J. Farm Sci., 30(4): (530-534) 2017

RESEARCH PAPER

Effect of different processing methods on proximate composition of greengram varieties

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(Received: February, 2017 ; Accepted:August, 2017)

Abstract: The effects of domestic traditional processes such as, soaking, germination, boiling, pressure cooking and microwave cooking, on the proximate composition of greengram varieties were studied. Different processing treatments such as soaking, boiling, pressure cooking and microwave cooking caused significant ($p < 0.05$) decrease in fat, crude protein, crude fibre and total ash content where as germination method caused significant increase in crude protein content in all the greengram varieties. A significant increase ($p<0.05$) was observed in moisture content and carbohydrate content in all the greengram varieties during different processing methods such as soaking, boiling , pressure cooking and microwave cooking, where as germination caused significant decrease in carbohydrate content. The percentage increase of moisture and carbohydrate content was the highest in germinated (17%) and boiled samples (6.4%) respectively in all the greengram varieties. Pressure cooking resulted in greater retention of crude protein (95%) and fat content (91.3%) compared to other cooking treatments, whereas germination resulted in greater retention of crude fibre (94.5%) and ash content (95%) among all the varieties of greengram. Among the processing treatments germination and cooking by pressure and microwave methods were found to be more effective in retention of crude protein, crude fibre, and ash when compared to other processing methods.

Key words: Cooking, Greengram, Germination, Proximate composition, Soaking

Introduction

Green gram is one of the important pulse crops in India since ancient times. It plays an important role in the diet of many people in developing countries and are major sources of dietary nutrients for people including vegetarians. It is an excellent source of high quality protein and is one of the cheapest and richest sources of plant protein and can be considered as the poor man's meat in developing countries like India. For human consumption the pulses are processed by various methods which include soaking, boiling, sprouting, pressure cooking and fermentation depending upon tradition and taste preferences. Food processing has the potential to alter the nutrient quality of Pulses. Therefore information is needed on the content and variability of important nutrients in the pulses in both raw and processed form. Hence, the present study was initiated to determine the effect of soaking, germination, boiling, pressure cooking and microwave cooking on proximate composition of green gram varieties with reference to the retention of protein content.

Materials and methods

The present investigation was undertaken during the year 2015-2016 at the Department of Food Science and Nutrition, College of Rural Home Science, University of Agricultural Sciences, Dharwad, Karnataka. Eight varieties of greengram such as DGGV-2, DGG-1, DGG-7, IPM-02-14, DGG-3, DGG-8, Selection-04 and DGG-6 were obtained from the AICRP on MULLaRP (Mungbean, Urdbean, Lentil, Lathyrus, Rajmah and Peas), Main Agriculture Research Station, University of Agricultural Sciences Dharwad.

Traditional domestic processing techniques like soaking, germination, boiling, pressure cooking and microwave cooking of seeds were employed to observe the nutritional variation as affected by these treatments. Control (un-processed) samples were ground in a mortar and pestle to pass through 60- mesh sieve and the resulting flour was stored in an airtight zip lock bags for further analysis. The remaining seeds were used for the processing experiment. For soaking the whole mung bean seeds were rinsed and soaked in distilled water (1:10, w/v) for 12 hr at room temperature. For germination the 12 hr soaked seeds were drained and tied in wet cotton cloth and allowed to germinate for 24 hr. Boiling was carried out by cooking the rinsed soaked seeds in distilled water (100^{o}C) in the ratio of 1:5 (w/v) on a hot plate until they became soft when felt between the fingers. Microwave cooking was done by placing the rinsed soaked seeds in a micro proof container with distilled water (1:5, w/v), then cooked in a microwave oven (LG, Model ER-50540, 2450 MHz, 1200W) on high power for 15 min (until the seeds were soft). For pressure cooking, a pressure cooker made of aluminum (3-L capacity, from TTK Prestige Ltd., Bangalore, India) was used. The rinsed grains were placed in the pressure cooker with distilled water (1:2, w/v) and cooked under 15-lb pressure. After every processing treatment the processed samples were dried in an electric hot air oven maintained at 50^{o}C for 20 hr and then ground in a pestle and mortar to pass through 60- mesh sieve and the resulting flour was stored in an airtight zip lock bags which were used for further analysis.

The processed greengram flour was analyzed for proximate composition by following the standard procedures of Association of Official Analytical Chemists (Anon., 2005). The carbohydrate content was calculated by deducting the sum of the value of moisture, protein, fat, ash and fiber from 100 (Anon.,

2005). Analysis of variance was used to test the difference between varieties, processing methods and interaction.

Results and discussion

Effect of processing methods on moisture contents of greengram varieties is given in Table 1.The moisture content in the raw greengram varieties varied between 10.04-10.48g/100 g. A significant increase ($p<0.05$) was observed in moisture content in all the greengram varieties during different processing methods such as soaking, germination, boiling, pressure cooking and microwave cooking as compared with raw greengram. However, irrespective of greengram varieties the average increase in moisture content was the highest during germination (17%) followed by soaking (7%), boiling (3.3%), pressure cooking (3.2%) and microwave cooking (2.9%) and irrespective of processing treatments the percentage increase in moisture content was the highest in the variety Selection-04 (7.8%). The increase in moisture content during soaking and germination could be attributed to hydration of the seeds during soaking and increase in water uptake due to increasing number of cells, these findings were similar to the results reported for mungbean seeds (Mubarak *et al.,* 2005).The moisture content of cooked greengram (boiled, pressure cooked, microwave cooked) was also higher than raw greengram due to absorption of water during cooking which had a dilution effect on all other nutrients, similar report has been made by Mubarak (2005) for boiled, pressure cooked, microwave cooked mungbean seeds (9.75-10.15 g/100 g).

Data regarding the crude fat content of control and processed greengram varieties are presented in Table 2. The crude fat content in the raw greengram varieties varied between 0.74-1.37g/100 g. A significant decrease ($p<0.05$) was observed in crude fat content in all the greengram varieties during different processing methods when compared to raw greengram. However irrespective of greengram varieties the percentage reduction in crude fat content of was the highest during germination method (46.9%), followed by microwave cooking (12%), boiling (9.7%) and pressure cooking (8.7%) whereas, the least reduction was found during soaking (5.9%). Irrespective of processing treatments the percentage reduction of crude fat content was the lowest in the variety IPM-02-14 (12.3%). The decrease in crude fat content in soaking and germination method could be attributed to, total solid loss during soaking (Kakati *et al.,* 2010) and use of fat as an energy source in sprouting process (Fouad *et al.,* 2015). Reduction in crude fat content of cooked mung bean seeds by boiling, pressure cooking and microwave cooking, has been indicated by

Table 1. Effect of processing methods on moisture content of greengram varieties (g/100 g)

Varieties	Processing methods					
	Raw	Soaking	Germination	Boiling	Pressure cooking	Microwave cooking
DGG-1	10.47±0.15	11.25±0.20 (7.4)	11.95±0.31 (14.1)	10.78±0.15 (3.0)	10.88±0.12 (3.9)	10.72±0.09 (2.4)
DGGV-2	10.36±0.06	11.08±0.24 (6.9)	12.02±0.19 (16.0)	10.68±0.11 (3.1)	10.82±0.25 (4.4)	10.61±0.32 (2.4)
DGG-3	10.39±0.06	11.12±0.16 (7.0)	12.19±0.24 (17.3)	10.81±0.19 (4.0)	10.61±0.24 (2.1)	10.72±0.28 (3.2)
Selection-04	10.04±0.05	10.91±0.18 (8.7)	11.93±0.44 (18.8)	10.42±0.42 (3.8)	10.33±0.42 (2.9)	10.51±0.46 (4.7)
IPM-02-14	10.07±0.03	10.72±0.19 (6.5)	11.98±0.20 (19.0)	10.53±0.35 (4.6)	10.38±0.48 (3.1)	10.33±0.22 (2.6)
DGG-6	10.18±0.12	10.82±0.24 (6.3)	11.83±0.17 (16.2)	10.44±0.39 (2.6)	10.55±0.44 (3.6)	10.52±0.35 (3.3)
DGG-7	10.48±0.05	11.15±0.15 (6.4)	12.13±0.18 (15.7)	10.72±0.37 (2.3)	10.81±0.23 (3.1)	10.72±0.36 (2.3)
DGG-8	10.37±0.13	11.10±0.06 (7.0)	12.31±0.29 (18.7)	10.70±0.28 (3.2)	10.63±0.29 (2.5)	10.60±0.35 (2.2)
Overall Mean	10.29±0.18	11.02±0.23 (7.0)	12.04±0.27 (17.0)	10.64±0.29 (3.3)	10.63±0.34 (3.2)	10.59±0.30 (2.9)
	Varieties		Processing		Varieties x Processing (Interaction)	
S.Em±	0.08		0.07		0.21	
C.D.	0.17		0.15		NS	
F- value	5.50		133.51		0.35	

Figures in the parentheses indicate percentage increase in moisture content of greengram varieties over the control (raw) values

Table 2. Effect of processing methods on Fat content of greengram varieties (g/100 g)

Varieties	Processing methods					
	Raw	Soaking	Germination	Boiling	Pressure cooking	Microwave cooking
DGG-1	0.85±0.03	0.82±0.04(3.5)	0.47±0.08(44.7)	0.78±0.11(8.2)	0.79±0.07(7.1)	0.71±0.11(16.5)
DGGV-2	1.26±0.03	1.18±0.19(6.3)	0.83±0.13(34.1)	1.15±0.24(8.7)	1.18±0.13(6.3)	1.13±0.18(10.3)
DGG-3	0.74±0.08	0.69±0.14(6.8)	0.18±0.08(75.7)	0.67±0.22(9.5)	0.68±0.20(8.1)	0.62±0.21(16.2)
Selection-04	1.31±0.09	1.22±0.09(6.9)	0.80±0.10(38.9)	1.18±0.04(9.9)	1.21±0.12(7.6)	1.15±0.12(12.2)
IPM-02-14	1.37±0.05	1.30±0.11(5.1)	0.85±0.32()38.0	1.29±0.18(5.8)	1.29±0.21(5.8)	1.28±0.08(6.6)
DGG-6	1.03±0.07	0.95±0.15(7.8)	0.47±0.17()54.4	0.90±0.10(12.6)	0.89±0.26(13.6)	0.91±0.15(11.7)
DGG-7	1.29±0.07	1.23±0.06(4.7)	0.88±0.26(31.8)	1.13±0.16(12.4)	1.17±0.13(9.3)	1.19±0.18(7.8)
DGG-8	0.95±0.06	0.89±0.17(6.3)	0.40±0.21(57.9)	0.85±0.18(10.5)	0.84±0.21(11.6)	0.81±0.24(14.7)
Overall Mean	1.10±0.23	1.03±0.24(5.9)	0.61±0.30(46.9)	0.99±0.25(9.7)	1.01±0.26(8.7)	0.98±0.27(12.0)
	Varieties		Processing		Varieties x Processing (Interaction)	
S.Em±	0.05		0.04		0.13	
C.D.	0.10		0.08		NS	
F- value	42.50		30.56		0.15	

Figures in the parentheses indicate percentage decrease in fat content of greengram varieties over the control (raw) values

Mubarak (2005) (1.85-1.82%) and the decrease was attributed to their diffusion into cooking water.

Effect of processing methods on crude protein content of greengram varieties is presented in Table 3. The crude protein content in the raw greengram varieties varied between 26-28 g/ 100 g. In all the processing methods the crude protein content decreased significantly ($p<0.05$) except in germination method, where a significant increase in crude protein content (8.4%) was found. However, irrespective of greengram varieties the percentage of reduction in crude protein content of greengram varieties was the highest during boiling method (6.5%) followed by microwave cooking (6.1%) and pressure cooking methods (5%), whereas the least reduction was found during soaking (3.7%). Irrespective of processing treatments the percentage reduction of crude protein content was the lowest in the variety Selection-04 (4.3%). The increase in crude protein content during germination method could be attributed to the use of seed components during the germination process (Mubarak, 2005) and breakdown of complex protein into simple forms. Also synthesis of new proteins (*eg:* proteases) by germinating seeds and compositional change after degradation of other undesirable constituents. The decrease in the crude protein content had been reported by Mubarak (2005) in different methods like boiling, pressure cooking, microwave cooking methods and has been attributed to leaching during boiling and also due to protease resistance complex linkage formation and also recombination of amino acid residues and further solublization of some easy hydrolyzing components in cooking water (Fagbemi, 2007).

Effect of processing methods on crude fibre content of greengram varieties is presented in Table 4. The crude fibre content in the raw greengram varieties varied between 4.81-6.93 g/100 g. A significant decrease ($p<0.05$) was observed in crude fibre content in all the greengram varieties during different processing methods. Irrespective of greengram varieties percentage of reduction in crude fibre content of greengram varieties was the highest during boiling method (13.3%) followed by microwave cooking (12.9%), pressure cooking (10.4%) and germination (5.5%), whereas the least reduction was found during soaking (3.3%). Irrespective of processing treatments the percentage reduction of crude fibre content was the lowest in the variety DGG-6 (6.7%). The decrease in crude fibre content during soaking and cooking treatments could be attributed to the dilution effect of nutrients in processed and cooked samples

Table 3. Effect of processing methods on protein content of greengram varieties (g/100 g)

Varieties	Processing methods					
	Raw	Soaking	Germination	Boiling	Pressure cooking	Microwave cooking
DGG-1	27.56±0.87	26.74±0.44(-3.0)	30.67±0.56(+11.3)	25.46±0.52(-7.6)	26.24±0.33(-4.8)	25.58±0.58(-7.2)
DGGV-2	26.70±0.45	25.87±0.04(-3.1)	28.95±0.35(+8.4)	24.64±0.17(-7.7)	25.73±0.58(-3.6)	25.19±0.53(-5.7)
DGG-3	28.61±0.47	27.22±0.35(-4.9)	30.29±0.31(+5.9)	26.87±0.30(-6.1)	27.09±0.69(-5.3)	26.76±0.39(-6.5)
Selection-04	27.26±0.96	26.38±0.66(-3.2)	29.38±0.56(+7.8)	25.96±0.83(4.8)	26.13±0.44(-4.1)	25.92±0.33(-4.9)
IPM-02-14	26.00±0.41	25.04±0.81(-3.7)	28.62±0.36(+10.1)	24.45±0.14(-6.0)	24.95±0.18(-4.0)	24.38±0.56(-6.2)
DGG-6	26.82±0.19	25.86±0.36(-3.6)	28.72±0.37(+7.1)	25.18±0.90(-6.1)	25.32±0.50(-5.6)	25.25±0.79(-5.9)
DGG-7	26.40±0.19	25.52±0.31(-3.3)	28.13±0.77(+6.6)	24.60±0.33(-6.8)	25.13±0.74(-4.8)	24.74±0.42(-6.3)
DGG-8	27.65±0.38	26.24±0.28(-5.1)	30.35±0.29(+9.8)	25.80±0.35(-6.7)	25.61±0.40(-7.4)	25.93±0.36(-6.2)
Overall Mean	27.00±0.89	25.97±0.82(-3.7)	28.92±1.02(+8.4)	25.28±1.10(-6.5)	25.77±0.79(-5.0)	25.47±0.84(-6.1)
	Varieties		Processing		Varieties x Processing (Interaction)	
S.Em±	0.16		0.14		0.41	
C.D.	0.33		0.29		NS	
F- value	38.84		218.45		1.00	

Figures in the parentheses indicate percentage change in crude protein content of greengram varieties over the control (raw) values

Table 4. Effect of processing methods on crude fibre content of greengram varieties (g/100 g)

Varieties	Processing methods					
	Raw	Soaking	Germination	Boiling	Pressure cooking	Microwave cooking
DGG-1	5.75±0.02	5.55±0.02(3.5)	5.57±0.26(3.1)	4.85±0.13(15.7)	4.74±0.12(17.6)	4.90±0.11(14.8)
DGGV-2	5.97±0.05	5.74±0.27(3.9)	5.62±0.27(5.9)	5.38±0.14(9.9)	5.09±0.77(14.7)	5.33±0.36(10.7)
DGG-3	5.57±0.05	5.24±0.24(5.9)	5.32±0.24(4.5)	4.60±0.29(17.4)	4.82±0.17(13.5)	4.85±0.12(12.9)
Selection-04	6.93±0.07	6.76±0.24(2.5)	6.57±0.30(5.2)	5.86±0.27(15.4)	6.02±0.29(13.1)	6.25±0.26(9.8)
IPM-02-14	5.49±0.07	5.32±0.30(3.1)	5.19±0.32(5.5)	4.79±0.58(12.8)	4.80±0.22(12.6)	4.84±0.10(11.8)
DGG-6	5.50±0.02	5.29±0.20(3.8)	5.19±0.27(5.6)	4.99±0.47(9.3)	5.24±0.16(4.7)	4.94±0.46(10.2)
DGG-7	4.81±0.03	4.74±0.18(1.5)	4.28±0.50(6.1)	4.19±0.12(12.9)	4.11±0.38(14.6)	4.56±0.41(5.2)
DGG-8	5.21±0.05	5.09±0.30(2.3)	5.03±0.33(3.5)	4.51±0.55(13.4)	4.56±0.56(12.5)	4.79±0.53(8.1)
Overall Mean	5.65±0.59	5.47±0.61(3.3)	5.35±0.67(4.9)	4.90±0.59(13.3)	4.92±0.63(12.9)	5.06±0.58(10.4)
	Varieties		Processing		Varieties x Processing (Interaction)	
S.Em±	0.10		0.08		0.25	
CD	0.20		0.17		NS	
F- value	61.72		24.87		0.65	

Figures in the parentheses indicate percentage decrease in crude fibre content of greengram varieties over the control (raw) values

with increase in the moisture content. (Akaerue, 2010). Similar results were reported by Bhagya *et al.* (2007) in a wild mangrove cultivar where cooking drained crude fibre (2.1-12.8%) of beans. The crude fiber was reduced by germination method which confirms the report of the Mubarak (2005) and Singh *et al. (*2015).

Effect of processing methods on ash content of greengram varieties is presented in Table 5. The ash content in the raw greengram varieties varied between 3.45-3.82 g/100 g. A significant decrease ($p<0.05$) in ash content was observed among all the greengram varieties during different processing methods when compared with raw greengram. Irrespective of greengram varieties percentage of reduction in ash content of greengram varieties was the highest during boiling method (31.2%) followed by microwave cooking (21.2%), pressure cooking (8.1%) and soaking (5.6%), whereas the least reduction was found during germination method (5%). Irrespective of processing treatments the percentage reduction of ash content was the lowest in the variety DGG-1 (11.2%). The decrease in ash content during boiling, pressure cooking, microwave cooking might be due to a differential loss of minerals during the process of treatments employed. The substantial reduction of ash content in the processed seeds might be due to leaching of both micro and macro elements in to the water through the mechanically broken and enhanced permeability of seed coat, when compared to unprocessed seed sample.

Effect of processing methods on carbohydrate content of greengram varieties is presented in Table 6. The carbohydrate content in the raw greengram varieties varied between 50.90-53.42 g/100 g. In all the processing methods the carbohydrate content increased significantly ($p<0.05$) except in germination method where in significant decrease was found (6%). However, irrespective of greengram varieties the average increase of carbohydrate content was the highest during boiling (6.4%) followed by microwave cooking (5.3%) and pressure cooking (3.9%), whereas the least increase was found in soaking method (1.2%). Irrespective of processing treatments the average increase of carbohydrate content was the highest in the variety DGG-3 (3.2%). The decrease in carbohydrate content during germination method in the present study corresponded well to the results of Mubarak (2005) who found that germination caused significant ($p d< 0.05$) decrease in carbohydrate fractions in mung bean seeds (sugars and starch by 36.1%, 8.78%, respectively). This could be due to the enhanced hydrolytic enzyme activities that promoted starch digestibility and use of carbohydrates as an energy source to start germination. The carbohydrate content was significantly increased by cooking

Table 5. Effect of processing methods on ash content of greengram varieties (g/100 g)

Varieties	Processing methods					
	Raw	Soaking	Germination	Boiling	Pressure cooking	Microwave cooking
DGG-1	3.64±0.08	3.47±0.07(4.9)	3.43±0.08(6.0)	2.56±0.17(29.9)	3.37±0.05(7.7)	3.38±0.14(7.4)
DGGV-2	3.60±0.04	3.45±0.08(4.2)	3.47±0.09(3.6)	2.58±0.02(28.3)	3.38±0.22(6.1)	2.71±0.11(24.7)
DGG-3	3.82±0.08	3.58±0.11(6.3)	3.56±0.06(6.8)	2.53±0.06(33.8)	3.17±0.21(17.0)	3.12±0.13(18.3)
Selection-04	3.45±0.05	3.67±0.04(4.9)	3.78±0.05(2.1)	2.40±0.30(37.8)	3.64±0.08(5.7)	2.91±0.35(24.6)
IPM-02-14	3.65±0.03	3.55±0.06(6.6)	3.69±0.03(2.9)	2.57±0.08(32.4)	3.59±0.06(5.5)	2.85±0.05(25.0)
DGG-6	3.73±0.02	3.68±0.01(4.7)	3.56±0.03(7.8)	2.77±0.08(28.2)	3.64±0.05(5.7)	3.11±0.12(19.4)
DGG-7	3.68±0.06	3.49±0.12(5.2)	3.49±0.03(5.2)	2.63±0.33(28.5)	3.38±0.14(8.2)	2.51±0.08(31.8)
DGG-8	3.48±0.02	3.48±0.07(7.9)	3.56±0.08(5.8)	2.63±0.01(30.4)	3.44±0.08(9.0)	3.09±0.26(18.3)
Overall Mean	3.63±0.13	3.55±0.11(5.6)	3.57±0.12(5.0)	2.58±0.18(31.2)	3.45±0.19(8.1)	2.96±0.30(21.2)
	Varieties		Processing		Varieties x Processing (Interaction)	
S.Em±	0.04		0.04		0.10	
CD	0.08		0.07		0.20	
F- value	5.70		276.78		4.71	

Figures in the parentheses indicate percentage decrease in ash content of greengram varieties over the control (raw) values

Table 6. Effect of processing methods on CHO content of greengram varieties (g/100 g)

Varieties	Processing methods					
	Raw	Soaking	Germination	Boiling	Pressure cooking	Microwave cooking
DGG-1	51.73±0.37	52.16±0.58(+0.8)	47.90±0.61(-7.4)	55.57±0.62(+7.4)	53.98±0.51(+5.8)	54.71±0.78(+2.2)
DGGV-2	52.11±0.51	52.69±0.37(+0.1)	49.10±0.86(-5.8)	55.56±0.55(+6.6)	53.80±0.70(+5.6)	55.04±0.39(+2.2)
DGG-3	50.90±0.54	52.16±0.45(+2.5)	48.45±0.64(-4.8)	54.52±0.59(+7.1)	53.63±0.33(+5.9)	53.92±0.48(+3.2)
Selection-04	51.01±1.04	51.06±0.64(+0.1)	47.54±0.92(-6.8)	54.18±0.63(+6.2)	52.67±1.04(+4.4)	53.26±0.63(+1.4)
IPM-02-14	53.42±0.34	54.06±0.46(+1.2)	49.67±1.02(-7.0)	56.37±0.70(+5.5)	54.98±0.55(+5.4)	56.31±0.66(+1.6)
DGG-6	52.73±0.20	53.40±0.34(+1.3)	50.23±0.66(-4.7)	55.71±1.20(+5.6)	54.35±1.02(+4.8)	55.27±1.27(+2.0)
DGG-7	53.34±0.23	53.87±0.11(+1.0)	51.09±0.43(-4.2)	56.72±0.72(+6.3)	55.41±0.52(+5.5)	56.28±1.27(+2.5)
DGG-8	52.33±0.61	53.19±0.11(+1.6)	48.36±0.41(-7.6)	55.51±0.95(+6.1)	54.92±0.68(+4.7)	54.78±0.94(+2.0)
Overall Mean	52.20±1.02	52.82±1.03(+1.2)	49.04±1.31(-6.0)	55.52±1.03(+6.4)	54.22±1.03(+5.3)	54.95±1.24(+2.1)
	Varieties		Processing		Varieties x Processing (Interaction)	
S.Em±	0.23		0.20		0.56	
C.D.	0.46		0.39		NS	
F- value	33.88		282.24		0.85	

Figures in the parentheses indicate percentage change in carbohydrate content of greengram varieties over the control (raw) values

treatments (boiling, pressure cooking and microwave cooking probably due to the heat involved, intern which reduced the other components as a result of denaturation and leaching, leading to an increase in carbohydrate contents. These results were in agreement with the findings of Mubarak (2005) for mungbean seeds wherein he reported that the increment in carbohydrate content of mung bean seeds observed after cooking treatments was significant (pd< 0.05).

Conclusion

From the present study it was concluded that soaking, germination, boiling, pressure cooking and microwave cooking influenced the proximate composition of greengram varieties. Among the processing treatments germination and cooking by pressure and microwave methods were found to be more effective in retention of crude protein, crude fibre, and ash when compared to other processing methods.

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