Minerals and antinutrients profile of *rabadi* after different traditional preparation methods

Vineeta Gupta · Ranjana Nagar

Revised: 7 February 2012 / Accepted: 17 February 2012 / Published online: 14 March 2012

© Association of Food Scientists & Technologists (India) 2012

Abstract *Rabadi* is a cereal and buttermilk based traditional fermented recipe of western region of India. There are many traditional preparation methods, which may alter biochemical composition of *rabadi*, therefore, in the present study, role of traditional processings (cooking, fermentation, dehulling, utensil, preparation methods and cereals) on minerals and antinutrients of pearl millet, wheat flour and refined wheat flour *rabadi* was investigated on fresh weight basis. Results showed that the process of cooking and fermentation enhanced minerals (Ca, Fe and P) in all types of *rabadi* samples at different levels of significance, while antinutrients (phytic acid, total phenols and oxalates) reflected a declining trend. Intercomparison of different types of *rabadies* exhibited that fermented- cooked –fermented samples were better than cooked –fermented *rabadies*. Dehulling caused a loss of minerals, but antinutrients were also degraded after dehulling; therefore dehulled sample showed very good nutritional profile after fermentation. Earthen pot *rabadi* samples presented better biochemical composition than *rabadies* prepared in steel pot. Intercomparison of different cereals based *rabadies* reflected superior position of fermented -cooked- fermented pearl millet flour *rabadi* than cooked- fermented pearl millet flour *rabadi*, wheat and refined wheat flour *rabadi* samples.

Keywords *Rabadi* · Fermentation · Cooking · Minerals · Antinutrients

Introduction

Traditional recipes and locally available food stuffs play a vital role in combating the problem of malnutrition due to their popularity and wide consumption. At the same time every foodstuff undergoes various preparation methods before consumption. It is not necessary that all the traditional preparation methods are good. Some may need improvement to save or release the nutrients present in foods. Various researches have been carried out to find out the effect of processings on traditional recipes (Kulkarni et al. 1997; Chaturvedi and Nagar 2001; Arora et al. 2009; Agrahar and Jha 2009; Choudhary et al. 2011; Patil and Khan 2011; Guzel and Sayar 2012). In the present study, *rabadi* was selected which is a cereal and buttermilk based staple traditional recipe of Western region of India. Some researches have been performed on *rabadies* prepared from pearl millet (Dhankher and Chauhan 1987), barley (Gupta et al. 1992), maize (Soni and Arora 2000), soyabean (Gupta and Nagar 2008) etc., but no work has been carried out to study the effect of different traditional preparation methods on nutritional composition of *rabadies*. In nutritional profile of cereals and millet grains, minerals stand at a very important position. These are essential as a structural part and to carry out many metabolic reactions. At the same time, cereals and millet grains are associated with antinutrients also, which are some nutrients inhibiting factors or toxic substances. These degrade the nutritional value of grains by making complexes with minerals and vitamins and rendering them unavailable to the body. Besides lowering the nutritive quality, some of the antinutrients may be hazardous to health.

Therefore in the present study, minerals and antinutrients were studied in pearl millet, wheat flour and refined wheat flour *rabadies* after different traditional preparation methods. Effect of cooking, fermentation, dehulling, preparation

V. Gupta (✉) · R. Nagar
PG Department of Home Science, University of Rajasthan,
Jaipur 302 004, India
e-mail: energy_vin@yahoo.co.in

method (Cooked fermented Vs Fermented cooked fermented) and utensil (steel Vs earthen pot) was studied in these rabadies. Different cereal based rabadies were intercompared to each other. It was very important to study because rabadi is a popular staple recipe of a large segment of population of India and no work has been done in the direction of traditionally prepared rabadies. Therefore finding out the best traditional preparation method of rabadi in terms of higher minerals with lowest antinutrient components will help us in vying the problem of malnutrition in a better way.

Materials and methods

For preparation of rabadi, pearl millet (*Pennisetum typhoides*), wheat (*Triticum astivum*) and refined wheat flour were procured in a single lot from the local market. These were cleaned from dirt, dust and other foreign materials. Pearl millet and wheat were ground in 'wiley mill' to prepare coarse flour. Buttermilk was procured from local dairy named as 'saras dairy' where all the milk and milk products are prepared at standardized conditions. Pearl millet grits were prepared by moistening the whole grains for 10–15 min. After this, it was ground in electric grinder for 6–7 s to remove hull portion. These dehulled grits were used for preparation of rabadi.

Preparation of rabadi Cereal flour or dehulled grits (100 g) were mixed with buttermilk (250 ml). It was diluted with plain water (600 ml). Salt (3 g) was added at the time of cooking. For fermentation, this homogenized mixture was kept in an incubator at 37 °C. Samples were cooked by boiling for 5 min followed by simmering for 25 min with constant stirring. A little amount of buttermilk was used as a starter for fermentation after cooking. *Rabadi* samples were separated at raw, cooked and fermented stages for biochemical estimations in fresh weight basis.

Samples under study Following *rabadi* samples were prepared for determining changes in minerals and antinutrients profile:

1. Pearl millet flour *rabadi*- cooked- fermented (CF) (T1),
2. Pearl millet flour *rabadi* –fermented –cooked- fermented (FCF) (T2),
3. Dehulled pearl millet grits *rabadi* – CF (T3),
4. Pearl millet flour *rabadi*- CF in earthen pot (T4),
5. Pearl millet flour *rabadi* –FCF in earthen pot (T5),
6. Wheat flour *rabadi* –CF (T6),
7. Refined wheat flour *rabadi*- FCF (T7).

Above samples were separated at raw, cooked and fermented stages for biochemical estimations on fresh weight basis.

Biochemical estimations Calcium content was determined by following the method of Hawk et al. (1968) using dry ashing method. Estimations of iron, phosphorus and oxalates were carried out by the standardized methods of Raghuramulu et al. (1983). Iron was estimated by wet ashing with acid by making use of the fact that ferric ions give blood red colour with potassium thiocyanate. Phosphorus was determined by Fiske Subbarow reagent method. In this, inorganic or ortho phosphates are converted into phosphomolybdic acid when reacted with ammonium molybdate and this phosphomolybdate is converted to higher oxides of molybdenum, when reduced by Fiske subbarow reagent. Oxalic acid was extracted with acid and precipitated as calcium oxalate by adding calcium chloride and titrated with N/20 KMnO₄ solution. Phytic acid was investigated by precipitating ferric ions from ferric phytate which were converted into phytate phosphorus and then phytic acid was calculated (Young 1936). Goldstein and Swain (1963) described the method of estimation of total phenols using saturated sodium carbonate and Folin's ciacaltea reagent.

Statistical analysis Biochemical analysis was done in triplicates and their mean $\pm$ SE were calculated. ANOVA was applied to find out significant difference among different parameters. Modified 't' test was used to know the significant difference between two samples.

Results and discussion

Table 1 is depicting the minerals and antinutrients of different *rabadi* samples after raw, cooked and fermentation stages.

Cooking The process of cooking significantly augmented Ca in T2 (32.28%), T3 (50.58%) and T4 (46.58%), while in other samples it showed a slight rise. Iron and phosphorus contents also showed significant increase in pearl millet flour *rabadi* –CF (T1) and wheat flour *rabadi* (T6). In general, all *rabadi* samples showed an increasing trend in mineral contents after cooking. A rise in minerals after heat treatment has been mentioned by Osman et al. (2009). It may be attributed to the addition of salt at the time of cooking (Akpapunam and Achinewhu 1985) or release of free form of minerals from their bound forms.

Besides this, oxalate content reflected a tremendous decline in all types of *rabadies*, which was 38.21%, 41.02%, 36.58%, 55.77% and 37.53% in T1, T2, T4, T5 and T6 samples, respectively. Phytic acid and total phenols showed a slight reduction. Arora et al. 2009 also revealed increased in vitro minerals availability after autoclaving of fermented food mixtures. Reduction in antinutrients after heat treatment is in consonance with the findings of Vadivel and

Table 1 Minerals and antinutrient profile of different types of rabadies at each stage of preparation (mg/100 g)

Samples	Ca	Fe	P	Phytic acid	Total phenols	Oxalates
T1-R	10.09±0.301 ^a	1.39±0.040 ^a	1029.6±3.54 ^a	484.2±4.81 ^a	67.3±1.06 ^a	29.63±0.271 ^a
T1-C	12.17±0.290 ^a	1.53±0.040 ^a	1232.9±6.36 ^a	420.0±8.13 ^{ab}	55.54±0.621 ^{ab}	18.31±0.311 ^b
T1-F(16 h)	20.95±0.412 ^b	2.09±0.050 ^b	1752.6±8.49 ^b	385.9±4.10 ^b	50.81±0.531 ^b	14.36±0.160 ^c
‘F’ Results	($\rho<0.01$)	($\rho<0.01$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)
T2-R	10.09±0.301 ^a	1.39±0.040 ^a	1029.6±3.54 ^a	484.2±4.81 ^a	67.3±1.06 ^a	29.63±0.271 ^a
T2-F(4 h)	14.84±0.301 ^b	1.40±0.030 ^a	1272.0±9.55 ^b	417.3±8.49 ^{ab}	60.5±1.41 ^a	28.11±0.470 ^a
T2-C	19.63±0.541 ^c	1.47±0.040 ^a	1461.0±14.07 ^b	414.1±5.66 ^{ab}	52.6±1.06 ^a	16.58±0.402 ^b
T2-F(16 h)	27.12±0.622 ^d	2.10±0.040 ^b	2018.0±9.48 ^c	350.7±7.42 ^b	34.69±0.641 ^b	14.00±0.15 ^b
‘F’ Results	($\rho<0.001$)	($\rho<0.01$)	($\rho<0.001$)	($\rho<0.01$)	($\rho<0.01$)	($\rho<0.001$)
T3-R	8.56±0.250 ^a	1.30±0.031 ^a	837.5±7.42 ^a	404.9±7.78 ^a	36.36±0.321 ^a	27.66±0.612 ^a
T3-C	12.89±0.711 ^b	1.44±0.030 ^{ab}	872.5±11.10 ^a	358.5±6.65 ^a	35.67±0.391 ^a	24.06±0.401 ^a
T3-F(16 h)	16.2±1.16 ^c	1.64±0.040 ^b	954.6±16.26 ^a	314.9±4.67 ^a	30.38±0.481 ^a	12.44±0.150 ^b
‘F’ Results	($\rho<0.01$)	($\rho<0.05$)	(NS)	(NS)	(NS)	($\rho<0.001$)
T4-R	10.09±0.301 ^a	1.39±0.040 ^a	1029.6±3.54 ^a	484.2±4.81 ^a	67.3±1.06 ^a	29.63±0.271 ^a
T4-C	14.79±0.390 ^b	1.89±0.040 ^b	1157.9±4.95 ^a	412.5±6.22 ^{ab}	54.49±0.601 ^a	18.79±0.352 ^b
T4-F (16 h)	27.92±0.601 ^c	2.12±0.060 ^b	1890.9±7.78 ^b	360.6±7.64 ^b	40.70±0.470 ^b	10.18±0.232 ^c
‘F’ Results	($\rho<0.01$)	($\rho<0.05$)	($\rho<0.001$)	($\rho<0.05$)	($\rho<0.001$)	($\rho<0.001$)
T5-R	10.09±0.301 ^a	1.39±0.040 ^a	1029.6±3.54 ^a	484.2±4.81 ^a	67.3±1.06 ^a	29.63±0.271 ^a
T5-F(4 h)	17.13±0.361 ^b	2.02±0.040 ^b	1571.6±2.83 ^b	427.8±6.01 ^{ab}	54.43±0.602 ^{ab}	27.38±0.631 ^a
T5-C	18.15±0.531 ^b	2.12±0.041 ^b	1731.2±11.17 ^b	369.1±7.78 ^{bc}	51.55±0.851 ^b	12.11±0.10 ^b
T5-F (16 h)	37.40±0.482 ^c	2.29±0.020 ^b	2418.8±14.57 ^c	320.2±6.15 ^c	30.52±0.782 ^c	8.46±0.081 ^c
‘F’ Results	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)
T6-R	15.77±0.351 ^a	0.92±0.020 ^a	808.5±14.14 ^a	363.1±4.95 ^a	30.62±0.541 ^a	15.24±0.222 ^a
T6-C	16.89±0.311 ^a	1.16±0.031 ^b	1160.6±21.22 ^b	214.7±3.39 ^b	27.72±0.472 ^a	9.52±0.110 ^b
T6-F(16 h)	33.3±1.13 ^b	1.77±0.040 ^c	1456.0±14.14 ^c	200.6±3.89 ^b	17.66±0.321 ^b	7.19±0.080 ^c
‘F’ Results	($\rho<0.01$)	($\rho<0.01$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.01$)	($\rho<0.001$)
T7-R	15.82±0.461 ^a	0.60±0.010 ^a	874.7±7.78 ^a	281.2±5.23 ^a	24.88±0.471 ^a	ND
T7-F(4 h)	18.56±0.391 ^{ab}	0.83±0.010 ^b	1559.4±24.75 ^b	273.2±3.89 ^a	18.30±0.32 ^b	ND
T7-C	20.64±0.601 ^b	0.89±0.020 ^b	1844.3±18.81 ^b	228.2±1.98 ^b	15.96±0.111 ^{bc}	ND
T7-F(16 h)	26.21±0.781 ^c	0.93±0.010 ^b	2673.2±31.4 ^c	223.7±2.54 ^b	12.65±0.230 ^c	ND
‘F’ Results	($\rho<0.01$)	($\rho<0.01$)	($\rho<0.001$)	($\rho<0.001$)	($\rho<0.001$)	

(n=3) Mean ± SE, Values with different superscripts are statistically different. R = Raw, C = Cooked, F = Fermented. Pearl millet flour rabadi – Cooked – fermented (T1), Fermented –cooked –fermented (T2), Cooked –fermented in earthen pot (T4), fermented –cooked –fermented in earthen pot (T5), Dehulled pearl millet grits rabadi (T3), wheat flour rabadi- Cooked – fermented (T6), Refined wheat flour rabadi - Fermented –cooked – fermented (T7)

pugalenthi (2008) and Oboh et al. (2010) who attributed it to the high temperatures. Lakra and Sehgal (2011) also found higher mineral availability and lower antinutrient after frying and fermentation of potato flour.

Fermentation It is evident from Table 1 that fermentation process caused an enhancement in all minerals in all types of *rabadi* samples. Calcium content was noted to be increased in the range of 25.91 (dehulled grits *rabadi* –T3) to 106.06% (Pearl millet flour *rabadi*- FCF in earthen pot). Iron content was enhanced in the range of 36.60% (T1- cooked fermented pearl millet flour *rabadi*) to 52.59% (T6- cooked fermented

wheat flour *rabadi*). Similarly, phosphorus content was found towards a rising trend (23.54%–78.28%). Fermented — cooked -fermented samples showed an overall greater rise because these samples were fermented two times. In antinutrients, total phenols and oxalates reflected a significant decline. Phytic acid content showed slight decrease in comparison to cooked stage, although this decline was significant as compared to raw stage. It may be due to increase in phytase activity (Ou et al. 2011). Oxalate content was not detected in refined wheat flour *rabadi* even at raw stage.

Enhanced minerals after fermentation have been supported by other studies also (Aliya and Geervani 1981; Dave

et al. 2008; Yang and Zhang 2009) who attributed it to the reduction in antinutritional factors because of increased enzymatic activities (Luo et al. 2009; Agrahar and Jha 2009; Arora et al. 2009; Azeke et al. (2011)).

Effect of preparation method When cooked –fermented and fermented- cooked- fermented samples were compared to each other, a significant increase in Ca was found in FCF *rabadies* (T2- 29.45% and T5- 33.95%) than their cooked fermented counterparts –T1 and T4, respectively. *Rabadi* FCF in earthen pot (T5) reflected significantly higher P (27.02%) content also than CF sample. Besides this, FCF *rabadies* prepared in steel (T2) and earthen pot (T5) unfolded a remarkably lower total phenols to the extent of 31.73% and 25.02%, respectively than CF (T1 and T4) type of *rabadies* (Table 2). Since FCF samples have been fermented twice-before and after cooking, therefore undoubtedly, these samples have better nutritional profile over the CF ones.

Dehulling Appraisal of Table 2 showed that dehulled pearl millet grits *rabadi* (T3) contained 22.53%, 21.54%, 45.53%,

18.39% and 40.21% lesser Ca, Fe, P, phytic acid and total phenol contents, respectively as compared to whole pearl millet flour *rabadi* (T1). It may be attributed to the removal of bran portion.

Utensil Earthen pot *rabadi* samples T4 (CF) and T5 (FCF) exhibited significantly higher Ca (33.27% and 37.90%, respectively) and lower oxalates (29.11% and 39.57%, respectively) in comparison to samples CF (T1) and FCF (T2) in steel pot (Table 2).

Effect of cereals Table 2 is eliciting that mineral content was more or less similar in all types of *rabadies* after fermentation. It was seen that Ca content was higher in wheat flour *rabadi* followed by pearl millet flour *rabadi* (FCF) and refined wheat flour *rabadies*, while pearl millet flour *rabadies* were superior for their Fe content. Refined wheat flour *rabadi* exhibited good amount of phosphorus content after fermentation process. Antinutrients were remarkably lesser in refined wheat flour *rabadi* followed by wheat flour and pearl millet flour *rabadies* (whether CF or FCF). In fact,

Table 2 Intercomparison of minerals and antinutrients of differently prepared *rabadies* (mg/100 g)

Variables	Ca	Fe	P	Phytic acid	Total phenols	Oxalates
Preparation method (Cooked fermented Vs Fermented –Cooked Fermented)						
T1	20.95±0.412	2.09±0.050	1752.6±8.49	385.9±4.10	50.81±0.531	14.36±0.160
T2	27.12±0.622	2.10±0.040	2018.0±9.48	350.7±7.42	34.69±0.641	14.00±0.15
‘t’ results	($\rho<0.01$)	(NS)	(NS)	(NS)	($\rho<0.01$)	(NS)
T4	27.92±0.601	2.12±0.060	1890.9±7.78	360.6±7.64	40.70±0.470	10.18±0.232
T5	37.40±0.482	2.29±0.020	2418.8±14.57	320.2±6.15	30.52±0.782	8.46±0.081
‘t’ results	($\rho<0.01$)	(NS)	($\rho<0.05$)	(NS)	($\rho<0.05$)	(NS)
Dehulling (Whole pearl millet flour Vs Dehulled pearl millet grits <i>rabadi</i>)						
T1	20.95±0.412	2.09±0.05	1752.6±8.49	385.9±4.10	50.81±0.531	14.36±0.160
T3	16.2±1.16	1.64±0.040	954.6±16.26	314.9±4.67	30.38±0.481	12.44±0.150
‘t’ results	($\rho<0.01$)	($\rho<0.05$)	($\rho<0.001$)	($\rho<0.01$)	($\rho<0.01$)	(NS)
Utensils (Steel Vs Earthen pot)						
T1	20.95±0.412	2.09±0.050	1752.6±8.49	385.9±4.10	50.81±0.531	14.36±0.160
T4	27.92±0.601	2.12±0.060	1890.9±7.78	360.6±7.64	40.70±0.470	10.18±0.232
‘t’ results	($\rho<0.01$)	(NS)	(NS)	(NS)	(NS)	($\rho<0.05$)
T2	27.12±0.622	2.10±0.040	2018.0±9.48	350.7±7.42	34.69±0.641	14.00±0.15
T5	37.40±0.482	2.29±0.020	2418.8±14.57	320.2±6.15	30.52±0.782	8.46±0.081
‘t’ results	($\rho<0.01$)	(NS)	(NS)	(NS)	(NS)	($\rho<0.001$)
Cereals						
T1	20.95±0.412 ^a	2.09±0.050 ^c	1752.6±8.49 ^b	385.9±4.10 ^a	50.81±0.531 ^a	14.36±0.160
T2	27.12±0.622 ^b	2.10±0.040 ^c	2018.0±9.48 ^b	350.7±7.42 ^a	34.69±0.641 ^b	14.00±0.15
T6	33.3±1.13 ^c	1.77±0.040 ^b	1456.0±14.14 ^a	200.6±3.89 ^b	17.66±0.321 ^c	7.19±0.080
T7	26.21±0.781 ^b	0.93±0.010 ^a	2673.2±31.4 ^c	223.7±2.54 ^b	12.65±0.230 ^d	ND
‘F’ Results	($\rho<0.05$)	($\rho<0.05$)	($\rho<0.05$)	($\rho<0.01$)	($\rho<0.05$)	(NA)

($n=3$) Mean ± SE, Values with different superscripts are statistically different. Pearl millet flour *rabadi* –Cooked – fermented (T1), Fermented – cooked –fermented (T2), Cooked –fermented in earthen pot (T4), fermented –cooked –fermented in earthen pot (T5), Dehulled pearl millet grits *rabadi* (T3), wheat flour *rabadi*- Cooked – fermented (T6), Refined wheat flour *rabadi* - Fermented –cooked –fermented (T7)

refined wheat flour *rabadi* did not show oxalate content even at raw stage.

Conclusion

On the basis of above results it can be concluded that both cooking and fermentation brought about positive changes in *rabadi* samples in terms of higher minerals and lower antinutrients. Dehulling caused loss of antinutrients but at the same time it was responsible for loss of minerals also. Fermented – cooked- fermented *rabadi* samples were better over cooked fermented ones. *Rabadi* prepared in earthen pot showed better nutritional profile. Therefore, pearl millet flour *rabadi*- FCF prepared in earthen pot may be considered the best than any other *rabadi*. Wheat and refined wheat flour *rabadies* were also good after 16 h fermentation process.

Acknowledgement Authors are grateful to the PG Department of Home Science, University of Rajasthan, Jaipur for providing essential infrastructure to accomplish present research work in a convenient manner and to University Grants Commission to providing funds for the study.

References

- Agrahar MD, Jha K (2009) Effect of sprouting on nutritional and functional characteristic of soyabean. *J Food Sci Technol* 46:240–243
- Akpanunam MA, Achinewhu SC (1985) Effect of cooking, germination and fermentation on the chemical composition of Nigerian cowpea (*Vigna unguiculata*). *Plant Foods for Hum Nutr* 35:353–358
- Aliya S, Geervani P (1981) An assessment of the protein quality and vitamin B content of commonly used fermented products of legumes and millets. *J Sci Food Agric* 32:837–842
- Arora S, Jood S, Khetarpaul N, Goyal R (2009) Effect of germination and probiotic fermentation on antinutrients and in vitro digestibility of starch and protein and availability of minerals from barley based food mixture. *J Food Sci Technol* 46:359–362
- Azeke MA, Egielewa SJ, Eigbogbo MU, Ihimire IG (2011) Effect of germination on the phytase activity, phytate and total phosphorus contents of rice (*Oryza sativa*), maize (*Zea mays*), millet (*Pennisetum glaberrimum*), sorghum (*Sorghum bicolor*) and wheat (*Triticum aestivum*). *J Food Sci Technol* 48:724–729
- Chaturvedi Y, Nagar R (2001) Levels of β -carotene and effects of processing on selected fruits and vegetables of the arid zone of India. *Plant Foods Hum Nutr* 56:127–132
- Choudhary M, Das P, Baroova B (2011) Nutritional evaluation of popped and malted indigenous millet of Assam. *J Food Sci Technol* 48:706–711
- Dave S, Yadav BK, Tarafdar JC (2008) Phytate phosphorus and mineral changes during soaking, boiling and germination of legumes and pearl millet. *J Food Sci Technol* 45:344–348
- Dhankher N, Chauhan BM (1987) Technical note: preparation, acceptability and B vitamin content of rabadi- a fermented pearl millet food. *Int J Food Sci Technol* 22:173–176
- Goldstein JL, Swain T (1963) Changes in tannins in ripening fruits. *Phytochem* 2:371–381
- Gupta V, Nagar R (2008) Physico- chemical and acceptability of rabadi (a fermented soyaflour product) as affected by cooking and fermentation time. *Int J Food Sci Technol* 43:939–943
- Gupta M, Khetarpaul N, Chauhan BM (1992) Preparation, nutritional value and acceptability of barley rabadi – an indigenous fermented food of India. *Plant Foods Hum Nutr* 42:351–358
- Guzel D, Sayar S (2012) Effect of cooking methods on selected physicochemical and nutritional properties of barlotto bean, chicken pea, faba bean and white kidney bean. *J Food Sci Technol* 49:89–95
- Hawk BP, Oser LB, Summerson HW (1968) Physiological chemistry. McGraw Hill Book Co, New York, p 644
- Kulkarni SG, Manan JK, Agarwal MD, Shukla IC (1997) Studies on physico chemical conditions, packaging and storage of black gram and green gram wari prepared in Uttar Pradesh. *J Food Sci Technol* 34:119–122
- Lakra P, Sehgal S (2011) Influence of processing on total and extractable mineral content of products prepared from potato flour. *J Food Sci Technol* 48:735–739
- Luo Y, Le B, Ji H, Ji B, Ji F, Chen G, Tian F (2009) Effect of soaking and cooking on selected variety for preparation of fibrinolytic *Douchi*. *J Food Sci Technol* 46:104–108
- Oboh G, Ademiluyi AO, Akindahunsi AA (2010) The effect of roasting on the nutritional and antioxidant properties of yellow and white maize varieties. *Int J Food Sci Technol* 45:1236–1242
- Osman NM, Mohamed Ahmed IA, Babiker EE (2009) Fermentation and cooking of sicklepod (*Cassia obtusifolia*) leaves: changes in chemical and amino acid composition, antinutrients and protein fractions and digestibility. *Int J Food Sci Technol* 45:124–132
- Ou K, Cheng Y, Xing Y, Li L, Nout R (2011) Phytase activity in brown rice during steeping and sprouting. *J Food Sci Technol* 48:598–603
- Patil SB, Khan MK (2011) Germinated brown rice as a value added rice product: a review. *J Food Sci Technol* 48:661–673
- Raghuramulu N, Nair KM, Kalyansundaram S (eds) (1983) A manual of laboratory techniques. National Institute of Nutrition, Hyderabad, pp 32–35
- Soni SK, Arora JK (2000) Indian fermented foods: biotechnological approaches. In: Marwaha SS, Arora JK (eds) Food processing: Biotechnological applications. Asiatech Pub Inc, New Delhi, pp p143–p190
- Vadivel V, Pugalenathi M (2008) Removal of antinutritional/toxic substances and improvement in the protein digestibility of velvet bean (*Mucuna pruriens*) seeds during processing. *J Food Sci Technol* 45:242–246
- Yang H, Zhang L (2009) Changes in some components of soymilk during fermentation with the *basidiomycete Ganoderma lucidum*. *Food Chem* 112(1):1–5
- Young L (1936) The determination of phytic acid. *Biochem J* 30:252–257