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APPLICATION OF CHICKPEA, MUNG BEAN AND LENTIL AS SUSTAINABLE PROTEIN SOURCE FOR THE FORMULATION OF PULSE BASED COMPOSITE FLOUR CHAPATTI (FLAT BREAD)

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Abstract

Sustainable diets are considered as sufficiently nutritious, economically affordable and environment friendly. Global trend shifts towards alternative protein enriched sustainable diets that are also environment friendly. In present research, an effort was made to study the pulse based composite flour that were envisaged as protein enriched product alternative to cereals. The objective of this study the feasibility of pulse flour incorporation at certain level of supplementation with minimal changes in functional and rheological behavior and sensory characteristics of pulse based composite flours @ 10, 20, 30, 40 and 50% replacement of wheat flour. 100% wheat flour was used as control. This supplementation had more pronounced effect on functional and rheological properties. Pulse flour supplementation resulted in an increase in water absorption capacity and decrease in oil absorption capacity of flour blends. An increase in bulk density (0.79±0.05 to 1.51±0.01gcm-3) and water absorption capacity from 0.50±0.02 to 0.96 ±0.03g/ml were observed. Whereas oil absorption capacity was decreased simultaneously (1.11±0.08 to 0.11±0.01 gg-1). The organoleptic characteristics of flat bread were carried out by taste panel for assessment of consumer acceptability. Essential amino acid lysine improved up to 0.64±0.02g100g-1 in composite flour. Sensorial scores for binary composition indicated that 10% mung bean and lentil flour, while 20% chickpea flour could be added to wheat flour without affecting the organoleptic characteristics. Thus, adding composite pule flour in the ratio of 20:10:10 of chickpea, mung bean and lentil actually gives as good palatability comparable to wheat flour chapatti with higher nutritional quality with respect to protein and acceptable consumer attitude.

Index Terms: Chickpea, Mung Bean, Lentil, Functional Properties, Protein Quality, Flat Bread (Chapatti).

1. INTRODUCTION

Sustainable produced protein rich food is on demand by the growing world population and to fulfil this demand pulses are most attractive crops that can be used in direct consumption or in processed form of flour, protein concentrate, starches or fiber and oil in case of oilseed legume crops [1]. Increasing sustainability of climate smart agriculture leads to the increasing food security by adapting and building resilience to ever changing circumstances [2], [3], [4]. Food consumption pattern is one of the most crucial reason for change in global environment. It includes whole supply chain management and land use system. The food system accounts around 25% of total greenhouse gas emission according to study conducted in recent years focused on meat production and consumption [5], [6] predicted a great contribution from livestock sector. On the other hand, pulses and legumes as an alternate source of protein can be grown in any context of environmental and ecological conditions, even in mountainous and hilly areas as well as on marginal lands.

Pulses like beans, pes, cowpea, lentils, and chickpea are most suitable to utilize in food products being rich in protein content. Pulses showed wide acceptability being economical, providing better source of conventional protein source [7]. Value addition is compulsory for these commodities to get benefit from their enhanced nutritional properties beneficial for population affected with protein as well as micronutrient deficiencies [8]. The recent technologies are helpful in processing and utilization of legumes and pulses [9].

Wheat crop is serving as a staple food of almost 90% population in the sub-continent. To outstrip the burden from wheat crop, wheat flour can be replaced with other non-cereal crop grains like pulses and legumes to acceptable level for product development. Besides that, wheat bread supplies a very low quantity of vital amino acids, especially lysine and threonine [3], [10]. It is frequently called an unbalanced diet as it contains a very low amount of lysine.

The objective of this study was to investigate the possibilities for pulses flour as a sustainable raw ingredient (chickpea, mung bean and lentil flours) for incorporation with wheat flour in making flat bread. The most suitable blending ratio of these pulse flours was selected on the basis of their functioning properties and rheological behavior. The chemical composition and sensorial quality of protein enriched flat bread (chapatti) were also studied.

2. MATERIALS AND METHODS

Raw materials: Commercially available fine wheat flour was procured from market, pulses of each type i.e., chickpea (var. Noor 13), Mung bean (Mung pari) and Lentil (Masoor 2009) were procured from Pulses Research Institute, AARI. Pulses flour were obtained by grinding the pulses through laboratory mill.

2.1. Compositional analysis of raw flours: The chemical analysis, moisture, fat, ash, protein and crude fiber were determined by using the methods followed by AACC [11].

2.2. Preparation of composite flour blends: The composite flour blends were prepared by substituting wheat flour with respective pulse flours (chickpea, mung bean and lentil) at replacement levels of 0, 10, 20, 30, 40 and 50% for chick pea, mung bean and lentil flour respectively while 100% wheat flour was served as control.

2.3. Functional properties

2.3.1. Bulk density: Bulk density of composite flour samples was calculated by adopting the method of [12] with slight modification. 1 gram of sample was taken in a graduated cylinder and 10ml distilled water was added into the flour sample taken in cylinder. The sample was tapped on the top of the bench to level the surface the volume of the sample was recorded as:

$$Bulk\ density = Volume\ of\ sample\ after\ tapping \div Weight\ of\ sample$$

2.3.2. Water holding capacity: Water holding capacity of flour samples were estimated by taking 1-gram flour sample in pre-weighed 25ml capacity centrifuge tube by adding water. The tube mixture was vortexed for 2 minutes followed by 20 min centrifugation at 4000rpm. The clear supernatant was removed carefully and then centrifuge tube was weighed again. Water absorption capacity was calculated as by weight differences before and after centrifugation [13].

2.3.3. Oil absorption capacity: The capacity of oil retention in composite flour samples were estimated by the modified process of [13].

2.4. Rheological properties: Composite flour samples were analyzed for rheological properties by means of Farinograph (Barbender, Duisburg, Germany) according to the procedure of AACC. Farinograph with 50g capacity was used. The parameters like water absorption, dough development time, dough stability time was observed for each composite flour sample.

2.5. Pasting properties: Pasting properties of composite flour samples were analyzed by Rapid Visco Analyser with the standard protocol [11]. The parameters obtained were peak viscosity (PV), through viscosity (TV), breakdown viscosity (BV), setback viscosity (SV), final viscosity (FV), peak time (PT) and pasting temperature.

2.6. Chapatti making: Chapattis (unleavened flat bread) were prepared by following the methods as reported by [14] with slight modifications. The chapatti dough was prepared by mixing composite flour with optimum quantity of water. The dough was divided into equal portions and was rolled into round sheets of 2mm thickness. The chapattis were baked on pan at 210^{o}C on each side until properly baked. After baking chapattis were cooled on wire rack at room temperature before packing in sealed pouches.

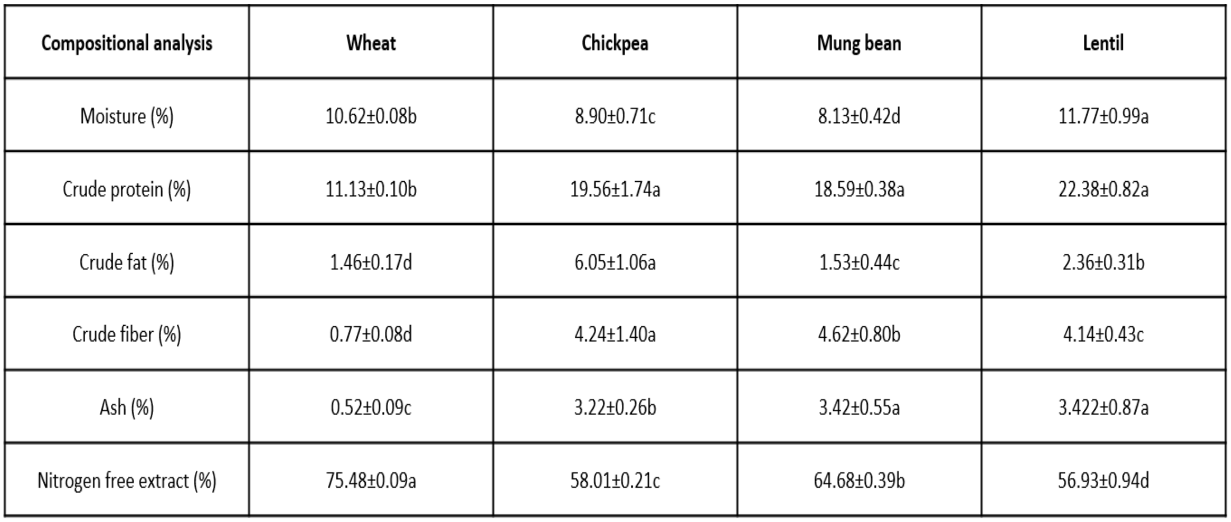
2.6.1. Sensory evaluation of chapattis: The sensory assessment was carried out in sensory evaluation lab. A panel of 15 members consisted of staff and post graduate students of the national institute of food science and technology (NIFSAT), UAF. The chapatti samples were coded with numbers and served to evaluate for organoleptic parameters. The panelists were provided with glass of water and instructed to rinse and swallow water between samples. They were asked to evaluate the composite flour chapattis for acceptability based on its color, aroma, taste, texture, chewability, foldability and over all acceptability using nine points hedonic scale (0= Dislike extremely to 9= Like extremely) following the method of [15].

2.6.2. Amino acid profile of composite flours: Amino acid contents of composite flours samples were analyzed by following the procedure of Ullah [16] by principle of ion exchange chromatography using Amino acid analyzer Biochrom 30++, Biochrom Ltd. Cambridge, UK.

2.7. Statistical analysis: The data obtained from various experiments were recorded during the study and subjected to statistical analysis by one-way Analysis of variance (ANOVA) using completely randomized design (CRD) factorial. All the measurements were performed in triplicate and results were expressed as average values with standard deviation. The significant difference between the treatments was estimated at 5% level of significance using statistics 8.1 and Microsoft excel. Comparison of means beyond ANOVA was performed by Tukey's comparison test [17].

3. RESULTS

3.1. Compositional analysis of wheat, chickpea, mung bean and lentil flours: The proximate composition varied significantly among wheat and pulse's raw flours. The protein, fat, ash and fiber contents in pulse flours were higher than that recorded in wheat flour as described in fig. 1. Highly significant differences ($p \leq 0.05$) were observed among four types of flours. Protein contents were observed to be highest in Lentil flour (22.38±0.82), followed by chickpea (19.56±1.74) and mung bean flour (18.59±0.38).



Compositional analysis	Wheat	Chickpea	Mung bean	Lentil
Moisture (%)	10.62±0.08b	8.90±0.71c	8.13±0.42d	11.77±0.99a
Crude protein (%)	11.13±0.10b	19.56±1.74a	18.59±0.38a	22.38±0.82a
Crude fat (%)	1.46±0.17d	6.05±1.06a	1.53±0.44c	2.36±0.31b
Crude fiber (%)	0.77±0.08d	4.24±1.40a	4.62±0.80b	4.14±0.43c
Ash (%)	0.52±0.09c	3.22±0.26b	3.42±0.55a	3.422±0.87a
Nitrogen free extract (%)	75.48±0.09a	58.01±0.21c	64.68±0.39b	56.93±0.94d

Fig 1: Proximate composition of raw flours

Values represent mean ±SD, One way ANOVA followed by Tukey's HSD multiple comparison test. Means having same letter in columns are non-significant

3.2. Functional properties of composite flour blends: The results pertaining to functional properties of composite flours have been presented in Fig. 2. The supplemented flours showed significant ($p<0.05$) differences among treatments with increasing trend in bulk density as the substitution level of chickpea, mung bean and lentil flours were increased from 10 to 50%. The flours bulk density was found in the range of 0.79±0.05 to 1.51±0.01gcm-3. The maximum value was recorded for treatments with 50% substitution of chickpea, mung bean and lentil flours (1.51±0.01), (1.41±0.01) and (1.41±0.08) gcm-3 respectively. Mean values of water absorption and oil absorption capacity showed significant variations among pulse based composite flour with 10 to 50% pulses flour substitution. A significant ($p<0.05$) increase among the treatments means was found within a range of 0.50±0.02 to 0.96±0.03gml-1 for water absorption capacity and a reduction from 1.11±0.08gg-1 to 0.11±0.01gg-1 for oil absorption capacity.

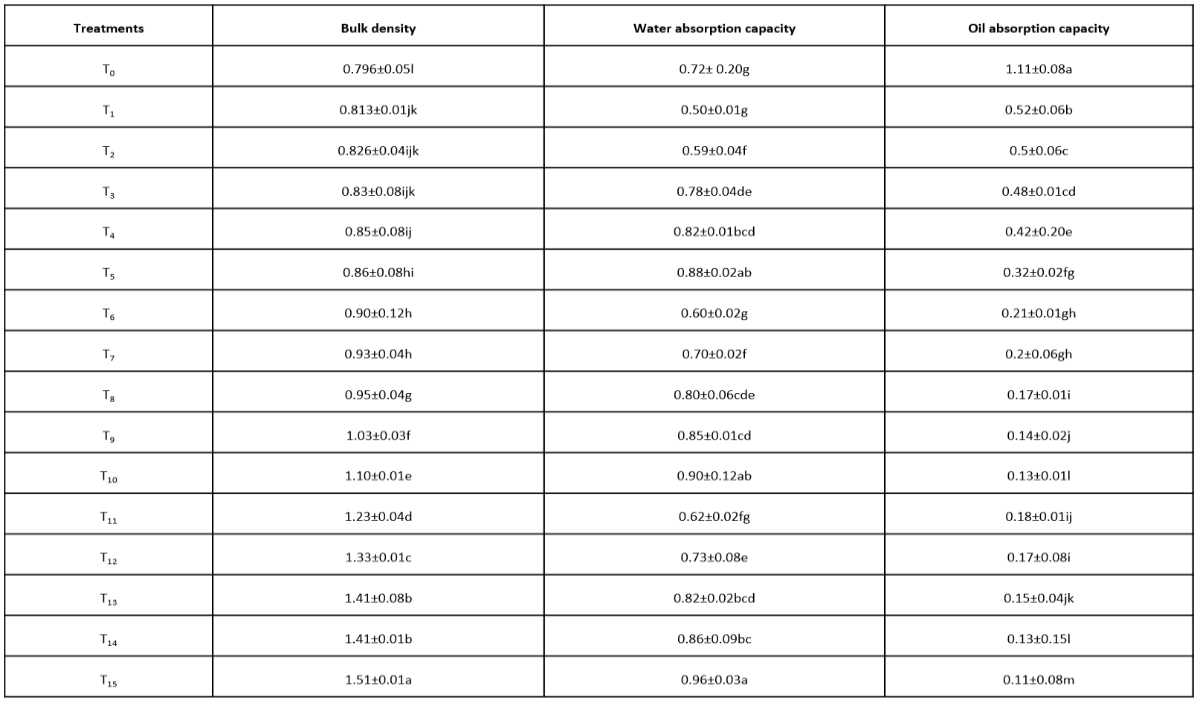
Treatments	Bulk density	Water absorption capacity	Oil absorption capacity
T_0	0.796±0.05l	0.72± 0.20g	1.11±0.08a
T_1	0.813±0.01jk	0.50±0.01g	0.52±0.06b
T_2	0.826±0.04ijk	0.59±0.04f	0.5±0.06c
T_3	0.83±0.08ijk	0.78±0.04de	0.48±0.01cd
T_4	0.85±0.08ij	0.82±0.01bcd	0.42±0.20e
T_5	0.86±0.08hi	0.88±0.02ab	0.32±0.02fg
T_6	0.90±0.12h	0.60±0.02g	0.21±0.01gh
T_7	0.93±0.04h	0.70±0.02f	0.2±0.06gh
T_8	0.95±0.04g	0.80±0.06cde	0.17±0.01i
T_9	1.03±0.03f	0.85±0.01cd	0.14±0.02j
T_{10}	1.10±0.01e	0.90±0.12ab	0.13±0.01l
T_{11}	1.23±0.04d	0.62±0.02fg	0.18±0.01ij
T_{12}	1.33±0.01c	0.73±0.08e	0.17±0.08i
T_{13}	1.41±0.08b	0.82±0.02bcd	0.15±0.04jk
T_{14}	1.41±0.01b	0.86±0.09bc	0.13±0.15l
T_{15}	1.51±0.01a	0.96±0.03a	0.11±0.08m

Fig 2: Functional properties of flour blends

Values represent mean ±SD, One way ANOVA followed by Tukey’s HSD multiple comparison test. Means having same letter in columns are non-significant

T_0= Wheat flour (100), T_1= Wheat: Chickpea (90:10), T_2= Wheat: Chickpea (80:20), T_3= Wheat: Chickpea (70:30), T_4= Wheat: Chickpea (60:40), T_5= Wheat: Chickpea (50:50), T_6= Wheat: Mung bean (90:10), T_7= Wheat: Mung bean (80:20), T_8= Wheat: Mung bean (70:30), T_9= Wheat: Mung bean (60:40), T_{10}= Wheat: Mung bean (50:50), T_{11}= Wheat: Lentil (90:10), T_{12}= Wheat: Lentil (80:20), T_{13}= Wheat: Lentil (70:30), T_{14}= Wheat: Lentil (60:40), T_{15}= Wheat: Lentil (50:50)

3.3. Farinographic properties of flour blends: The flours of different sources differ in rheological behavior as compared to wheat flour therefore, it is crucial to study flour behavior to find out the suitability of best combination for further utilization in production. The mean values for water absorption capacity varies significantly ($p<0.05$) form 58.7±0.08% to 62.1±0.08% with supplementation of pulse flours (Fig.3). Chickpea flour supplemented treatments exhibited WAC in the range of 59.4±0.04% to 61.5±0.09%. Likewise, incremental increase in WAC from 59.04±0.08% to 61.1±0.07 % and from 59.16±0.08% to 62.1±0.08% was observed with addition of mung bean and lentil flours. Dough development time (DDT) was increased after supplementation and highest value was observed for composite flour chickpea (7.8±1.20 min), mung bean (7.96±1.46 min) and lentil (7.65±0.04 min) at 50% level of supplementation. However, dough stability time (DST) showed declining trend with increasing percentage of chickpea, mung bean and lentil flours. Highest dough stability was observed for wheat flour (10.73±0.16 min) and lowest for lentil supplemented flour (7.02±0.04 min).



Treatments	Bulk density	Water absorption capacity	Oil absorption capacity
T_0	0.796±0.05l	0.72± 0.20g	1.11±0.08a
T_1	0.813±0.01jk	0.50±0.01g	0.52±0.06b
T_2	0.826±0.04ijk	0.59±0.04f	0.5±0.06c
T_3	0.83±0.08ijk	0.78±0.04de	0.48±0.01cd
T_4	0.85±0.08ij	0.82±0.01bcd	0.42±0.20e
T_5	0.86±0.08hi	0.88±0.02ab	0.32±0.02fg
T_6	0.90±0.12h	0.60±0.02g	0.21±0.01gh
T_7	0.93±0.04h	0.70±0.02f	0.2±0.06gh
T_8	0.95±0.04g	0.80±0.06cde	0.17±0.01i
T_9	1.03±0.03f	0.85±0.01cd	0.14±0.02j
T_{10}	1.10±0.01e	0.90±0.12ab	0.13±0.01l
T_{11}	1.23±0.04d	0.62±0.02fg	0.18±0.01ij
T_{12}	1.33±0.01c	0.73±0.08e	0.17±0.08i
T_{13}	1.41±0.08b	0.82±0.02bcd	0.15±0.04jk
T_{14}	1.41±0.01b	0.86±0.09bc	0.13±0.15l
T_{15}	1.51±0.01a	0.96±0.03a	0.11±0.08m

Fig 3: Farinographic characteristics of flour blends

Values represent mean ±SD, One way ANOVA followed by Tukey's HSD multiple comparison test. Means having same letter in columns are non-significant

3.4. Pasting properties of composite flours: Composite flours showed significant ($P<0.05$) differences in pasting properties as compared to wheat flour, but in general the pasting temperature in composite flours were lower than that of the control i.e., 100%wheat flour (Fig. 4). The mean values for peak viscosity of composite flours showed decreasing trend with the addition of pulses flour. Peak viscosity (PV), through viscosity (TV) and final viscosity (FV) showed a decline in their respective values as the ratio of supplemented flours were increased from 10 to 50 percent. For chickpea flour supplemented treatments, the PV declined from 2654.5±0.40 to 1950.66 ±0.47cP, for mung bean flour the PV decreased from 2744.6±0.43 cP to 1850.56±0.41cP and for lentil supplemented flours PV value decreased from 2885.33±0.47 to 1776.5±0.40 for 10 to 50 percent replacement of wheat flour with respective pulse flours. The mean values for through viscosity and final viscosity for wheat flour were 1586.6±0.44 and 3185±0.40cP respectively. Least values for through viscosity were observed in composite flours having 50% chickpea, mung bean and lentil flours as 1098±0.82 (T_{13}), 1195.66±0.47 (T_{14}) and 1285.73±0.52 cP (T_{15}) correspondingly. A significant reduction in final viscosity was observed as the level of pulses flour were increased. For composite flours it was ranged from 2802±0.81 to 2241±0.40 for chickpea, from 2991.53±0.41 to 2071.66±0.47cp for mung bean and from 2985.63±0.41cp to 2012.03±0.36 cP for lentil flour in 10 to 50 percent supplementation. Pasting temperature of flour samples was found to be increased from 67.84±0.01to 79.17 ±0.04 °C.

Treatments	Peak Viscosity (cp)	Through viscosity (cp)	Breakdown Viscosity (cp)	Setback viscosity (cp)	Final Viscosity (cp)	Peak Time (min)	Pasting Temperature (ºC)
T_0	3289.40±0.43a	1586.6±0.44a	1403.00±0.81a	1598±0.81a	3185±0.40a	5.8±0.01a	67.84±0.01k
T_1	2654.50±0.40d	1392.43±0.32f	1262.46±0.36c	1489.3±0.3d	2802±0.81f	5.74±0.08b	70.15±0.03ij
T_2	2564.66±0.47f	1309.16±0.23klm	1189.50±0.40f	1443.3±0.94e	2711±0.81i	5.70±0.00cd	72.4±0.01g
T_3	2461.33±0.94h	1372.83±0.62i	966.43±0.32j	1425.4±0.43f	2789±0.40g	5.68±0.06e	71.26±0.01h
T_4	2160.66±0.47i	1284.73±0.52m	777.00±0.82l	1370.4±0.43h	2603±0.48j	5.58±0.00g	74.22±0.00ef
T_5	1950.66±0.47j	1098.00±0.816o	686.00±0.48m	1143.23±0.20n	2241±0.40n	5.36±0.02i	76.75±0.01d
T_6	2744.6±0.43c	1485.70±0.52de	1258.03±0.12e	1520.5±0.42b	2991.53±0.41b	5.71±0.00cd	72.30±0.01g
T_7	2616.43±0.32e	1384.33±0.47h	1088.10±0.21g	1504.5±0.40c	2860.03±0.12e	5.68±0.04e	73.2±0.08f
T_8	2474.33±0.47gh	1386.23±0.16g	922.60±0.43k	1372.76±0.20i	2687.23±0.20j	3.66±0.00l	73.11±0.00f
T_9	1904.6± 0.43l	1310.50±0.40kl	693.63±0.44n	1292.5±0.45k	2350.33±0.47m	5.48±0.01h	77.65±0.04c
T_{10}	1850.56±0.41n	1195.66±0.47n	665.10±0.08o	1174.73±0.52m	2071.66±0.47o	5.32±0.02j	78.55±0.01b
T_{11}	2885.33±0.47b	1523.53±0.41b	1362.00±0.16b	1468.56±0.41d	2985.63±0.41c	5.73±0.00bc	71.22±0.04h
T_{12}	2741.6 ±0.43c	1491.43±0.32c	1259.33±0.47de	1396.5±0.40g	2755.00±0.40h	5.73±0.01bc	72.3±0.16g
T_{13}	2475.2±0.28g	1482.00±0.81e	1055.40±0.32h	1369.23±0.94j	2572.13±0.26k	5.63±0.00f	75.54±0.01e
T_{14}	1925.66±0.47k	1361.00±0.12j	995.20±0.16i	1273.53±0.41l	2374.33±0.24l	5.47±0.01hi	76.14±0.02cd
T_{15}	1776.5±0.40m	1285.73±0.52k	875.8±0.16j	1185.23±0.40mn	2012.03±0.36p	5.31±0.01k	79.17±0.04a

Fig 4: Pasting properties of composite flours

Values represent mean ±SD, One way ANOVA followed by Tukey’s HSD multiple comparison test. Means having same letter in columns are non-significant.

3.6. Sensory evaluation of chapatti: Sensory scores for overall acceptability of all the treatments showed significant difference and similar variation was noticed in substituted treatments and control one. Pulse types and percent substitution cause significant effect on overall acceptability of final product (chapatti).

The results revealed that T_2 with 20:80 chickpea and wheat flour had highest overall acceptability scores (7.95±0.47) among the pulse flour supplemented treatments followed by T_6 (7.75±0.46) with 10:90 mung bean: wheat ratio and T_{11} (6.8±0.51) with 10:90 lentil: wheat ratio in prepared chapattis [Fig.5].

Higher level of substitution showed radical decline in acceptability scores. With increased level of pulse flour supplementation, the foldability of chapatti was dropped from a certain level of acceptability. Highest scores were observed for T_2 (7.80±0.47) for 20:70 chickpea: wheat flour ratio followed by T_6 (7.95±0.15) and T_{11} (7.25±0.25) with 10% substitution level of both mung bean and lentil flours with wheat flour.

High level of substitution up to 50% showed declining trend for foldability scores of chapattis. Color scores, taste and flavor scores also decreased with increasing percentage of chickpea, mung bean and lentil flours. Figure 1 depicted the variations among the chapattis prepared with different level of pulse flour substitution on color, size etc.

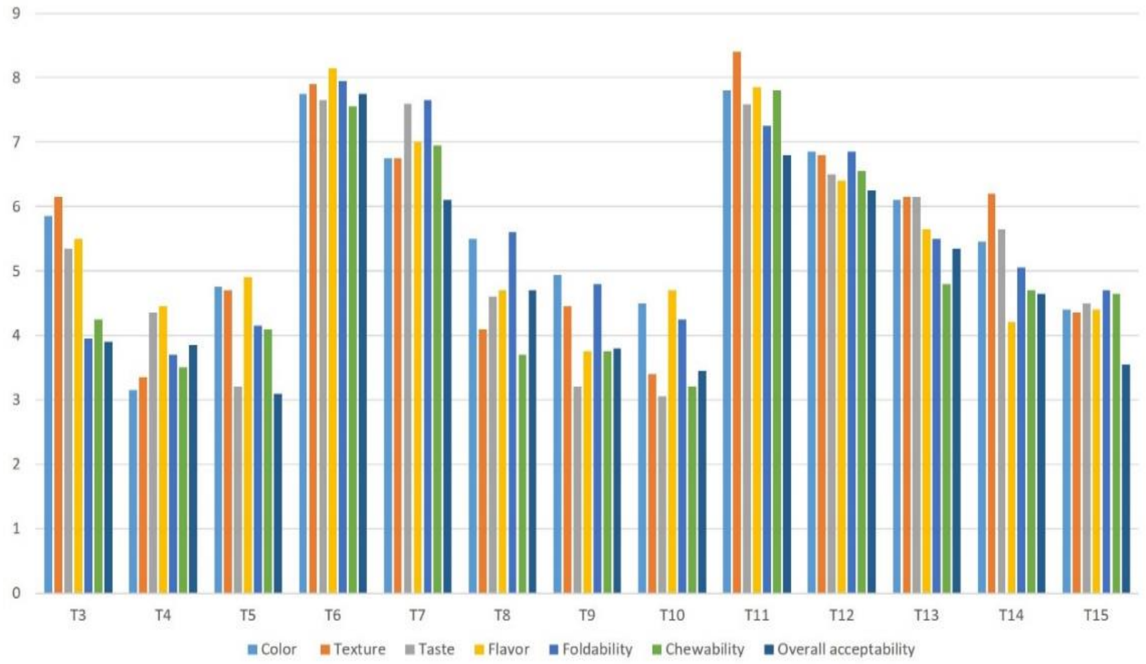


Fig 5: Sensory Scores of Chapatti

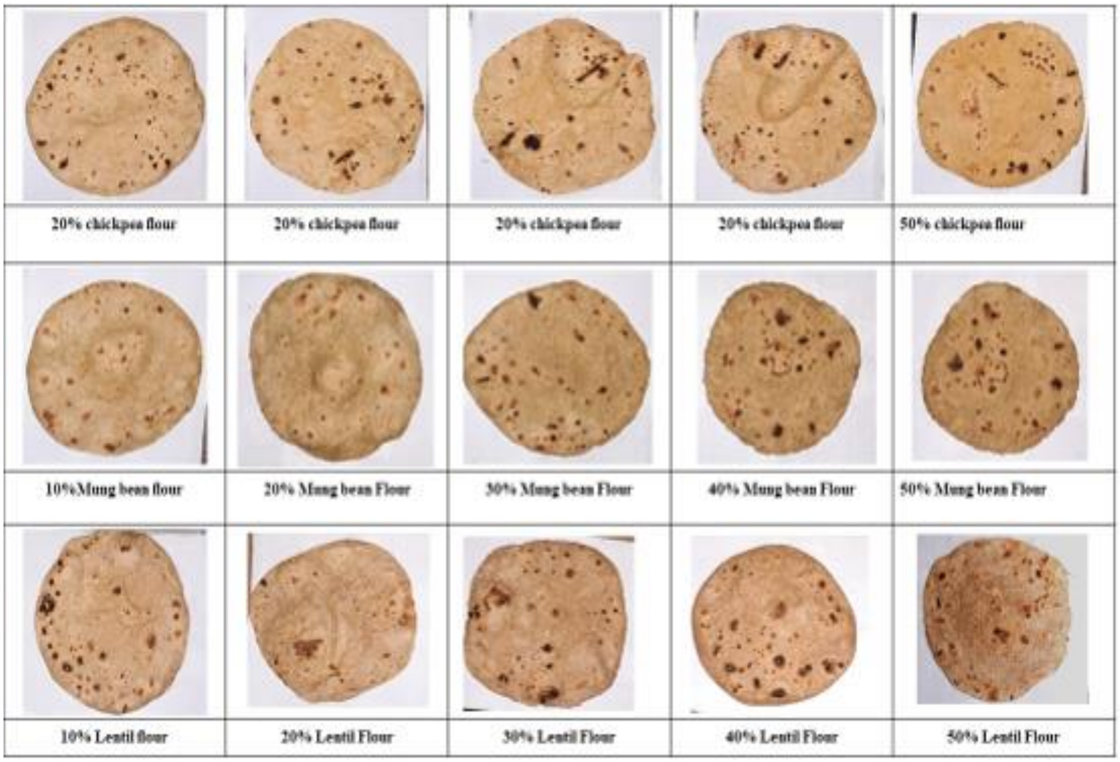


Fig 6: Chapattis prepared with pulses (chickpea, mung bean and lentil) incorporated wheat flour

3.7. Amino acid profile of composite flours: The selected composite flour samples for best suited ratio of individual pulses, chickpea, mung bean and Lentil with wheat flour were further evaluated for amino acid profile to estimate the extent of variation for essential amino acids specifically lysine.

The data pertaining to mean values of selected composite flours under the Fig. 6 illustrated significant variations for amino acid composition. Maximum lysine content (0.700±0.24g100g-1) was found in T_2, wheat and mung bean composite flour treatment, followed by T_3 (Wheat: Lentil) and T_1 (Wheat: Chickpea) with 0.56±0.02g100g-1 and 0.50±0.19g/100g lysine contents respectively.

The observed lysine contents in tertiary composite flour with all three pulses (chickpea, mung bean and lentil) with wheat flour were 0.640±0.02 g100g-1 which was clearly higher as compared to that of wheat flour (0.374±0.368 g100g-1) [Fig.7].

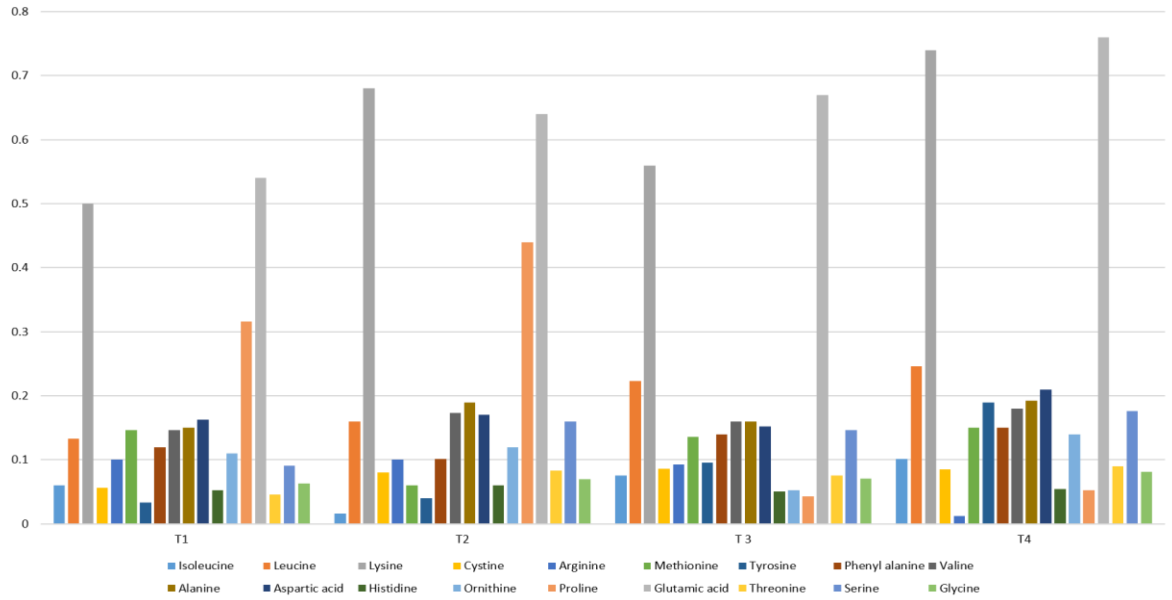


Fig 7: Amino acid profile of selected composite flours

T_1= Composite flour with 20% Chickpea flour, T_2= Composite flour with 10% Mung bean flour, T_3= Composite flour with 10% Lentil flour, T_4= Composite flour with 20:10:10% Chickpea, Mung bean and Lentil flour

4. DISCUSSION

Compositional analysis of chickpea, mung bean and lentil flours showed high level of protein, fat and fiber compared to wheat flour. Lentil flour represented highest protein contents. High percentage of fat contents was observed in chickpea flour as compared to mung bean and lentil but clearly high from that of wheat flour. Mung bean flour depicted highest fiber contents as compared to chickpea, lentil and wheat flour. These compositional changes are due to the nature and variety of seeds. Environmental and soil condition may also affect the nutritional 0composition of the commodity. These outcomes are closely associated with the findings of [18] who worked on ready to use therapeutic food by utilizing mung bean, chickpea and peanut presented the proximate composition of chickpea and mung bean having 6.8% moisture, 22% protein, 1.4% fat, 3.50% fiber and 3.40% ash in mung bean while for chickpea these values were considered as 9.8, 20.50, 3.8, 3.90 and 2.90% moisture, protein, fat, fiber and ash respectively. Similarly, [19] worked on legume flour and delineated that legumes or pulses offer better quality proteins.

Functional properties of flour play a vital role in defining the flour behavior. Bulk density Water holding capacity and Oil absorption capacity of pulse based composite flours were compared with wheat flour and observed that water absorption capacity of pulses supplemented flours were high as compared to that of wheat flour (0.50 ±0.01) as well as supplemented flours showed increasing trend with increasing the substitution level with chickpea, mung bean and lentil flour. Variation in particle size distribution may also have influenced the WAC. According to [20] oil absorption capacity is an important parameter to take in consideration while developing a new food product as it can influence the shelf stability of food product. High water absorption capacity for mung bean date supplemented flour and represented water absorption capacity ranged from 1.00 to 1.60 g/ml and Oil absorption capacity as 1.18 to 1.64g/g. The present results for bulk density and the water absorption capacities of supplemented flours are in accordance with the previous findings of [21] and [22] testified an increase in water absorption capacity from 1.6-1.8 g/ml. The incremental increase in WAC and decrease in oil absorption capacity of composite flours are in concordance with the outcomes of [23] who studied the pasting and rheological properties of amaranthus based composite flours and predicted significant increase in WAC from 1.7845 to 2.6842g/ml flour and a decrease in OAC from 1.40 to 1.02g/g.

The pasting properties showed declining trend with increasing percentage of supplemented pulse flours. Decrease in peak viscosity might be due to the weak gluten framework of supplemented flours as pulses have less gluten content as compared to wheat flour. The breakdown viscosity also decreases as increase in pulse flour percentage. This decrease in breakdown viscosity may be due to restricted swelling of the starch granules, which increased the tendency of the hydrophilic chain of the fiber in composite flours to bind with hydrogen bonds of the water, causing a decrease in available water for starch granules.

The pasting properties of pulses flours showed increasing trend in pasting temperature for chickpea, yellow pea and lentil in the range of 60.35 to 86.80, 65.76 to 82.13 and from 62.50 to 81.92 respectively after germination [24], which are in close relation with the current findings. The lower BD and FV as increase in composite flours indicate the ability of the flour to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear stress during stirring [25]. Present results for pasting properties are supported by the outcomes of [26] explicated reduction in PV, TV, BDV and set back viscosity from 3040 to 2107cP.

In general, the viscosity of composite flour was lower than wheat flour. The significant difference in the pasting profile of the composite flour compared with its 100% flour might be as a result of restricted swelling of the starch granules, which ultimately increase the tendency of the hydrophilic chain formation of the fiber present in composite flours to bind with hydrogen bonds of the water.

This condition may decrease the availability of water for starch granules. It can be related with the susceptibility of protein to heat damage in supplemented four. Generally, the lower breakdown (BD) and final viscosity (FV) indicate the ability of the flour to form a sticky paste or gel after cooking and cooling, it shows resistance of the paste to shear stress during stirring [25].

Rheology of dough concerns the flow and deformation of substances and their behavior in the transient area between solids and fluids. Likewise, rheological study also defined a relationship between the stress acting on a given material and the resulting deformation and/or flow that takes place. Knowledge of the fundamental rheological properties of any dough can be used as quality indicators for cereal products. These properties of doughs describe the deformation of dough and rapture of granules, under applied stress and could be used as a tool in the selection and specification of appropriate raw materials for different bakery products [27]. Similarly, setback viscosity indicates tendency of starch retrogradation. Increasing trend of starch retrogradation was observed as the level of pulses flour was increased in composite flours. The value of setback viscosity for wheat flour was perceived as 1598±0.81. Composite flours with higher level of substitution (40-50%) showed significantly ($P \leq 0.05$) lower setback viscosity than that of wheat flour except for composite flours with less replacement ratio. The blending of chickpea, mung bean and lentil flour gave the flours a longer paste peak times, and hence the starch granules swelled gradually and had better resistant to mechanical damage.

The results showed that the supplementation of pulses more than a certain level may influence the functionality of dough that further stimulate the processing aspects and sensory attributes of end product. It is depicted that the supplementation at lesser extent may not negatively affect the functional attributes of the composite flours and ultimately product quality. However, it cannot be described the best suited treatment from functional properties unless it is clear that how the supplementation level affected the organoleptic attributes of the end product.

For this purpose, the product development was conducted for best binary combination of each pulse flour with wheat flour. From the results of sensory scores, it was found that the addition of pulses flours influenced the sensory attributes specially color on account of the presence of color pigments within the pulses flours and up to 50% addition altered the specific chapatti flavor that was undesirable for consumers. Chickpea flour supplementation up to 20% showed better scores for consumer’s acceptance regarding all sensory attributes and in case of mung bean and lentil flours 10% supplementation level was found acceptable.

The acceptance of high percent of chickpea flour substitution might be due to its low pigmentation and smooth texture as compared to mung bean and lentil. The chapatti prepared with chickpea, mung bean and lentil flour in 20% chickpea flour10% mung bean flour and 10% lentil flour with wheat flour were considered best regarding consumers acceptability.

Current findings exhibited that composite flour comprising of chickpea, mung bean and lentil in combination with wheat flour possess high concentration of certain essential and non-essential amino acids as compared to that of wheat and individual pulse flours. It can be predicted from the results that composite flour possesses better amino acid profile and can provide sufficient quantity to the consumers.

Current findings also revealed that the essential amino acid concentration within pulses' flour especially Lysine that is deficient in wheat is relatively on higher side that proved that these pulses can provide quality protein if included in our diet on regular basis. [28] also recounted high amino acid profile of mung bean flour while evaluating the complementarity of amino acids in cooked pulses/cereal blends. The quantity and quality of protein are both determinants of the adequacy of diets, for meeting protein and amino acid requirements.

The current values for amino acid contents in pulses based composite flours indicated an improved amino acid profile, specially essential amino acid contents as compared to the distribution of some amino acids within the wheat [29] who observed values of Aspartic acid, glutamic acid, within the range of 0.13 to 0.409 and 0.706 to 1.259 g/100g whereas leucine, arginine and histidine that are essential amino acids were predicted in the range of 0.321 to 0.552, 0.118 to 0.895 and from 0.088 to 0.244g/100g. Improved functional properties, nutritional profile, and product quality certainly improved by adding pulses and legumes in traditional flour diets [30], [31], [32].

5. CONCLUSION

Findings of the research confirmed that pulses based composite flour can be effectively utilized in chapatti (flat bread) making. An acceptable level of pulse flours up to 30% provided better nutritional value with comparable rheological behavior and other quality parameters like color, flavor and texture, wheat flour. Since pulses are considered sustainable crops possessing protein with complete amino acid profile, fiber and phytochemicals, hence pulses based composite flour chapattis can provide quality protein to improve protein deficiency among Asian countries.

The study indicated that pulses have higher potential to act as alternative to wheat flour in wheat-based baking products. The study encourages the utilization of pulses flour of chickpea, mung bean and lentil in blended composite flours at commercial level to earn economic benefit and eventually consumers will get more choices.

Further study can be conducted on pulse ingredients to exploit to their full potential for particular functionality or application, understanding the physicochemical, functional and nutritional value of whole pulses as well as its milling fractions, effect of their combination in processing stages and product development.

6. Conflict of Interest

All authors declare no conflict of research.

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