Asian Journal of Home Science (June to November, 2009) Vol. 4 No. 1 : 76-80

Comparative nutritional analysis of products developed from brinjal grown under canal water and sodic water treated with amendments

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Accepted : *March, 2009*

ABSTRACT

Quality of irrigation water affects the crop yield, physical characteristics and nutrient composition of vegetables. Present study, therefore was designed to observe the ameliorating effect of gypsum and farm yard manure on nutritional quality of products prepared with the brinjal grown under sodic water. Bulk samples of brinjal being grown under soil irrigated with canal water (control) and sodic water treated with gypsum and FYM to neutralize 50 % sodicity (G_1F_2) and to neutralize complete sodicity (G_2F_2) were obtained from the Vegetable Research Farm, CCS Haryana Agricultural University, Hisar. Three types of brinjal products *i.e. bharta*, *brinjal pakoda* and *brinjal potato vegetable* were developed and were analyzed for proximate composition and carbohydrate and dietary fibre profile. Contents of protein, fat, crude fibre, ash, carbohydrate and total soluble sugars among three types of brinjal products ranged from 11.70-19.82, 11.27-26.65, 5.50-15.55, 4.95-9.30, 39.88-55.84 and 3.40-4.66 per cent (DM), respectively. All three brinjal products prepared using brinjal irrigated with G_1F_2 treated water contained ($P<0.05$) lower amount of protein, fat, crude fibre and total dietary fibre, but significantly higher contents of ash, carbohydrates, total soluble sugar, oxalic acid and polyphenols than those irrigated with canal water and G_2F_2 treated water. It may be concluded that use of amendments *i.e.* gypsum and FYM under sodic condition improved the nutrient composition of vegetable products prepared with brinjal grown under sodic water. Complete neutralization of sodicity with these amendments is required to produce the healthy vegetables and their products.

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Key words : Proximate, Brinjal products, Dietary fibre, Antinutrients, Sodic water, Gypsum, Farm yard manure

Brinjal (*Solanum melongena* L.) also known as eggplant or aubergine belongs to the family Solanaceae. It is one of the most popular and principal vegetables crops commonly grown as annual plant all over the world. Brinjal, being quite high in nutritive value, has been an important component of human diet since ancient times and can be well compared with tomato (Anonymous, 2007). In India, area under brinjal cultivation is estimated at 0.51 million ha with total production of 8,200,000 Mt (FAO, 2005). *Bharta*, *brinjal pakoda*, baked brinjal and *brinjal potato vegetable* are main products prepared with brinjal. Quality of irrigation water affects the crop yield, physical characteristics (Rani *et al*., 2008) and nutrient composition of vegetables being grown under that situation. Sodic water is characterized by low total salt concentration (EC < 4 dS/m), sodium absorption ratio (>10 m.mol L^{-1}) and residual sodium carbonate (> 2.5 me/L). Continuous use of sodic water for irrigation as such causes soil sodification and at the same time it adversely affects the plant growth and yield of crop under most situations (Yadav *et al.*, 2002). Soil amendments like gypsum ($CaSO_4$) and FYM have been found useful under sodic water irrigation. Soil irrigated with sodic water for a long time becomes deficient in calcium and addition of gypsum to that soil meets that requirement. On the other hand, sodic water affects the physical properties of soil, in that situation farm yard manure improves the physical properties of soil and further improves the performance of the crop. Though the researches have been done in India and abroad to observe the effect of sodic water on yield and quality of some crops, and use of amendments under sodic condition. But no research has been done on nutritional analysis of products prepared with vegetables grown under sodic water with the ameliorating effect of gypsum and farm yard manure. Present study, therefore was designed to observe the ameliorating effect of gypsum and farm yard manure on nutritional analysis of products prepared with the brinjal grown under sodic water.

METHODOLOGY

Procurement of material:

Bulk samples of brinjal variety (HE-12) being grown under soil irrigated with canal water (control) and soil irrigated with sodic water having RSC (Residual Sodium Carbonate) 11.5 meq/l, treated with gypsum and FYM *i.e.* (G_1F_2): 50% neutralization of RSC with gypsum + 20 tons FYM/ha and (G_2F_2): 100% neutralization of RSC with gypsum + 20 tons FYM/ha were obtained from the Vegetable Research Farm, CCS Haryana Agricultural University, Hisar. Three types of brinjal products, *bharta*, *brinjal pakoda* and brinjal potato vegetable were

developed using standard recipes (Rani *et al.*, 2008). Other ingredients used in development of brinjal products were purchased from the local market, Hisar in a single lot. Ionic composition and quality parameters of sodic water used in experiment have been shown in Table 1.

Table 1 : Ionic composition and quality parameters of sodic water

Ion/parameter	Values
CO^{2-}_3	0.7 (me l^{-1})
HCO^{-}_3	13.3 (me l^{-1})
Ca^{2+}	1.0 (me l^{-1})
Mg^{2+}	1.5 (me l^{-1})
Na^{+}	15.8 (me l^{-1})
Cl^{-}	4.0 (me l^{-1})
SO_4^{2-}	6.0 (me l^{-1})
EC	2.4 (dSm^{-1})
RSC_{iw}	11.5 (me l^{-1})
SAR_{iw}	14.0 (m mol $l^{-1})^{½}$

Nutritional analysis:

Finely grounded and moisture free samples of brinjal products were used for nutrient analysis. Moisture, crude fat, ash, total nitrogen, crude fibre and total carbohydrates by difference method were estimated in by employing the standard method of analysis (AOAC, 1995). Crude fat was estimated using soxhlet apparatus. A factor of 6.25 was applied to convert the amount of nitrogen to crude protein.

Total soluble sugars were extracted by the method of Cerning and Guilhot (1973). Reducing sugars were estimated by Somogyi's modified method (Somogyi, 1945). Amount of non-reducing sugars was calculated as the difference between the amounts of total soluble sugars and reducing sugars. Starch from the sugar free pellet was estimated by employing the method of Clegg (1956).

Dietary fibre constituent in brinjal sample was estimated by employing the method of AOAC (1995). Oxalic acid in all vegetable samples was estimated by employing the method (NIN, 1983). Polyphenolic compounds were extracted from the sample by the method given by Singh and Jambunathan (1981).

Statistically analysis:

Statistically data were analyzed using SPSS statistical package (version 11.0) for windows (SPSS Inc., Chicago IL, USA). Mean ± SE of three independent determinations were calculated. ANOVA was done to determine differences in nutrient composition among three types of brinjal products.

RESULTS AND DISCUSSION

Proximate composition:

The results of proximate composition of *bharta*, *pakoda* and brinjal-potato vegetable prepared from brinjal given different water treatments for irrigation have been presented in Table 2. Moisture, protein, fat, crude fibre, ash and carbohydrate contents among different types of brinjal products ranged from 44.97-86.46,11.70-19.82, 11.27-26.65, 5.50-15.55, 4.95-9.30 and 39.88-55.84 per cent, respectively. Different water treatments given to brinjal crop did not effect the moisture content of its products. Irrespective of water treatments, out of three brinjal products, brinjal-potato vegetable had higher moisture content followed by *bharta* and *pakoda*. High moisture content of brinjal-potato vegetable most probably due to pressure cooking. More moisture might have been retained in the vegetables through pressure cooking than roasting sauting and frying methods. Similar content of the moisture in *bharta* was observed by Bhupinder and Harinder (1992).

Type I *bharta*, *pakoda* and brinjal-potato vegetable prepared with the brinjal irrigated with G_1F_2 treatment (50% neutralization of sodicity) contained significantly ($P<0.05$) less protein, fat and crude fibre but high ash and carbohydrate contents than the control products prepared with the brinjal irrigated with canal water and type II products prepared with the brinjal irrigated with G_2F_2 treatment (complete neutralization of sodicity). On the other hand, type II and control products had almost similar protein, fat, crude fibre, ash and carbohydrate contents. Irrespective of water treatments used for irrigation of brinjal crop, out of three brinjal products *bharta* contained higher ash and crude fibre content, the content of protein and carbohydrates were higher in brinjal-potato vegetable, whereas *pakoda* had the highest fat content. The varying proximate composition might be due to different cooking methods applied in the preparation of various products and also probably due to variation in the type and amount of ingredients used in the product recipes. These findings corroborate with those of Alvi *et al.* (2003) and Kala and Prakash (2006).

This decrease in protein content might be because of less content of protein in brinjal grown under sodic condition due to the competition between ions present in sodic water (chloride, carbonates and bicarbonates) and nitrates present in soil at the same absorption site, which ultimately caused reduced uptake of NO_3 and nitrogen. The higher ash content of products prepared using brinjal irrigated with G_1F_2 treated water might be associated with the higher but misbalanced mineral contents of brinjal grown under G_1F_2 treatment. Nitrogen content was found

Table 2 : Effect of gypsum and FYM on proximate composition of products prepared using brinjal grown under sodic condition (%, on dry matter basis)

Treatments	Moisture*	Protein	Fat	Crude fibre	Ash	Carbohydrate
Brinjal *bharta*						
Control	73.83±0.48	15.74±0.48	21.45±0.34	15.55±0.32	7.00±0.17	40.26±0.72
Type-I	73.51±0.29	11.74±0.32	18.49±0.40	13.55±0.26	9.30±0.29	46.92±0.82
Type-II	73.79±0.37	16.42±0.27	21.31±0.35	15.44±0.31	6.95±0.17	39.88±0.91
C.D. (P=0.05)	NS	1.28	1.26	1.01	0.76	2.85
Brinjal *pakoda*						
Control	45.14±0.25	14.32±0.36	26.65±0.78	6.23±0.36	5.00±0.15	47.80±0.69
Type-I	44.97±0.27	11.70±0.23	24.50±0.46	5.50±0.23	6.50±0.23	51.80±0.86
Type-II	45.12±0.30	14.77±0.31	26.48±0.45	6.18±0.16	4.95±0.26	47.62±0.70
C.D. (P=0.05)	NS	1.04	2.02	0.42	0.76	2.62
Brinjal-potato vegetable						
Control	86.46±0.43	19.00±0.23	12.90±0.34	11.50±0.23	6.55±0.25	50.05±0.66
Type-I	86.10±0.23	14.17±0.21	11.27±0.27	10.02±0.18	8.70±0.23	55.84±1.00
Type-II	86.43±0.25	19.82±0.36	12.82±0.25	11.42±0.31	6.50±0.22	49.44±0.83
C.D. (P=0.05)	NS	0.96	1.01	0.85	0.81	2.92

Values are mean±SE of three independent determinations

* Moisture content was analyzed on fresh weight basis

Control: Products prepared with brinjal irrigated with canal water

Type I: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_1F_2 (50% neutralization of sodicity)

Type II: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_2F_2 (100% neutralization of sodicity)

to be higher in potatoes produced with irrigation of canal water and decreased with increase in sodicity, the maximum nitrogen content (0.1.6 g kg^{-1}) was observed in FYM 20t/ha + gypsum 5.4t/ha where sodicity was 100 per cent neutralized (Singh *et al.*, 2002).

Carbohydrate profile:

Among three types of *bharta*, *pakoda* and brinjal-potato vegetable, the content of total soluble sugar varied from 3.60-4.10, 3.40-3.87 and 4.10-4.66 per cent, respectively on dry matter basis (Table 3). Reducing sugar and starch contents of all brinjal products were almost the same irrespective of water treatments used for irrigation. Brinjal *pakoda* and brinjal-potato vegetable had similar values for total soluble and non-reducing sugar, irrespective of the fact whether the brinjals used were irrigated with canal water or G_1F_2 and G_2F_2 treated water. On the other hand, the brinjal *bharta* (type I) prepared from brinjal grown under G_1F_2 treatment had significantly ($P<0.05$) higher total soluble and non-reducing sugars than control and type II products. Out of three products, brinjal-potato vegetable had higher sugars and starch which might be due to use of mild heat treatment which would have increased the sugar content and the use of potato having higher starch content in the vegetable.

Dietary fibre constituent:

Total soluble and insoluble dietary fibre of various types of brinjal products varied from 27.90-40.57, 10.47-11.86 and 17.43-28.71 per cent, respectively on dry matter basis (Table 4). Three types of brinjal *bharta* had almost similar total, soluble and insoluble dietary fibre whether the brinjals used in their preparation were irrigated with canal water or G_1F_2 and G_2F_2 treated water. On the other hand, type I *pakoda* had significantly ($P<0.05$) lower total and insoluble dietary fibre than control and type II *pakoda*. Similarly, type I brinjal-potato vegetable also contained significantly ($P<0.05$) lower extent of total dietary fibre than control and type II brinjal-potato vegetable. Irrespective of water treatments given to brinjal, out of three brinjal products, *pakoda* had lower dietary fibre constituents than rest of the two products *i.e. bharta* and brinjal-potato vegetable. This might be due to variation in type and amounts of ingredients used in the preparation of various products. Similar results were reported by previous workers (Khanum *et al.*, 2000; Kala and Prakash, 2006).

Antinutrients:

The contents of oxalic acid and polyphenols among different types of brinjal products ranged from 120.05-132.50 and 1067.00-1610.00 mg per 100g, respectively (Table 5). Type I products had significantly ($P<0.05$) higher oxalic and polyphenols than control and type II products whereas control and type II products had almost similar amount of these antinutrients. Irrespective of water

Table 3 : Effect of gypsum and FYM on sugar and starch contents of products prepared using brinjal grown under sodic condition (%, on dry matter basis)

Treatments	Total soluble sugar	Reducing sugar	Non-reducing sugar	Starch
Brinjal *bharta*				
Control	3.60±0.11	1.00±0.08	2.60±0.03	28.59±0.74
Type-I	4.10±0.12	1.10±0.08	3.00±0.10	27.93±0.54
Type-II	3.69±0.16	0.98±0.10	2.71±0.06	28.39±0.40
CD (P<0.05)	0.46	NS	0.25	NS
Brinjal *pakoda*				
Control	3.40±0.20	0.72±0.04	2.68±0.16	26.95±0.34
Type-I	3.87±0.21	0.79±0.03	3.08±0.18	26.32±0.55
Type-II	3.50±0.23	0.71±0.04	2.79±0.18	26.76±0.19
CD (P<0.05)	NS	NS	NS	NS
Brinjal-potato vegetable				
Control	4.10±0.17	1.30±0.08	2.80±0.08	55.00±0.66
Type-I	4.66±0.32	1.43±0.03	3.23±0.29	53.73±0.71
Type-II	4.20±0.18	1.28±0.04	2.42±0.61	54.62±0.82
CD (P<0.05)	NS	NS	NS	NS

Values are mean±SE of three independent determinations
Control: Products prepared with brinjal irrigated with canal water
Type I: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_1F_2 (50% neutralization of sodicity)
Type II: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_2F_2 (100% neutralization of sodicity)

Table 4 : Effect of gypsum and FYM on dietary fibre constituents of products prepared using brinjal grown under sodic condition (%, on dry matter basis)

Treatments	Total dietary fibre	Soluble dietary fibre	Insoluble dietary fibre
Brinjal *bharta*			
Control	40.57±0.56	11.86±0.49	28.71±0.06
Type-I	38.60±0.69	11.26±0.30	27.34±0.38
Type-II	40.30±0.46	11.80±0.32	28.50±0.78
CD (P<0.05)	NS	NS	NS
Brinjal *pakoda*			
Control	29.33±0.48	11.02±0.21	18.31±0.26
Type-I	27.90±0.46	10.47±0.34	17.43±0.80
Type-II	29.14±0.38	10.95±0.20	18.19±0.58
CD (P<0.05)	1.03	NS	0.86
Brinjal-potato vegetable			
Control	35.29±0.70	11.50±0.24	23.79±0.45
Type-I	33.70±0.30	10.92±0.37	22.78±0.67
Type-II	35.09±0.71	11.43±0.48	23.66±0.16
CD (P<0.05)	1.81	NS	NS

Values are mean±SE of three independent determinations
Control: Products prepared with brinjal irrigated with canal water
Type I: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_1F_2 (50% neutralization of sodicity)
Type II: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_2F_2 (100% neutralization of sodicity)

treatments, out of three products, brinjal-potato vegetable contained the highest amount of oxalic acid whereas the polyphenols were higher in brinjal *pakoda*. In brinjal-potato vegetable, incorporation of potato might have led to higher oxalic acid as potato contains more oxalic acid than brinjal. Similarly the added chickpea flour in *pakoda* might have increased the contents of polyphenols.

Conclusion:

Brinjal products *i.e. bharta*, *pakoda* and brinjal potato vegetable prepared with brinjals grown under G_1F_2 treatment where the sodicity was neutralized upto 50 % with gypsum and physical properties of soil were improved by FYM, had significantly less protein, fat and crude fibre but higher ash, sugars, oxalic acid and polyphenols.

Contents of protein, fat and crude fibre were increased ($P<0.05$) in all three products as the brinjals grown under G_2F_2 treatment (complete neutralization of sodicity) were used in their preparations, whereas these compositions were statistically at par in products prepared with brinjals grown under canal water. It may be concluded from the results of present study that complete neutralization of sodicity with best amendments like gypsum and farm yard manure is required to improve the nutrient composition of vegetables and further processed products with these vegetables as equal to vegetables growing with safe water.

Table 5 : Effect of gypsum and FYM on antinutrient content of products prepared using brinjal grown under sodic condition (mg/100g, on dry matter basis)

Treatments	Oxalic acid	Polyphenols
Brinjal *bharta*		
Control	120.05±0.49	1347.20±3.12
Type-I	122.86±0.90	1392.42±4.34
Type-II	120.40±0.40	1334.88±3.76
C.D. (P=0.05)	2.20	13.06
Brinjal pakoda		
Control	125.00±1.15	1557.50±4.62
Type-I	127.89±1.10	1610.00±5.20
Type-II	125.32±0.76	1540.00±4.33
C.D. (P=0.05)	2.52	18.36
Brinjal - potato vegetable		
Control	129.70±0.98	1079.25±5.05
Type-I	132.50±0.75	1115.50±4.73
Type-II	130.00±1.15	1067.00±4.62
C.D. (P=0.05)	2.37	16.62

Values are mean±SE of three independent determinations
Control: Products prepared with brinjal irrigated with canal water
Type I: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_1F_2 (50% neutralization of sodicity)
Type II: Products prepared with brinjal irrigated with sodic water (RSC 11.5 Me l^{-1}) treated with G_2F_2 (100% neutralization of sodicity)

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