IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Research Article
March 2021 Vol.:18, Issue:1

Effect of Soy-Sorghum Fortification on Sensory and Nutritional Characteristics of Unleavened Wheat Bread (*Chapattis*)

IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

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Submitted: 12 February 2021
Revised: 03 March 2021
Accepted: 22 March 2021

HUMAN JOURNALS

www.ijsrm.humanjournals.com

Keywords: Unleavened wheat bread, *Chapatti,* organoleptic nutritional

ABSTRACT

The present research on undertaken to study the effect of soy and sorghum fortification with wheat flour on nutritional and sensory attributes of nutritious chapatti. Chapatti prepared using 100% wheat flour served as control. Soy *dhal* was pretreated with 4 salt solutions viz. sodium carbonate (Type I), sodium bicarbonate (Type II), sodium tripolyphosphate (Type III), and sodium chloride (Type IV). Two types of blends were prepared from wheat, soy (4 salt-treated) and sorghum in two different proportions viz., 'A' wheat flour: soy flour: sorghum flour (75:15:10) and 'B' wheat flour: soy flour: sorghum flour (85:10:05). Based on sensory evaluation scores, Type I treated soydhal was selected for further study. *Chapattis* were prepared using two blends of wheat, soybean, and sorghum, to improve their nutritional quality. The chapatti prepared from wheat flour served as control chapatti. The sensory evaluation of the *Chapattis* revealed that their overall acceptability by the judges was 'liked moderately'. The incorporation of soy and sorghum flour to wheat significantly increased the protein and ash contents by 16 and 28 percent, respectively. The sugar content of the developed *Chapatti* was at par with the control. Simple dough making and roasting involved in *Chapatti* making significantly decreased the phytic acid(20%) and polyphenol (65%) contents of developed *Chapatti* over the unprocessed composite flour. As a result, *in vitro* protein and starch digestibility of *Chapatti* improved significantly by 7 and 28 percent, respectively over the unprocessed composite flour.

INTRODUCTION:

*Chapattis (*unleavened bread), the staple food for the majority of the Indians, is prepared mainly from wheat flour. *Roti* or *Chapatti* is the unleavened tortilla type round pancake made by the traditional method. It is generally consumed as a part of the main course meal throughout the day. The majority of Indians depend on wheat mainly for fulfilling their energy needs and partly for protein needs. But protein content is low in wheat and the problem of malnutrition which is quite prevalent in India is due to dependence on wheat (Hussain, 2004). Sorghum (Jowar) is considered an important staple nutritious cereal grain. It is most commonly used in the form of *roti, Chapatti,* or *bhakari.* However, sorghum alone is not a good source of nutritionally balanced protein. The protein content of sorghum varies from 6 to 12 percent and the range of its PER is quite low i.e., from 0.5 to 1.8 (Hoseney et al., 1981). Soybean with 40 percent protein and 20 percent oil is one of the cheapest sources of protein and fat. However, soybean has not gained a significant place in the diet of rural people in India due to its extraordinary beany flavor and prolonged cooking time. The supplementation of wheat-based diets with soybean and sorghum can help in enhancing the nutritional quality of *chapatti* by improving the quality and quantity of protein. Besides, salt treatments, as used in the present study help to reduce the beany flavor as well as the cooking time of soybean as reported by Khetarpaul et al. (2004).

Sorghum flour also serves as a supplement to soy diets in various products like *pakora, murukku, roti, laddu, unpaved, pattu, sevai* (Jayalakshmi and Neelakantan, 1987). The combination of sorghum with legume forms a potentially good source of protein. It was observed that when children were fed the sorghum-legume blend daily, for more than a year, they showed no sign of any deficiency and grew well (Hoseney *et al.*, 1981).

Some work has been done on the nutritional and textural qualities of *Chapattis* made from a combination of soy, peanut, and cottonseed flour (Bhat and Vivian, 1980) and wheat, Bengal gram, and soybean (Kaur and Hira, 1988). But not much work has been done on *chapatti* prepared from wheat soy and sorghum flour. Hence, the present study was conducted to evaluate the sensory evaluation and nutritional quality of the developed *Chapatti* from wheat-soy-sorghum flour.

MATERIALS AND METHODS:

MATERIALS:

Soybean variety PK 416 was procured from the Department of Plant Breeding, CCS Haryana Agricultural University, Hisar. Whole wheat flour and sorghum were purchased from the market of Hisar city. Sorghum was cleaned of stones and straws and ground to pass through a 0.5 mm mesh sieve.

METHODS:

Processing of soybean

The whole soybean was blanched in boiling water for 10 min and then dipped in cold water immediately. Husk was removed manually by rubbing the seeds. The soy *dhal* thus obtained was dried in an oven at 60° ± 2°C till constant weight was achieved.

Presoaking treatments in salt solutions

Soy *dhal* was given pretreatments with 4 salt solutions (Khetarpaul et al.,2004) namely sodium carbonate, sodium bicarbonate, sodium tripolyphosphate, and sodium chloride (0.75% for 6 hrs). This *dhal* was ground to a fine flour and further used in combination with wheat and sorghum for the development of *Chapatti*.

Preparation of unleavened bread (chapatti)

Chapatti was prepared using wheat, soy, and sorghum flour, using the conventional method (Rawat, 1990). Two types of *Chapattis* were prepared using different proportions of wheat flour, various salt-treated soy flour, and sorghum flour as given below.

Type I/II/III/IV *Chapatti*

	A	B
Wheat flour	75 g	85 g
Soy flour	15 g	10 g
Sorghum flour	10 g	5 g

Type I	Sodium carbonate treated soy *dhal*
Type II	Sodium bicarbonate treated soy *dhal*
Type III	Sodium chloride treated with soy *dhal*
Type IV	Sodium tripolyphosphate treated soy *dhal*

Sensory evaluation

The control and developed *Chapattis* were evaluated organoleptically using the 9-point hedonic scale as per the method given by ISI (1971) and Swaminathan (1987). The rating scale used was: 9 = Very desirable, 8 = Desirable, 7 = Moderately desirable, 6 = Slightly desirable, 5 = Neither like nor dislike, 4 = Slightly undesirable, 3 == Moderately undesirable, 2 = Undesirable, 1 = Very undesirable. According to this method, 10 judges comprising scientists of Deptt. of Foods & Nutrition were selected as they were accustomed to soy *dhal* intake in their diets as well as the organoleptic hedonic scale used in the present study. Each judge was served different types of *Chapattis* (unleavened bread) without telling them about various salt treatments. They were asked to give scores for color, appearance, flavor, texture, and taste as per their senses. They were provided with water and requested to wash their mouth after tasting each product. The overall acceptability was the mean of all the organoleptic characteristics.

Nutritional analysis

The best accepted *Chapatti* having the highest score was further selected for nutritional evaluation.

The selected developed *chapati*, as well as control chapati, were dried in an oven at 60°C ± 2°C till constant weight was achieved. After drying, the samples were ground to a fine powder and analyzed for the following parameters:

a) Proximate nutrients

Moisture, crude protein, fat, ash, and crude fiber contents of raw flour as well as *chapati* were estimated using the standard method of analysis (AOAC, 1990).

b) Carbohydrate profile

Sugar content

Total soluble sugars, reducing sugar and non-reducing sugar contents were determined by the method of Hulme and Narain (1931).

c) Antinutrients

Phytic acid and polyphenol contents were determined using the method of Davies and Reid (1979) and Singh and Jambunathan (1981), respectively.

d) *In-vitro* protein and starch digestibility

In vitro protein and starch, digestibility was estimated by the modified method of Mertz et al. (1983) and Singh et al. (1982), respectively.

Statistical analysis

The relevant data were subjected to statistical analysis for calculation of mean and standard error. The data were analyzed in a complete randomized design for analysis of variance (Panse and Sukhatme, 1961). For testing the significance of the difference between two sample means, the 't' test was used as per the standard method of Snedecor and Cochran (1967).

RESULTS AND DISCUSSION:

Sensory evaluation of *Chapatti*

The results in Table 1 reveal the sensory scores of control *Chapatti* prepared from wheat flour and nutritious *chapatti* prepared using wheat + soy + sorghum flour.

In Type I *Chapatti*, the color and appearance of the nutritious *Chapatti* were found to fall in the "liked moderately" category and the sensory scores differed non-significantly over the control *Chapatti*. However, the flavor of A and B type *Chapattis* was "liked slightly" by the judges, which might be because of the sodium carbonate treatment given to soy dhal. Similar results were reported earlier (Singh and Rao, 1995) indicating that the soaking of pigeon pea in a 1%

solution of sodium carbonate adversely affected the color, flavor, and taste. A non-significant difference was found in the texture and overall acceptability of control and developed *Chapatti*.

In Type II *Chapatti*, the color and appearance of A and B *Chapatti* differed non-significantly as compared to control *Chapatti*. However, a significant decrease in the flavor, texture, taste, and overall acceptability of the developed *Chapatti* was found over the control *Chapatti.*

In Type III *Chapatti*, no significant difference was found in the color and texture as compared to the control one. The appearance of the A and B type *Chapatti* was "liked moderately" by the judges. However, the flavor and taste were "liked slightly" by the panelists. As a result, the overall acceptability scores of the developed *Chapatti* decreased significantly.

In Type IV *Chapatti*, the color and appearance differed non-significantly over the control one, however, the scores were slightly less. The scores for flavor, texture, taste, and overall acceptability of the developed *Chapatti* decreased significantly when compared with control *Chapatti*. The taste of the developed *Chapatti* was "neither liked nor disliked" by the judges.

Overall, all four types of *Chapattis* were found to be acceptable. Type III *Chapatti* i.e. sodium chloride treated soy dhal + wheat + sorghum *Chapatti* (both A and B) had equal scores for overall acceptability. So, Type A *Chapatti* having a higher proportion of soy (15) and sorghum (10) mixed with wheat flour (75) was finally selected for nutritional evaluation.

Similar results were reported earlier by workers using different combinations of wheat, soy, or sorghum. No significant difference in the preference between *Chapatti* prepared by using pure wheat flour and the blended flour containing 20 percent defatted soy flour was observed (Rathod and Williams, 1973). *Chapatti* prepared, using sorghum: soy blends (85:15 and 70:30) was acceptable but further increase in the level of sorghum decreased the organoleptic scores (Jayalakshmi and Neelakantan, 1987).

Nutritional evaluation

The results presented in sensory evaluation of *Chapattis* given in Table 1 revealed that all the four salt-treated *Chapattis* were acceptable to the judges. So, Type I (*Chapatti* A) having the highest score was evaluated nutritionally.

Proximate composition of flours and *Chapattis*

The proximate composition of wheat, soy, and sorghum flour has been presented in Table 2. Wheat flour contained 12.11 percent moisture, which was significantly higher than soy flour. On the other hand, protein (33.8 g), fat (23.4 g), ash (5.1 g) and crude fiber (3.9 g) contents were significantly higher in unprocessed soy flour as compared to those of wheat and sorghum. Comparison of wheat and sorghum flour revealed that protein, ash and crude fiber contents were higher in wheat flour, however, the differences were non-significant. Similar values for protein, fat, and ash contents of sorghum and soybean have been reported (Jayalakshmi and Neelakantan, 1987).

The composite flour containing wheat, soy, and sorghum in proportion (75:15:10) had 11.63 percent moisture and a significant increase in moisture content was found in *Chapatti* using the same flour. The increase in moisture content was due to the addition of water while making the dough. The protein content of the *Chapatti* increased by 16.25 percent as compared to unprocessed composite flour. Non-significant change in fat and crude fiber content of the developed *Chapatti* was found over the unprocessed flour. However, ash content increased significantly by 28 percent ($P<0.05$) as compared to unprocessed composite flour. These findings are in agreement with other studies wherein an improvement in the moisture, protein, and ash content of *Chapatti* prepared with incorporation of soy flour with wheat flour was observed (Kaur and Hira, 1988; Rawat et al., 1994).

Sugar content (Total soluble, reducing, and non-reducing sugars) of flours and *Chapatti*

Results in Table 3 reveal that total soluble sugar ranged between 2.55 to 6.39 percent in unprocessed flours of wheat, soy, and sorghum; soy flour had the highest amount (6.39) followed by wheat flour (4.17) and sorghum flour (2.55). As a result, the non-reducing sugar content was the highest in soy flour. No significant difference was found in the reducing sugar contents of all three flours. The results showed that the total soluble sugar content of soy, wheat, and sorghum was more than 2.5% and a major part was represented by non-reducing sugar, whereas, reducing sugars were present in traces. These findings are consistent with those reported earlier in wheat (Kumari, 1995), soybean (Duhan, 1994), and sorghum ((Sangwan, 2002). However, lower values of total soluble, reducing, and non-reducing sugar content of soybean varieties have also been reported (Foda et al., 1984).

Total soluble sugar and reducing sugar contents of the unprocessed composite flour and developed *Chapatti* were 4.34 and 4.50 percent and 0.53 and 0.63 percent, respectively; the values of total soluble and reducing sugars in developed *Chapatti* were slightly higher than that of the control, however, the differences were non-significant. The increase in sugar content of developed *Chapattis* might be due to the roasting of *chapatti* as well as the higher value of sugar in soybean. Similar results have been reported by Dogra et al. (2001) who observed an increased amount of sugar during the roasting of soybean. The increase in sugar content due to roasting might be attributed to the hydrolysis of starch into oligosaccharides and monosaccharides.

Antinutrients of flours and *Chapatti*

Results in Table 4 reveal the antinutrients in raw flours of wheat, soy, sorghum, and also the unprocessed composite flour and developed *Chapatti* in which wheat, soy, and sorghum were incorporated in 75:15:10 proportions. Soy flour contained significantly higher (1494.72 mg/100 g) phytic acid content as compared to wheat and sorghum flour. The phytic acid content was the lowest (518.75 mg/100 g) in sorghum flour. Polyphenol content was the highest in soy flour, followed by wheat and sorghum flour. Similar findings have been observed for wheat (Jood, 1990), soy (Duhan, 1994), and sorghum (Sangwan, 2002).

The phytic acid content of the unprocessed composite flour and *Chapatti* prepared by using unprocessed composite flour was 744.96 and 565.95 mg/100 g, respectively (Table 4). A significant decrease (20.03%) in the phytic acid content of the developed *Chapatti* was found over the unprocessed composite flour. Roasting and baking of the *Chapattis* reduced the phytic acid and polyphenol contents of the *Chapattis.* A similar effect of roasting and baking of the *Chapatti* on antinutritional content was reported earlier (Rawat et al., 1994; Dogra et al., 2001). The apparent decrease in phytic acid content observed due to the roasting of *Chapatti* may be attributed to the formation of insoluble complexes between phytic acid and other components (Kumar et al., 1978).

The polyphenol content of the developed *Chapatti* decreased significantly by 65.42 percent as compared to unprocessed composite flour. The apparent decrease in polyphenol during cooking is most likely due to the change in their solubility or chemical reactivity (Ayyagari et al., 1989). The reduction in polyphenol content may also be due to the binding of polyphenols with other organic substances and protein or from alterations in the chemical structure of polyphenols that cannot be determined by available chemical methods (Reddy et al., 1985). A similar effect of cooking on polyphenol content was reported earlier in moth bean (Laurena et al., 1987), peas (Bishnoi et al., 1994), and Nigerian seed legume (Adewusi and Falade, 1996).

In-vitro* protein and starch digestibility of flours and *Chapatti

Protein digestibility (*in vitro*) of flours of wheat, soy, and sorghum ranged between 60.42 to 71.17 g/100 g, being the lowest in soy flour and the highest in wheat flour (Table 5). The protein digestibility (*in vitro*) of unprocessed composite flour was 68.62 g/100 g and a significant improvement (7.23%) in protein digestibility of the developed *Chapatti* (73.58 g/100 g) was found. Improvement in protein digestibility (*in vitro*) of *Chapatti* might be due to a significant reduction in phytic acid and polyphenol contents which adversely affects protein digestibility (Tan et al., 1984; Kadam et al., 1986). Besides, an increase in protein digestibility during heat processing occurs due to the opening of protein structure through denaturation leading to increased accessibility of the protein to enzymatic attack (El-Faki et al., 1984; Wu et al., 1994) and structural disintegration of enzyme inhibitors (Vijayakumari et al., 1995). Reduction in antinutritional factors like phytate and tannins as found in the present study (Table 4), may also be responsible for increased protein digestibility. Srivastav et al. (1990) reported that the roasting process significantly improved *in vitro* protein digestibility of roasted and ground Bengal gram, maize, and soybean. Rawat et al. (1994) reported higher *in vitro* digestibility of soy-fortified *Chapattis* which was slightly greater than that observed for whole wheat *Chapattis* (71.3%). Protein digestibility of whole wheat flour, soy flour, wheat soy blends, and the sorghum-soy blend was 77.20, 85.72, 80.02, and 76.60 percent, respectively (Lindell and Walker, 1984). The higher values of wheat-soy blends and sorghum-soy blend might be because of the higher *in vitro* protein digestibility of wheat and soy flour used in their study.

Starch digestibility (*in vitro*) expressed as mg maltose released/g of raw ingredients viz. wheat, soy and sorghum used in the present study was found to be 33.29, 24.33 and 34.72, respectively (Table 5).

The comparison of starch digestibility of unprocessed composite flour and developed *Chapattis* revealed a significant ($P<0.05$) improvement which was 28.17 percent. An increase in starch digestibility as a result of cooking may be attributed to loss of heat-labile antinutrients and inhibitors like phytates and tannins (Table 4) leading to improved starch digestibility. Besides, heat processing might have resulted in the rupture of starch granules followed by its hydrolysis enhancing the amylolytic process, thereby increasing the starch digestibility (Chowdhary, 1993).

The enhancement in starch digestibility due to heat treatments has also been reported by other workers in amphidiploids of black gram and mungbean parents (Kataria et al., 1992) and moth bean (Bravo et al., 1998; Negi, 1999).

CONCLUSION:

From the results of the present study, it can be concluded that blending of soy and sorghum along with wheat flour can be done easily for the preparation of *Chapattis*. No extra efforts or time is needed for preparing such *Chapattis* and these are nutritionally superior having lower amounts of antinutrients viz. phytic acid and polyphenols and significantly higher digestibility of protein and starch. This supplementation may help in overcoming the problem of malnutrition among the most vulnerable sections of society.

ACKNOWLEDGEMENT:

The authors thank ICAR for financial support under the National Agricultural Technological Project scheme to CCS Haryana Agricultural University, Hisar, India for researching "Enhancing utilization of soybean through the development of value-added food products".

REFERENCES:

1. Adewusi, S.R.A., and Falade, O.S.(1996). The effect of cooking on the extractability, tannin, phytate, sugar and mineral solubility. *Journal of Food Science Technology Alimentos*, 2(4), 231-239.
2. AOAC. (1990). Official Methods of Analysis of the Association of Official Analytical Chemists. Arlington, Virginia, USA, 2,15-22.

3. Ayyagari, R., Narsingh Rao, B.S., and Roy, N. (1989). Lectins, trypsin inhibitors, BOAA and tannins in legumes and cereals and the effect of processing. *Food Chemistry*, 14, 229-238.
4. Bhat, C.M., and Vivian, V.M. (1980). Effect of incorporation of soy, peanut and cottonseed flours on the acceptability and protein quality of Chapattis. *Journal of Food Science and Technology*, 17(4), 168-171.
5. Bishnoi, S., Khetarpaul, N., and Yadav, R.K. (1994). Effect of domestic processing and cooking methods on phytic acid and polyphenols content of pea cultivars. *Plant Foods for Human Nutrition*, 45, 381-388.
6. Bravo, L., Siddhuraju, P., and Calixto, F.S. (1998). Effect of various processing methods on the in vitro starch digestibility and resistant starch content of Indian pulses. *Journal of Agricultural Food Chemistry,* 46, 4667-4674.
7. Chowdhary, S. (1993). Preparation and nutritional evaluation of some traditional foods from pearl millet. M.Sc. Thesis. CCSHAU, Hisar, India.
8. Davies, N.T. and Reid, H. (1979). An evaluation of phytate, zinc, copper, iron and manganese contents and zinc availability from soy-based textured vegetable protein meat substitutes or meat extenders. *British Journal of Nutrition,* 41, 579-589.
9. Dogra, J., Dhaliwal, Y.S. and Kalia, M. (2001). Effect of soaking, germination, heating and roasting on the chemical composition and nutritional quality of soybean and its utilization in various Indian leavened products. *Journal of Food Science and Technology*, 38(5), 453-457.
10. Duhan, R. (1994). Nutritional and sensory evaluation of some traditional food products developed from soybean. M.Sc. Thesis. CCSHAU, Hisar, India.
11. El-Faki, H.A., Venkataraman, L.U. and Desikacher, H.S.R. (1984). Effect of processing on the in vitro digestibility of protein and carbohydrates in some Indian legumes. *Plant Foods for Human Nutrition*, 34, 127-133.
12. Foda, Y.H., Allam, M.H., Mohmod, R.M. and El. Shotanovi, G.A. (1984). Studies on some chemical and nutritional properties of soybean seeds. *Annals of Agricultural Sciences*, 29, 299.
13. Hoseney, R.C., Varriano, M.E. and Dendy, D.A.V. (1981). Sorghum and the millets. P 71. In Y.Pomeranz (Eds.), Advances in cereal science and technology. Vo. IV. Am. Assoc. Cereal Chemists, Inc; St. Paul, MN.
14. Hulme, A.C. and Narain, R. (1931). The ferricyanide method for determination of reducing sugars. A modification Hagedom Jensen Hones technique. *Biochemical Journal*, 25, 1051-1061.
15. Hussian, S. (2004). Biochemical and technological properties of flaxseed supplemented wheat flour. M.Sc.Thesis National Institute of Food Science & Technology, University of Agriculture, Pakistan.
16. ISI. (1971). Guide for sensory evaluation of foods. (IS:6723 Part-II). Indian Standards Institution, Manak Bhawan, New Delhi.
17. Jayalakshmi, N. and Neelakantan, S. (1987). Studies on the acceptability of sorghum-soy blends in South Indian dishes and their keeping quality. *The Indian Journal of Nutrition and Dietetics*, 4,136-141.
18. Jood, S. (1990). Studies on nutritional quality of wheat, maize and sorghum as affected by infestation of Trichoderma, granarium and Rhizopertha dominica. Ph.D. Thesis. Haryana Agricultural University, Hisar, India.
19. Kadam, S.S., Ghorpade, V.M., Adsule, R.N. and Salunkhe, D.K. (1986). Trypsin inhibitor in moth beans; thermal stability and changes during germination and cooking. *Plant Foods for Human Nutrition*, 36, 43-46.
20. Kataria, A., Chauhan, B.M. and Punia, D. (1992). Digestibility of proteins and starch (in-vitro) of amphidiploids (black gram x mungbean) as affected by domestic processing and cooking. *Plant Foods for Human Nutrition*, 42, 117-125.
21. Kaur, R.D. and Hira, C.K. (1988). Supplementary effect of Aestivum wheat (*Triticum aestivum L.*), bebngal grama (*Cicer arietinum L.*) and soybean (*Glycine max L.*) on protein quality of durum wheat (*Triticum durum Dest.*). *Journal of the Science Food and Agriculture*, 46, 201-209.
22. Khetarpaul, N., Grewal, R., Goyal, R. and Garg, R. (2004). Development of partially defatted soy flour and dhal. *Food Chemistry,* 87(3), 355-359.
23. Khetarpaul, N., Goyal, R. and Garg, R. (2005). Effect of salt solution pretreatment on the cooking quality and consumer acceptability of soy dhal. *British Food Journal*, 107(5), 344-352.
24. Kuamri, S. (1995). Studies on chemical composition and protein quality of triticales. Ph.D. Thesis. CCSHAU, Hisar.

25. Kumar, K.G., Venkataraman, L.V., Jaya, T.V. and Krishnamurthy, K.S. (1978). Cooking characteristics of some germinated legumes: Changes in phytins, Ca^{++}, Mg^{++} and pectin. *Journal of Food Science,* 43, 85-93.
26. Laurena, A.C., Garcia, V.V. and Mendoza, E.M.T. (1987). Effect of heat on the removal of polyphenols and in vitro protein digestibility of cowpea (*Vigna unguiculata*). *Plant Foods for Human Nutrition,* 37, 187-192.
27. Lindell, M.J. and Walker, C.F. (1984). Soy enrichment of Chapattis made from wheat and non-wheat flours. *Cereal Chemistry,* 61, 435-38.
28. Mertz, E.T., Kirleiz, A.W. and Axtell, J.D. (1983). In vitro digestibility of proteins in major food cereals. *Federation Proceedings,* 42(5), 6026.
29. Negi, N. (1999). Nutritional evaluation of some high yielding varieties of mothbean (Phaseolus aconitifolius Lacq.): Effect of domestic processing and cooking methods. M.Sc. Thesis. CCSHAU, Hisar, India.
30. Panse, Y.G. and Sukhatme, P.V. (1961). Statistical methods of agricultural coworkers. 2nd Edn. Indian Council of Agricultural Research, New Delhi, 12, 87.
31. Rathod, K.L. and Williams, S.W. (1973). Acceptance of soybean-enriched wheat flour for use in Chapattis. *The Indian Journal of Nutrition and Dietetics,* 10, 18-26.
32. Rawat, A. (1990). Nutritional and microbiological quality of soy-defatted Chapattis. M.Sc. (Food Tech.) Thesis. G.B. Pant University of Agriculture and Technology, Pantnagar, India.
33. Rawat, A., Singh, G., Mittal, B.K. and Mittal, S.K. (1994). Effect of soy-fortification on quality characteristics of Chapattis. *Journal of Food Science and Technology,* 31(2), 114-116.
34. Reddy, N.R., Pierson, M.D., Sathe, S.K. and Salunkhe, D.K. (1985). Dry bean tannins: A review of nutritional implications. *Journal of American Oil Chemist Society,* 62, 541-548.
35. Sangwan, V. (2002). Development of nutritional evaluation of wheat, sorghum, soybean composite flour biscuits. Ph.D. Thesis. CCSHAU, Hisar.
36. Singh, U. and Jambunathan, R.. (1981). Studies on desi and kabuli chickpea (Cicer arietinum) cultivars. Level of protease inhibitors, level of polyphenolic compounds and in vitro protein digestibility. *Journal of Food Science,* 46, 1364-1367.
37. Singh, U. and Rao, P.V. (1995). Dhal of pigeonpea as influenced by salt solution of enzyme pretreatments. *Journal of Food Science and Technology,* 32(2), 122-125.
38. Singh, U., Khedekar, M.S. and Jambunathan, R. (1982). Studies on desi and kabuli chickpea cultivars. The level of amylase inhibitors, levels of oligosaccharides and in vitro starch digestibility. *Journal of Food Science,* 47, 510.
39. Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Co., New Delhi.
40. Srivastava, P.P., Das, H. and Prasad, S. (1990). Effect of roasting process variables on in vitro protein digestibility of bengal gram, maize and soybean. *Food Chemistry,* 35, 31-37.
41. Swaminathan, M. (1987). Sensory Methods of Analysis of Foods. In: Food Science, Chemistry and Experimental Foods. pp 286-299.
42. Tan, N., Wong, K. and Luman, B.O. (1984). Relationship of tannin levels and trypsin inhibitor activity of raw and heat treated winged beans. *Journal of Agriculture Food Chemistry,* 32, 819.
43. Vijayakumari, K., Siddhuraju, P. and Janaradhanan, K. (1995). Effect of various water or hydrothermal treatments on certain antinutritional compounds in the seeds of the tribal pulse. *Plant Foods Hum. Nutr.* 48, 17-29.
44. Wu, W., William, W.P., Kunkel, M.E., Acton, J.C., Wardlow, F.B., Huang, Y. and Grimes, L.W. (1994). Thermal effects on in vitro protein of red kidney ban (*Phaseolus vulgaris L.*). *Journal of Food Science,* 5, 1187-1191.

Table No. 1: Sensory evaluation of *chapati* prepared from wheat flour and soy + wheat + sorghum flour

Salt treatment of soy dhal	Type of *chapati*	Colour	Appearance	Falvour	Texture	Taste	Overall acceptability
Sodium carbonate (Type I)	Control	7.8 ± 0.13	7.8 ± 0.26	7.8 ± 0.25	7.8 ± 0.36	7.9 ± 0.31	7.82 ± 0.42
	A	7.6 ± 1.16	7.3 ± 0.13	6.9 ± 0.20	7.2 ± 0.22	7.0 ± 0 .33	7.40 ± 0 .35
	B	7.6 ± 0.16	7.3 ± .21	6.8 ± 0.13	7.2 ± 0.15	6.9 ± 0 .13	7.40 ± 0 .34
	CD (P<0.05)	NS	NS	0.56	NS	0.66	0.55
Sodium bicarbonate (Type II)	Control	7.8 ± 0.13	7.8 ± 0.26	7.8 ± 0.25	7.8 ± 0.36	7.9 ± 0.31	7.82 ± 0.42
	A	7.6 ± 0.16	7.3 ± 0.18	6.8 ± 0.23	7.2 ± 0.22	6.2 ± 0.28	7.20 ± 0.29
	B	7.5 ± 0.17	7.1 ± 0.21	6.4 ± 0.25	6.8 ± 0.21	4.7 ± 0.28	7.00 ± 0.13
	CD (P<0.05)	NS	NS	0.62	0.77	0.88	0.52
Sodium chloride (Type III)	Control	7.8 ± 0.13	7.8 ± 0.26	7.8 ± 0.25	7.8 ± 0.36	7.9 ± 0.31	7.82 ± 0.42
	A	7.6 ± 0.16	7.3 ± 0.21	6.7 ± 0.13	7.1 ± 0.25	6.2 ± 0.13	7.20 ± 0.16
	B	7.5 ± 0.17	7.3 ± 0.18	6.7 ± 0.23	7.1 ± 0.13	6.2 ± 0.26	7.20 ± 0.17
	CD (P<0.05)	NS	0.52	0.63	NS	0.75	0.53
Sodium tripolyphospahte (Type IV)	Control	7.8 ± 0.13	7.8 ± 0.26	7.8 ± 0.25	7.8 ± 0.36	7.9 ± 0.31	7.82 ± 0.42
	A	7.5 ± 0.17	7.2 ± 0.21	6.8 ± 0.25	7.1 ± 0.29	5.9 ± 0.29	7.00 ± 0.13
	B	7.4 ± 0.16	7.2 ± 0.21	6.7 ± 0.13	7.0 ± 0.13	5.3 ± 0.13	7.00 ± 0.13
	CD (P<0.05)	NS	NS	0.62	0.67	0.66	0.60
Overall CD (P<0.05)		NS	0.50	0.58	0.69	0.72	0.53

Values are mean ± SE of 10 independent determinations.

Control = *Chapati* prepared from wheat flour

A = *Chapati* of wheat: soy: sorghum flour

75 15 10

B = *Chapati* of wheat: soy: sorghum flour

85 10 5

Table No. 2: Proximate composition of flour and *chapati* prepared from wheat, soybean and sorghum (g/100 g, dry matter basis)

	Moisture	Protein	Fat	Ash	Crude fibre
Flours					
Unprocessed wheat	12.11 ± 0.61	12.31 ± 0.44	1.08 ± 0.05	1.90 ± 0.20	1.89 ± 0.07
Unprocessed soy	9.8 ± 0.63	33.80 ± 1.32	23.4 ± 0.98	5.1 ± 0.18	3.9 ± 0.29
Unprocessed sorghum	10.79 ± 0.48	10.16 ± 0.32	1.81 ± 0.02	1.58 ± 0.06	1.59 ± 0.10
Chapati					
Unprocessed composite flour (control)	11.63 ± 0.22	15.32 ± 0.44	4.40 ± 0.32	2.35 ± 0.20	2.16 ± 0.10
Wheat+soy+sorghum *chapati*	32.31 ± 0.70	17.81 ± 0.72	4.83 ± 0.14	3.01 ± 0.25	2.53 ± 0.20
't' value	27.97	1.76	1.22	2.06	1.67
CD (P<0.05)	1.78	2.37	1.50	0.60	0.55

Values are mean ± SE of three independent determinations.

Table No. 3: Sugar content (total soluble, reducing and non-reducing sugar) of flour and wheat: soy: sorghum *chapatti* (g/100 g, on dry matter basis)

Flour	Total soluble sugars	Reducing sugar	Non-reducing sugar
Unprocessed wheat	4.17 ± 0.22	0.61 ± 0.03	3.56 ± 0.20
Unprocessed soy	6.39 ± 0.14	0.60 ± 0.05	5.79 ± 0.08
Unprocessed sorghum	2.55 ± 0.17	0.43 ± 0.07	2.12 ± 0.19
Chapati			
Unprocessed composite flour (control)	4.34 ± 0.04	0.53 ± 0.06	3.81 ± 0.10
Wheat+soy+ sorghum *chapati*	4.50 ± 0.18	0.63 ± 0.02	3.87 ± 0.21
't' value	0.84	1.61	0.26
CD (P<0.05)	0.52	NS	0.52

Values are ± SE of three independent determinations.

Table No. 4: Phytic acid and polyphenol contents of flours and *chapattis* (mg/100 g, on dry matter basis)

Flours	Phytic acid	Polyphenol
Unprocessed wheat	625.19 ± 7.1	455.12 ± 4.6
Unprocessed soy	1494.72 ± 45.6	615.61 ± 3.9
Unprocessed sorghum	518.75 ± 5.3	366.27 13.5
Chapati		
Unprocessed composite flour (Control)	744.96 ± 16.8	470.31 ± 2.7
Wheat+soy+sorghum	565.95 ± 26.7	162.61 ± 5.1
't' value	5.67*	53.83*
CD (P<0.05)	80.23	22.67

Values are ± SE of three independent determinations.

*Statistically significant

Table No. 5: Protein digestibility (*in vitro*, g/100 g) and starch digestibility (*in vitro*, mg maltose released/g) of flour and *chapatti* (on dry matter basis)

Flours	Protein digestibility	Starch digestibility
Unprocessed wheat	71.17 ± 0.8	33.29 ± 0.5
Unprocessed soy	60.42 ± 0.7	24.33 ± 0.4
Unprocessed sorghum	61.78 ± 0.5	34.72 ± 0.5
Chapati		
Unprocessed composite flour (Control)	68.62 ± 0.6	32.09 ± 0.7
Wheat + soy + sorghum *chapati*	73.58 ± 0.2	41.13 ± 0.1
't' value	3.97	8.73
CD (P<0.05)	1.89	1.91

Values are mean ± SE of three independent determinations.