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Bioevaluation of Oilseed Enriched Wheat Chapatties

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ABSTRACT

Chapatties prepared at 10% replacement level with cottonseed, mustard and Sunflower seed flours were fed to albino rats for determination of true digestibility, net protein utilization (NPU), biological value (BV), net protein retention (NPR), protein efficiency ratio (PER) and feed efficiency. It was concluded that higher digestibility value (93.50) was noted for casein diet while the lowest (77.90, 80.40) were found in whole wheat, chapati diets. All the experimental diets were higher than the values of whole wheat, flour and less than the digestibility value for casein. Similarly, the casein diets had the highest NPU value (64.30) whereas whole wheat, chapaties had the lowest (37.59, 43.10) values for NPU. There was an increase in NPU values in all the oilseed enriched chapties as compared to whole wheat chapattis. In enriched chapaties it was highest (51.79) in diets containing peela raya oilseed flour and lowest (45.37) in hysun 33. Whole wheat diets had the lowest (48.24, 53.59) biological values. The BV increased in all the enriched chapati that was higher than whole wheat flour chapati diets and less than casein diet. It was highest in diets containing mustard seeds (peela raya, raya anmol) followed by cottonseeds (CIM, 240, NIAB, 78) and sunflower seeds (hysin, 33; Suncom, 110). An increase in NPR in all the experimental diets was observed as compared to wheat chapati diets that had the lowest NPR of 4.12. NPR of casein diets was 5.45, being the highest among the enriched chapati diets. It was highest (4.91) in raya anmol enriched diet and lowest (4.59) in hysun 33. PER increased in all the enriched chapati diets as compared to whole wheat. Among the enriched chapaties it was highest (1.97) in peela raya diets and lowest (1.51) in hysin 33. The PER was 2.51 in case of casein diet being the highest. The rats consumed significantly lowest (3.89) feed per unit gain in weight on casein diet and the highest (7.16, 7.39) on diets containing whole wheat flour alone. Enrichment of wheat flour with various oilseed flours improved the feed efficiency significantly.

Key Words: Biological evaluation; Enriched; Flour; Nutrition; Chapati

INTRODUCTION

Chapati, the major wheat based food product, is one of the important staple food in the Subcontinent. Unfortunately, lysine is the first limiting amino acid in wheat flour. Tryptophan, threonine and methionine are also low in wheat when compared to the FAO standards (FAO/WHO, 1973). The deficiencies of essential amino acids lead to poor utilization of proteins and thus contribute to the prevalence of malnutrition. Protein deficiency also results in predisposition to parasitic and infectious diseases and general ill-health. The specific maladies such as Kwashiorkor and Marasmus are more prevalent due to protein deficiency. In adults, apart from direct ill-health, protein deficiency results in reduced capacity for physical work. The wheat products deficient in lysine further aggravate the situation due to its losses during baking. The lysine is destroyed more than 10% during baking (Saab *et al.*, 1981).

Protein malnutrition is a serious problem in the developing countries where growing population and lack of agricultural development and productivity result in a limited supply of quality and quantity of protein. The use of inexpensive high protein sources to complement amino acid patterns of cereal based foods are highly recommended to augment the nutritional level of the diet available to a common man. Therefore, enrichment of the staple food i.e. wheat flour with protein rich oilseed flours such as cottonseed, mustard and sunflower may substantially improve the protein content and quality of the diet. However, the commercially available defatted cottonseed, sunflower and mustard flours seem to have an excellent potential for bakery products. The supplementation of non-wheat proteins at high levels adversely affect the rheological properties, reduces loaf volume and gives poor acceptability to breads. In recent years, small amounts of lipid surfactants or dough conditioners, such as sodium stearoyl-2-lactylate and calcium stearoyl-2-lactylate are used to counteract the deleterious effect on the quality of baked product. These help to improve the quality, thereby improving the functional, textural and sensory properties of high-protein products (Serna-Saldivar *et al.*, 1988).

Proteins from oilseeds may help in solving protein deficiency problems to combat the malnutrition prevalence in Pakistan. The use of oilseed flours for preparation of indigenous products such as chapati has not been carried out extensively. Thus, there was a need to explore the possibility of using oilseed protein enriched wheat flour for the production of nutritious chapatti without sacrificing its biological characteristics.

MATERIALS AND METHODS

The proposed study was carried out on the supplementation of wheat flour with different oilseed meals/flours for producing high protein, nutritious and acceptable chapati. The following raw material were used Faisalabad 85 and Chakwal 86 wheat varieties were procured from the Wheat Research Institute, Ayub Agricultural Research Institute, Faisalabad. Flours were prepared by grinding the two wheat varieties through Udy cyclone mills and sieving through 20 mesh sieve. Flours (12% moisture) were packed in separate air tight containers and stored at room temperature until utilized.

The oilseeds (CIM, 240; NIAB, 78; Peela Raya; Raya Anmol; Hysun, 33 & Suncom, 110) were procured from oilseed section, Ayub Agricultural Research Institute, Faisalabad and processed in such a way to get defatted, detoxified and low fibre flours. The oilseed flours were blended with wheat flours at suitable levels for chapati preparation.

Biological studies of different oilseed enriched wheat chapattis were conducted according to the methods described by Miller and Bender (1955) using albino rats. True digestibility, NPU, BV, NPR, PER and feed efficiency of the diets (Table I) were measured through biological assays as described below.

Sixty-four weanling albino rats (21 days) were used for the biological assay of experimental diets. The rats were fed to a stock diet for one week so that they weighed 50-60 g prior to experiment and then randomly divided into 16 groups of four rats each. Each group was weighed (173±2.5 g) and housed separately in metabolic cages. The diets were randomly assigned to experimental groups and were fed *ad libitum* for a period of ten days. The temperature of the animal room was maintained at 30±2°C. Each group of four rats was separately kept in wire screen mesh bottom; underneath each cage meal tray covered with a sheet of filter paper was placed. Composite weight of each group of the rats was recorded daily with electronic top loading balance. At the end of 10 days, the faecal material was collected and brought to a constant weight by drying at 100°C and stored in polyethylene bags for estimation of nitrogen. The spilt food collected from each cage was dried and weighed.

At the end of the experiment, rats were killed by chloroform anesthesia. The skull and abdominal cavities were opened and whole body was dried in an oven at 100°C till to a constant weight. The dried carcass was run through electric grinder and stored for nitrogen determination.

RESULTS AND DISCUSSION

The results regarding sensory evaluation showed that chapatties prepared from wheat flours enriched with to 10% oilseed flours were found to be acceptable by a panel of judges. Therefore, biological evaluation was carried out on chapatties prepared from wheat flour enriched with 10% oilseed flours. The biological assay was carried out on albino rats to study the following biological parameters.

True digestibility, net protein utilization, biological value, net protein retention, protein efficiency ratio, feed efficiency were determined as under.

The reference diet casein (O) excelled in true digestibility, net protein utilization, biological value, net protein ratio, protein efficiency ratio and feed efficiency ratio as compared to all other experimental diets (Table I).

The results indicated that TD differed significantly ($P<0.01$) by the differences in experimental diets, however, differences between crop years were observed to be non-significant (Table II).

The results for true digestibility of different oilseed enriched wheat flours (Table II) ranged between 77.90-93.50%. The true digestibility among the wheat flours enriched with different oilseed flours differed significantly and was found to be significantly higher in the experimental diet I (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Peela Raya) while it was significantly the lowest in experimental diet M (Flour of Wheat Variety Faisalabad,-85 with out Supplementation). The true digestibility was found to be higher in experimental diets C (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Peela Raya), I (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Peela Raya) and J (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Raya Anmol) but was found to be non-significantly different among the diets. The experimental diets A (Flour of Wheat Variety Faisalabad,-85 Supplemented with Cotton Variety CIM, 240), B (Flour of Wheat Variety Faisalabad,-85 Supplemented with Cotton Variety NIAB, 78), D (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Raya Anmol), G (Flour of Wheat Variety Chakwal,-86 Supplemented with Cotton Seed Variety CIM, 240) and L (Flour of Wheat Variety Chakwal,-86 Supplemented with Sunflower Variety Suncom, 110) were also statistically at par with each other for true digestibility.

The true digestibility was observed to be significantly ($P<0.01$) higher in experimental diets of wheat flour enriched flour than the diets of un-enriched wheat flours. The differences in true digestibility between the diets containing un-supplemented wheat flour of wheat variety Faisalabad,-85 (M) and Chakwal,-86 (N) was also found to be significant. Hence, it may be concluded from the results that supplementation of oilseed flours in wheat flours significantly improved the true digestibility of the diets.

The TD of chapatties of wheat flour enriched with oilseed flours ranged from 81.47 to 85.16% while in un-enriched wheat flour diets yielded true digestibility 77.90% and 80.40% for Faisalabad,-85 (M) and Chakwal,-86 (N) wheat varieties, respectively.

The TD of Saudi breads has been reported maximum

Table I. Composition of experimental diets

Diets	Specifications*	Proportion	Ingredients							Total (g)	Crude protein (%)
			Flour (g)	Corn starch (g)	Corn oil (g)	Glucose (g)	Mineral mixture (g)	Vit.mixture (g)	Casein (g)		
A	CSF_1+F_1	10+90	58.99	21.01	5.00	5.00	5.00	5.00	-	100.00	10
B	CSF_2F_1	10+90	63.09	16.91	5.00	5.00	5.00	5.00	-	100.00	10
C	MSF_1+F_1	10+90	63.17	16.83	5.00	5.00	5.00	5.00	-	100.00	10
D	MSF_2F_1	10+90	61.31	18.69	5.00	5.00	5.00	5.00	-	100.00	10
E	SSF_1+F_1	10+90	65.48	14.52	5.00	5.00	5.00	5.00	-	100.00	10
F	SSF_2+F_1	10+90	65.01	14.99	5.00	5.00	5.00	5.00	-	100.00	10
G	CSF_1+F_2	10+90	60.49	19.51	5.00	5.00	5.00	5.00	-	100.00	10
H	CSF_2+F_2	10+90	61.69	18.31	5.00	5.00	5.00	5.00	-	100.00	10
I	MSF_1+F_2	10+90	59.88	20.12	5.00	5.00	5.00	5.00	-	100.00	10
J	MSF_2+F_2	10+90	60.42	19.58	5.00	5.00	5.00	5.00	-	100.00	10
K	SSF1+F_2	10+90	64.43	15.5	5.00	5.00	5.00	5.00	-	100.00	10
L	SSF_2+F_2	10+90	63.89	16.11	5.00	5.00	5.00	5.00	-	100.00	10
M	F_1	100	78.55	01.45	5.00	5.00	5.00	5.00	-	100.00	10
N	F_2	100	80.38	00.62	5.00	5.00	5.00	5.00	-	100.00	10
O	Casein	--	-	67.52	5.00	5.00	5.00	5.00	12.50	100.00	10
P	Protein free	--	-	80.00	5.00	5.00	5.00	5.00	-	100.00	0.04

*CSF_1+F_1 = CIM240+Faisalabad85, CSF_2F_1 = NIAB78+Faisalabad85, MSF_1+F_1= Peela Raya+Faisalabad85, MSF_2+F_1= Raya Anmol+Faisalabad85, SSF_1+F_1= Hysun33+Faisalabad85, SSF_2+F_1= Suncom110+Faisalabad85, CSF_1+F_2=CIM240+Chakwal86, CSF_2+F_2=NIAB78+Chakwal86, MSF_1+F_2= Peela Raya+Chakwal86, MSF_2+F_2= Raya Anmol+Chakwal86, SSF_1+F_2=Hysun33+Chakwal86, SSF_2+F_2=Suncom110+Chakwal86, F_1= Wheat flour (Faisalabad85), F_2=Wheat flour (Chakwal86).

Table II. Biological parameter of different experimental diets

Diets	Specifications	Proportion	Biological parameters					
			True digestibility	Net protein utilization	Biological value	Net protein retention	Protein efficiency ratio	Feed efficiency
A	CSF1+F1	10+90	83.23efg	47.07de	56.54e	4.67cde	1.57ef	5.62f
B	CSF2+F1	10+90	83.70ef	46.99de	56.13e	4.74be	1.54f	6.28cd
C	MSF1+F1	10+90	84.91bcd	50.76bc	59.76bc	4.90bc	1.94b	5.53f
D	MSF2+F1	10+90	84.07cde	49.34cd	58.67cd	4.81be	1.83c	5.97e
E	SSF1+F1	10+90	81.47i	45.37e	55.67e	4.59ef	1.49fg	6.96b
F	SSF2+F1	10+90	82.13hi	46.07e	56.08e	4.65de	1.51fg	6.50c
G	CSF1+F1	10+90	83.97de	49.23cd	58.61cd	4.78be	1.71d	6.40c
H	CSF2+F1	10+90	82.92fgh	47.29de	57.02de	4.75be	1.62e	6.49c
I	MSF1+F1	10+90	85.16b	51.79b	60.80b	4.83bcd	1.97b	5.98e
J	MSF2+F1	10+90	85.02bc	51.49bc	60.55b	4.91b	1.85c	5.65f
K	SSF1+F1	10+90	82.42ghi	46.97de	56.97de	4.73be	1.50fg	5.96e
L	SSF2+F1	10+90	83.05eh	47.00ed	56.58e	4.69be	1.52f	6.13de
M	Wheat flour F1	0+100	77.90k	37.59g	48.24g	4.12g	1.42h	7.16ab
N	Wheat flour F2	0+100	80.40j	43.10f	53.59f	4.43f	1.45gh	7.39a
O	Casein	-	93.50a	64.30a	68.80a	5.45a	2.51a	3.89g
P	Non-protein	-	-	-	-	-	-	2.96h

Means is a column sharing same letters are statistically non-significant (P>0.01)

of 89.7% in the diets containing sorghum protein in the blends (Nnam, 2004). Siddique *et al.* (1996) reported an improvement in biological value of whole wheat flour supplemented with chickpea flour for chapati making. The present results are contrary to the findings of Burque *et al.* (1979) who found a decrease in true digestibility when wheat flour was supplemented with 4% detoxified cottonseed flour for chapatties. However, in the present case cottonseed flour supplementation in wheat flour improved true digestibility. The differences in true digestibility value in the present studies as compared to other studies may be due to the differences in the level of protein concentration as well as the differences in method of experimental diets preparation.

The mean values for net protein utilization of different oilseed flour enriched wheat flour are given in Table II. The NPU of oilseed enriched wheat flours ranged from 45.37 to 51.79% while in un-enriched wheat flour diets, NPU was found to be 37.59 and 43.10% for wheat variety Faisalabad,-85 (M) and Chakwal,-86 (N), respectively.

It has been reported by Siddique *et al.* (1996) that an increase in NPU was observed in supplemented chapatties prepared with chickpea flour of whole wheat flour Barque *et al.* (1979) observed 70.03 and 40.65% NPU for casein and cottonseed flour enriched diets, respectively. These results were further supported by the findings of Anwar (1980) and Ilahi (1978) who estimated 48.16, 48.0, 44.25 and 43.0% NPU values for wheat flours. In the present research findings it was observed that an increase in NPU occurred as a result of enrichment of whole-wheat flour with different oilseed flours. This increase may be associated with the increase in protein contents of enriched chapattis, which ultimately increased the lysine contents of the end product.

The mean values for BV of different experimental diets ranged between 48.24-68.80% (Table II). The BV differed significantly in different diets supplemented with oilseed flours. The highest BV was found in diet I and the lowest in the diet M. The differences among experimental diets C (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Peela Raya), I (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Peela Raya) and J (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Raya Anmol) were found to be non-significant. The differences among experimental diets A (Flour of Wheat Variety Faisalabad,-85 Supplemented with Cottonseed Variety (CIM, 240), B (Flour of Wheat Variety Faisalabad,-85 Supplemented with Cottonseed Variety (NIAB, 78), D (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Raya anmol), G (Flour of Wheat Variety Chakwal,-86 Supplemented with Cotton Variety CIM, 240), K (Flour of Wheat Variety Faisalabad,-85 Supplemented with Sunflower Seed Variety Hysun, 33) and L (Flour of Wheat Variety Chakwal,-86 Supplemented with Suncom, 110) were also found to be non-significant. The BV was higher in experimental diets enriched of oilseed wheat flours than the flours having no supplementation. The differences in BV between the diets containing un-supplemented wheat flours of wheat variety Faisalabad,-85 (M) and Chakwal,-86 (N) were also found to be significant.

The BV of wheat flour enriched with different oilseed flours ranged between 55.67-60.80% while in un-enriched wheat flour diets, BV was found 48.24 and 53.59% for Faisalabad,-85 (M) and Chakwal,-86 (N), respectively.

The results on BV showed that there was a significant increase in the BV of wheat flours when enriched with any oilseed flour whereas it was observed to be the highest when wheat flour enriched with mustard seed flour. An improvement in BV of chapatti, was also observed by Siddique *et al.* (1996) who supplemented chapati with chickpea flour. The present results agreed with the findings of Anwar (1980) and Kausar (1976) who reported biological value for wheat flour as 56, 92, 56, 50, 67 and 63% respectively, whereas Burque *et al.* (1979) and Saeed (1972) observed lower value of 52, 51 and 52%. The differences may be due to wheat variety, age and sex of test animals, the protein intake and the differences in the duration of the experimental periods. The BV of all the oilseed enriched wheat flour diets was higher as compared to diets containing un-enriched wheat flour indicating an improvement in wheat protein due to oilseed protein enrichment in wheat flour. The improvement in biological value supports the assumption that the pattern of limiting amino acids in wheat flour was improved as a result of enrichment with oilseed flours.

The mean values for net protein retention of different oilseed enriched wheat flours are given in Table II. The NPR ranged between 4.12-5.45 among different experimental diets. The NPR of oilseed enriched wheat flours ranged from 4.59 to 4.91 while in un-enriched wheat flour diets, net protein retention was found to be 4.12 and 4.43 for wheat variety Faisalabad,-85 (M) and Chakwal,-86 (N), respectively.

A significant difference was observed among the experimental diets prepared flour different wheat flours enriched with different oilseed flours. The NPR was the highest in the experimental diet J (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Raya Anmol) followed by C (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Peela Raya) and I (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Peela Raya) and the lowest was in experimental diet M (Flour of Wheat Variety Faisalabad-85 with out Supplementation). The differences among all the oilseed flour supplemented diets were non-significant except the experimental diets A (Flour of Wheat Variety Faisalabad-85 Supplemented with Cottonseed Variety (CIM, 240), E (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Peela Raya) and F (Flour of Wheat Variety Faisalabad,-85 Supplemented with Sunflower Variety Suncom, 110).

The differences in NPR between the un-supplemented diets containing wheat flour of wheat variety Faisalabad,-85 (M) and Chakwal-86 (N) were found to be significant ($P<0.01$).

The results revealed that there was a significant increase in NPR values of wheat flour diets when enriched with oilseed flour at 10% level of supplementation. Various research workers have reported (Rawat *et al.,* 1994) that oilseed flour addition enhanced the nutritional level of supplemented diets when added at different level in the wheat flour. The present research findings are in close agreement with these studies reported by Siddique *et al.* (1996) and Rawat *et al.* (1994) for nutritional evaluation of blended chapatti flour.

The PER of different oilseed enriched wheat flours are given in (Table II). The PER ranged between 1.42-2.51 among different experimental diets. The PER of wheat flour enriched with oilseed flours ranged between 1.50-1.97 while in un-enriched wheat flour diets, protein efficiency ratio was 1.42 and 1.45 for wheat variety Faisalabad-85 (M) and Chakwal-86 (N), respectively.

A significant difference was observed among the experimental diets prepared with flour of different wheat varieties enriched with different oilseed flours. The PER was significantly higher in the experimental diet I (Flour of Wheat Variety Chakwal,-86 Supplemented with Mustard Seed Variety Peela Raya) followed by C (Flour of Wheat Variety Faisalabad,-85 Supplemented with Mustard Seed Variety Peela Raya) and J (Flour of Wheat Variety Faisalabad-85 Supplemented with Mustard Seed Variety Raya Anmol). The differences between the diets I and C were non-significant. The PER was significantly lower in experimental diet M (Flour of Wheat Variety Faisalabad,-85 without Supplementation). The experimental diets A (Flour of Wheat Variety Faisalabad-85 Supplemented with Cottonseed Variety CIM 240), B (Flour of Wheat Variety Faisalabad,-85 Supplemented with Cotton Variety NIAB

78), E (Flour of Wheat Variety Faisalabad-85 Supplemented with Sunflower Seed Variety Hysun 33), F (Flour of Wheat Variety Faisalabad-85 Supplemented with Sunflower Variety Suncom, 110), K (Flour of wheat Variety Faisalabad-85 Supplemented with Sunflower Variety Hysun 33) and L (Flour of Wheat Variety Chakwal-86 Supplemented with Suncom 110) were found to be statistically at par with respect to PER. However, PER was higher in experimental diets containing oilseed enriched flours in wheat flours than the wheat flours having no enrichment. The differences in protein efficiency ratio between the un-supplemented diets containing wheat flour of wheat variety Faisalabad-85 (M) and Chakwal-86 (N) was also found to be significant ($P<0.01$).

The results revealed that there was a significant increase in the PER of the wheat flours when enriched with any oilseed flour.

The results also showed that the enrichment of whole wheat flour with different oilseed flours had significant effect on the PER. In a former study, Faridi *et al.* (1983) reported a PER of 1.61 for bread and 1.99 for whole-wheat flour respectively. Effect of soy-fortification on nutritional quality of chapatti was evaluated by Rawat *et al.* (1994) who reported an increase in PER of soy-meal fortified chapatties from 1.3 to 1.7 and increased in vitro protein digestibility from 71.3 to 73.1%. Similarly, Siddique *et al.* (1996) observed significant improvement in PER of chickpea flour supplemented chapatti. The differences in PER observed during this study may be due to the difference in baking, variety and agronomic factors. Improvement in PER of whole-wheat flour due to oilseed flour enrichment is also in agreement with these findings.

The feed efficiency was affected significantly by the experimental diets. The mean feed efficiency values of oilseed flour enriched wheat flour (Table II) revealed that it differed significantly for feed efficiency. The FE of diets enriched with CIM, 240 (A) and Raya Anmol (J) also did not differ significantly with each other. The lowest FE was exhibited by non-protein (P) followed by the casein diet (O). The FE between wheat flour diets enriched with NIAB, 78 (B) and CIM, 240 (G) did not differ significantly.

The FE of all oilseed enriched wheat flour diets ranged between 5.53-6.96, respectively while, that of whole-wheat chapatti diets were 7.16 to 7.39. The feed efficiency of the diet containing casein was 3.89.

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