}	7.25±0.86^{ab}	6.84±0.72^{c-f}
T_8	7.36±0.90^{a-d}	6.85±0.94^{e}	7.16±1.21^{ab}	6.49±1.005^{cde}	6.80±0.81^{abc}	7.48±0.78^{abc}
T_9	7.48±0.96^{a-d}	7.52±1.23^{a}	7.36±0.70^{ab}	7.52±0.91^{ab}	6.40±1.08^{bcd}	6.87±0.40^{b-f}
T_{10}	6.16±1.20^{e}	6.12±0.88^{de}	5.80±1.25^{c}	6.16±0.98^{ef}	5.68±1.24^{d}	5.88±1.047^{g}
T_{11}	6.64±0.90^{de}	6.68±0.85^{cd}	6.72±0.84^{ab}	7.20±1.01^{a-d}	7.08±1.03^{abc}	6.50±0.80^{efg}
T_{12}	7.56±0.71^{abc}	7.76±1.17^{a}	6.84±0.74^{ab}	7.28±1.13^{a-d}	7.40±0.91^{ab}	7.55±0.83^{a}
T_{13}	6.29±0.77^{e}	6.24±0.77^{de}	6.56±1.04^{bc}	6.20±0.76^{ef}	6.28±1.24^{cd}	6.30±0.79^{fg}
T_{14}	7.80±0.50^{a}	7.80±0.91^{ab}	7.40±1.29^{a}	7.60±0.91^{ab}	7.60±0.957^{a}	7.57±0.67^{ab}

Means ± S.D Means carrying same letters in a column differed non-significantly ($p > 0.05$)

T_0=RUTF with 100% peanut act as control; T_1=RUTF with 80% peanut and 20% chickpea; T_2=RUTF with 60% peanut and 40% chickpea; T_3=RUTF with 40% peanut and 60% chickpea; T_4=RUTF with 20% peanut and 80% chickpea;T_5=RUTF with 100% chickpea; T_6=RUTF with 80% peanut and 20% mung bean; T_7=RUTF with 60% peanut and 40% mung bean; T_8=RUTF with 40% peanut and 60% mung bean; T_9=RUTF with 20% peanut and 80% mung bean;T_{10}=RUTF with 100% mung bean; T_{11}=RUTF with 20% chickpea and 80% mung bean; T_{12}=RUTF with 40% chickpea and 60% mung bean ; T_{13}=RUTF with 60% chickpea and 40% mung bean ; T_{14}=RUTF with 80% chickpea and 20% mung bean

The panelists preferred T5 (7.68±0.852) developed by using 100% chickpea followed by T14 (7.60±0.913) i.e. RUTF with 80% chickpea and 20% mung bean and T12 (7.40±0.913) *i.e.* RUTF with 40% chickpea and 60% mung bean whereas the lowest value was seen in RUTF prepared with 100% mung bean (6.16±0.987) and RUTF with 60% chickpea and 40% mung bean (6.20±0.764). Mean values for smoothness of RUTF exhibited better liking for RUTF made from100% chickpea (7.69±111) followed by T14 (7.60±0.95) and T12 (7.28±1.137) whereas the lowest value of mouth feel was seen in T10 (5.68±1.249) and T13 (6.28±1.24).Means for overall acceptability exhibited maximum acceptance for RUTF having 100% chickpea (7.78±0.816), followed by RUTF having 80% chickpea and 20% mung bean (7.57±0.674) and RUTF with 40% chickpea and 60% mung bean (7.55±0.830) whereas the lowest value (5.88±1.04) was seen in T10 (RUTF prepared with 100% mung bean).

DISCUSSION

The use of locally grown sources to produce RUTF adopting WHO simple recipe and standards is highly recommended. The chemical analysis of groundnut showed presence of 47% fat, 38.61% protein content, 5.80% moisture, 3.70% crude fiber, and 3.80% total ash (Atasie *et al*., 2009). In another study, six groundnut varieties were found to contain 7.3-8.9% moisture, 32.7-53.1% crude fat, 19.7-31.3% crude protein, and 3.0-7.4% ash. These variations in composition were attributed to genetic, climatic, and varietal differences. The high protein content of groundnut makes it a supreme ingredient for addition in food supplements for man and livestock (Musa *et al*., 2010).

The chemical composition of pea, chickpea, lentil, and bean cultivars was evaluated for their functional properties and food applications. It was found that these pulses have substantial amounts of protein (16.89-34.7%), fat (1.60-6.60%), dietary fiber (4.30-30.34%), ash (1.14-4.16%) and carbohydrates (54.72-65.40%). Additionally, it was suggested that chickpea is an ideal ingredient for the diets of infants due to better functional properties and presence of protein of high biological value (Boye *et al.*, 2010).

In a study, whole white chickpea was blended in wheat flour to produce cakes. The results depicted significant differences regarding moisture (7.90-8.47%), crude protein (23.06-25.18%), fat (3.81-7.22%), crude fiber (1.14-2.78%) and ash (3.27-3.46%) in white and whole chickpea flours (Gomez *et al*., 2008). Kaur *et al.* (2007) characterized Indian Desi and Kabuli chickpea cultivars. The results showed comparatively higher levels of protein (20.6-24.3 vs. 26.7%) and ash (2.72-2.88 vs. 2.91%) in Kabuli chickpea. In a study on composition of chickpea, impact of various methods of cooking exhibited variation in protein (23.15-23.21%), ash (3.51-3.52%), fat (6.17-6.22%) and crude fiber (4.62-4.96%) on dry weight basis (Alajaji and El-Adawy, 2006).

Butt and Batool (2010) has reported 8.30% moisture, 25.90% protein, 1.2% fat, 4.36% ash, 4.61% fiber and 63.89% NFE in

mung bean. According to food composition tables of Pakistan, the moisture content, crude protein, crude fat, crude fiber, total ash, and NFE of peanut, chickpea, mung bean and powdered milk are ranged from 3.7 to 9.8, 20.5 to 25.0, 1.4-44.0, 2.5-3.9, 2.8 to 5.9 and 4.10 to 59.0%, respectively (GOP/UNICEF/NWFP, 2001). Likewise, USDA Food Composition Database depicted highest moisture in chickpea (10.8%) followed by mung bean (8.2%), peanut (7%) and powdered milk (4.0%). Likewise, the crude protein content of peanut, chickpea, mung bean and powdered milk was 32.3, 22.3, 17.0 and 23.0%, respectively. Peanut was rich in oil content (52.5%) followed by chickpea (6.6%), mung bean (0.4%), and powdered milk (0.30%). The mung bean, chickpea and peanut have 10.8, 7.0, and 4.0% crude fiber, respectively (USDA, 2018).

According to Marconi and Panfil (1998) dried cow milk is good source of protein (27.7%), fat (27.3%) and ash (6.1%). A study conducted on physico-chemical and polarization of raw sugar revealed moisture and ash content in sucrose ranged 0.2 to 0.5 and 0.1 to 0.3%, respectively (Din and Rasool, 2015).Habibullah *et al.* (2007) studied proximate composition of mung bean contain 8.3 to 9.4% moisture, 20.8 to 23.7% protein content, 1.9 to 2.2% crude fat , 3.0 to 3.9% ash contents and 6.8 to 7.1% crude fiber.

Legumes are good source of minerals that are essential for the growth and development. The mineral analysis of peanut showed that it contains sodium (10.55 mg/100g), potassium(705 mg/100 g), magnesium (3.98 mg/100 g), calcium (2.28 mg/100 g), iron (6.97 mg/100 g), zinc (3.20 mg/100 g) and 10.55 mg/100 g phosphorous (Atasie *et al*., 2009). The consumption of 100 g chickpea seeds provide 5.80 mg iron, 4.18 mg zinc and magnesium, which meet the dietary needs of male (1.05 mg of iron; 4.2 mg of zinc) and females (1.46 mg of iron; 3.0 mg of zinc), respectively (Jukanti *et al.,* 2010).

The results for mineral analysis of raw chickpea showed that contains 121mg/100g Na, 870mg/100g K, 176mg /100g Ca, 176mg/100g Mg, 226mg/100g P, 2.11mg /100g Mn, 4.32mg/100g Zn, 1.10mg/100g Cu, and 7.72mg /100g Fe, respectively (Alajaji and El-Adawy, 2006). Likewise, Mung bean cultivars from Bangladesh contain 32.92mg/100 Na, 1145mg/100 K, 315mg/100 P, 132mg/100 Mg, 72 mg/100 Ca, 5.04 mg/100 Fe, 2.83 mg/100 Zn and 1.66 mg/100 Cu, respectively (Paul *et al.,* 2011).

In another study, the mineral analysis of two local varieties of mung bean namely M1 and NM-92showed relatively higher concentration of Na (22mg/100), K (1443mg/100g), Ca (216mg/100g), Mg (204mg/100g), P (374mg/100g), Fe (11.34mg/100g), and Zn (1.88mg/100g) in M1in comparison to the concentration of minerals found in NM-92. Likewise, the concentration of NM-92 had somewhat higher values of Cu (1.92 mg mg/100g), Mn (1.49mg mg/100g) and Pb (2.64 mg mg/100g) was higher inNM-92 (Habibullah *et al*., 2007). The assessment of elements in powdered milk revealed different levels of Fe (21.73ppm), Zn (3.24ppm), Cu (0.54ppm), and Cr (0.18 ppm), respectively (Birghila *et al.*, 2008).

RUTF are being manufactured globally using locally available crops. Most recently Hassan *et al.,* (2016) developed chickpea based novel RUTF and assessed for chemical composition and efficacy through animal model. The developed RUTF contained 2.07% moisture, 3.51% ash, 12.42% crude protein, 31.33% crude fat, 3.17% crude fiber and 50.63% nitrogen free extract whereas peanut based commercial RUTF "Plumpy'nut" exhibited different levels of moisture (2.02%), ash (3.63%), crude protein 12.56%), crude fat (32.33%), fiber (2.15%) and NFE (49.33%). It was found that novel indigenous chickpea based RUTF is like Plumpy'nut with respect to nutritional value and protein quality.

In another study, three types of RUTF were developed by mixing chickpea, rice, soybean meal, banana, sugar, and different amino acids. The compositional analysis depicted moisture, protein, fat, carbohydrates, and ash 3.92 to 5.43, 14.51 to 17.98, 1.61 to 4.05, 69.39 to 76.74 and 1.98 to 2.42%, respectively (Valencia *et al*., 1988). In Bangladesh rice-lentil and chickpea-based RUTF were prepared using indigenous raw materials and packed in 50g sachet. The results showed 1.0-1.2% moisture, 5.1-6.0% protein, 14.8-15.9% total fat, 267.6-24.9% carbohydrates and 1.9-2.5% ash 1.2g for 50g packet (Ahmed *et al.,* 2014).

In a study acceptability of 2 RTUF by HIV patients in Vietnam was checked by developing mung bean, rice and soy based high-energy bar for integrated management of acute malnutrition (HEBI) and served along with Plumpy'nut. The chemical composition of HEPI revealed 2.5% moisture, 34.67% lipids, 15.33% protein, and 42.50% carbohydrates (Nga *et al.,* 2013; Brown *et al.,* 2015). In India, "RUTF Agra" was developed using equal amount of peanut, puffed rice, Bengal gram and jaggery. The results showed that 9.5% protein, 26.25% fat and 62% carbohydrate (Sandeep and Mona, 2014). The researchers suggested use of developed formulations for hospitalized children in nutritional rehabilitation.

The standard peanut based RUTF should contain at least 10-12% protein, 45-60% lipids, maximum 2.5% moisture and 520-50 Kcal energy (WHO, 1999; Wagh and Deore, 2015). In a study fluid milk-based diet (F-100) and peanut-based RUTF developed for rehabilitation of severely malnourished children showed presence of 13.6g/100g protein and 35.7g/100g lipid (Diop *et al.,* 2003). Dibari *et al.,* (2013) developed novel RUTF formulations using maize, soy, sorghum, peanut butter, and milk powder for pediatric treatment. The results showed 13.6 to 15.3g/100 protein and 33.6 to 35.7g/100g lipids. Likewise, peanut-based RUTF was evaluated for effectiveness in malnourished children in Nigeria. The developed RUTF were found to contain 11.6g protein and 29.5 g/100 lipids (Kam *et al*., 2016).

Nga *et al.,* (2013) manufactured culturally acceptable RUTF using locally available ingredients like mung bean, soy, rice, sesame, whey protein, and whole milk powder and complying. The results showed 15.33 g protein, 34.67 g lipids, 42.50 g carbohydrate and 2.5% moisture content, 1.61% omega 3 and 4.82% omega 6.The recommended dietary allowances (RDA) of phosphorus, magnesium, iron, and zinc for children aged from 0.5 months to 8 years are ranged from 275-500, 75-130, 7-11, and 3-5 mg/100g (Whitney and Rolfes, 2016).

The standard peanut-based RUTF should contain at least 290 mg/100g Na, 1100-1400 mg/100g K, 300-600 mg/100g Ca & P, 80-140 mg/100g Mg, 10-14 mg/100g Fe, and 11-14 mg/100g Zn (WHO, 1999; Wagh and Deore, 2015). In a study fluid milk-based diet (F-100) and peanut-based RUTF developed for rehabilitation of severely malnourished children showed the highest concentration of potassium (1111 mg/100g) followed by phosphorus (349 mg/100g), calcium (320 mg/100g), magnesium (92 mg/100g), zinc (14 mg/100g), and iron (1.5 mg/100g), respectively (Diop *et al.,* 2003). In a study, 1022 mg/100g K, 276 mg/100g Ca & P, 84.6 mg/100g mg, 10.6 mg/100g Fe, and <267 mg/100g Na contents were reported in peanut-based RUTF (Kam *et al*., 2016). The study conducted on chickpea sesame-based RUTF (100g) contained 304.1 mg calcium, 1.7 mg copper, 92.7 µg iodine, 10.5 mg iron, 351 mg phosphorus, 935.6 mg potassium, and 12.4 mg zinc (Bahwere *et al*., 2009).

Consumer acceptability of newly developed products is carried out using senses of vision, touch, smell, and taste. Appearance is an essential criterion related to acceptability of newly developed products. Similarly, texture is another vital criterion linked with consumer preferences. Overall acceptability is a major detrimental criterion for consumer acceptability of newly formulated products. In a study RUTF were developed by using ingredients available locally such as soybeans, maize and peanuts and assessed for consumer acceptability. The results showed that soya-based RUTF were liked more for its appearance, and texture whereas maize-based RUTF was liked the most for flavor as compared with peanut-based RUTF (Wamunga and Wamunga, 2017).

The smoother texture is preferred in complementary foods (Muhimbula *et al.,* 2011). Likewise, consumer have better acceptability for local products or products having greater proportion of locally used ingredients as they are more familiar with their taste, texture, and other sensory attributes (Kure and Wyasu, 2013). In the present study, RUTF containing 100% chickpea or higher proportions of chickpea in blends were more liked by the judges due to better texture, smoothness, flavor, and overall acceptance. This was might be due to more utilization of chickpea and mung bean in daily diets of the local inhabitants resulting in preference due to adaptability. The flavor of all formulations was acceptable as peanut, mung bean and chickpea were roasting before milling into fine powder.

Appearance and flavor are greatly enhanced whereas anti-nutritional factors are decreased by roasting of legumes and cereals (Oyenuga, 2013).Roasting also enhance acceptability by imparting a nutty flavor to the food. Most of the anti-nutritional factors or toxic effects of legumes (trypsin inhibitor, hemagglutinin, goitrogenic agents, cyanogenic glucosides, alkaloids, etc.) are partially or fully eliminated by roasting (Ndidi *et al.,* 2014).

***Conclusion*:** Quality evaluation and consumer acceptability of the locally developed formulation exhibited prospects of producing RUTF in Pakistan using locally grown chickpea, mungbean and peanut. Additionally, mung bean and chickpea-based formulations are free from the risk of any allergen which are present in Plumpy'nut based RUTF currently procured through UNICEF from "Nutriset, France", in the country. Although all formulations were acceptable to the consumer with respect to appearance, flavor, texture, mouthfeel, smoothness and overall acceptability; however, T_5 (100% chickpea based RUTF), T_{13} (RUTF with 60% chickpea and 40% mung bean); and T_{14}(RUTF with 80% chickpea and 20% mung bean) were declared beast alternatives for commercially available Plumpy'nut based RUTF. This local production of RUTF will also help to reduce the cost for importing RUTF alongwith sustainable provision.

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