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Effect of reconstitution and urea treatments of *bajra* grain (*Pennisetum typhoideum*) on its chemical and physical characteristics

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ABSTRACT

Bajra grain was reconstituted by adding sufficient amount of water to raise the moisture content to 28%. For urea treatments, 1, 4, 6 and 10% urea (w/w) was dissolved in calculated quantity of water to be added to the grain to raise its moisture content to the same level to that of reconstitution. The untreated, reconstituted and urea treated grain, in triplicate, were stored in oxygen limiting atmosphere in polythene bags for 21 days. Crude protein (CP) of *bajra* grain increased slightly but nonsignificantly due to reconstitution, however, the significantly ($P<0.01$) increasing trend of CP was observed in 1, 4, 6 and 10% urea treated grain. Nitrogen free extract (NFE) content was significantly higher in raw, reconstituted and 1% urea treated grain as compared to other urea treatments. The DM loss was lowest in 1% and was highest in 6% urea treated grain. The pH decreased due to reconstitution while urea treatments increased it. Lactic acid increased from 0.39% in raw to 2.21% in reconstituted grain, however, in urea treated grain it was non detectable. Starch content significantly decreased due to reconstitution and urea treatment of grain, whereas total sugars and reducing sugars content increased. Loss of urea nitrogen increased significantly with the increase in urea level. On aeration, fungus appeared in reconstituted grain on sixth day, in 1% urea treated on ninth day, but in 4, 6 and 10% urea treated grain no fungus was visible up to 13 days. Maximum rise in temperature was observed 1 day after incubation of grain and it was maximum 30°C in reconstituted grain and minimum 18°C in 6% urea treated grain. Reconstitution of *bajra* grain increased its nitrogen solubility, irrespective of the solvents used.

Key words: Animal nutrition, *Bajra* grain reconstitution, Chemical parameters, *Pennisetum typhoideum*, Physical parameters, Urea treatment

The chemical composition of *bajra* grain is comparable to barley, but the digestible crude protein and total digestible nutrients in *bajra* are 5.1 and 60.6% in comparison to barley 7.4 and 86.0%, respectively (Ranjhan 1991). The reason for the difference in nutritive value between *bajra* grain and barley are unknown, however, Hale and Theurer (1972) reported that the poor nutritive value of millets is mainly owing to the insoluble protein fraction, which encapsulate the starch granules making them unavailable to the animal system. Simpson *et al.* (1985), Kishore *et al.* (1993), Singh and Lohan (1998) and Raman *et al.* (1999) reported that reconstitution improved the protein solubility, resulting in increased nutritive value without adding much to the cost of feeding. Mixing urea with sorghum grain prevents mould growth and is an effective method of preserving high moisture grain (Russel *et al.* 1988). Electron micrographs showed the starch granules of urea treated grain to be less crystalline and therefore, they should be more easily digested than the untreated grain (Hill *et al.* 1991). Moreover, if urea is added at the time of reconstitution, the product can be used as a concentrate or protein supplement. The present study is an attempt to see the effect of reconstitution and urea treatments of *bajra* grain on its physical and chemical characteristics.

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MATERIALS AND METHODS

Reconstitution was performed by adding sufficient quantity of water to raise the moisture content of *bajra* grain to 28%. For urea treatment 1, 4, 6 and 10% urea (w/w) was dissolved in calculated quantity of water so as to raise the moisture content of *bajra* grain to the same level that of reconstitution. The untreated (T_1), reconstituted (T_2), urea with 1 (T_3), 4 (T_4), 6 (T_5) and 10% (T_6) treated *bajra* grain in triplicate was stored in an oxygen limiting atmosphere in polythene bags. After the incubation period of 21 days, representative wet samples were taken for the estimation of pH, lactic acid, visible fungal development and nitrogen loss;

the other parameters were determined after drying the sample in hot air oven. The prepared samples were analyzed for DM, N, CP, EE, CF, TA, reducing sugar, Ca and P contents (AOAC 1990). Starch (Mc Cready *et al.* 1950) and lactic acid (Barker and Summerson 1941) were determined and pH was recorded by using digital pH meter (5 g sample + 50 ml water, shaken for 1 hr, filtered and pH recorded). Total sugars (Dubois *et al.* 1956) and nitrogen solubility (Wohlt *et al.* 1973) were determined. For visual fungal growth, samples (400 g each) were kept in open containers in laboratory at room temperature (16 to 20°C) and relative humidity (60 to 70%) and daily observations were taken. For recording temperature variation, *bajra* grain 5 kg each were given different treatments in triplicate, which were then filled in polythene bags, sealed and placed in plastic buckets having a thick layer of wheat straw and mud at the bottom. The space between the bag and bucket was filled tightly with wheat straw and mud. High neck thermometers were inserted into bags to reach the centre of the bag. Adhesive plaster was stuck around the thermometer and polythene bag at the point pierced. The bucket was filled with wheat straw and the top was plastered with mud. The temperatures were recorded daily at 9 AM. The data were statistically analysed (Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

The data related to proximate constituents and macro minerals of raw, reconstituted and urea treated *bajra* grain are presented in Table 1. The DM content in reconstituted and urea treated *bajra* grain was significantly (P<0.01) lower as compared to raw *bajra* grain, which might be due to addition of water at the time of processing. Naturally, the CP of the product was higher (P<0.01) due to addition of urea and the level of CP content increased with an increase in the level of urea added. Otherwise there was no effect of the processing technique on the CP content. Singh and Lohan (1998) also reported similar results in reconstituted *bajra* grain. The EE content due to reconstitution remained uninfluenced (P<0.01). The EE content decreased due to urea treatment being significantly (P<0.01) lower in T_5 and T_6 than in T_1, T_2, T_3 and T_4 treatments. This difference was due to the addition of higher level of urea in T_5 and T_6 which replaced a substantial amount of grain and hence decreased EE content. The NFE content in T_1, T_2, T_3 was significantly (P<0.01) higher than the content in T_4, and T_5 whereas, in T_6 the content was lowest (P<0.01) as compared to other treatments. Addition of urea decreased NFE content, which might be due to the weight of urea that replaced the weight of grain in urea, treated grain. The contents of CF, total ash, Ca and P did not differ (P<0.01) amongst the treatments.

The results pertaining to the effect of reconstitution and urea treatments on DM loss, pH, lactic acid, starch, total and reducing sugars of raw and treated *bajra* grain are presented in Table 2. The DM loss was maximum (P<0.01) in T_6 followed by T_5, T_4, T_2 and was minimum in T_3 (P<0.01). The DM loss due to reconstitution (T_2) was lower than the reported value of DM loss (2.4%) in sorghum grain when reconstituted at 30% moisture (Simpson *et al.* 1985). Minimum loss of DM in T_3 indicated that urea when added @ 1% in the grain acted as a preservative and hence reduced the DM loss that occurred in reconstituted grain. Increase in DM loss due to the increase in the urea level in grain indicated that the loss of ammonia present in free form after reconstitution added towards the DM loss of grain. In untreated raw *bajra* the pH was near to neutral. In T_2 due to reconstitution pH decreased significantly (P<0.01) and was acidic. The acidic pH of the reconstituted grain was due to the production of lactic acid in anaerobic fermentation and was in line with the pH 4.4 as reported by Hale (1980) in reconstituted sorghum grain and pH 4.22 as reported by Stock *et al.* (1991) in reconstituted corn. In urea treated grain the alkaline pH was because of ammonia released from urea. Russel *et al.* (1988) reported that added urea was hydrolysed to ammonia and increased pH to 9.2 in milo. Lactic acid content was 0.39% in raw and 2.21% in reconstituted *bajra* grain, and the differences were significant (P<0.01). Similar increase in lactic acid from 0.01% in dry corn to 1.06% in reconstituted corn was reported

Table 1. Effect of reconstitution and urea treatments on the proximate consitutuents and macro minerals of *bajra* grain (% DM basis)

Parameters	Treatments						CD
	T_1	T_2	T_3	T_4	T_5	T_6	
DM	89.64^a±0.42	71.60^b±0.46	71.63^b±0.80	71.20^b±1.05	71.55^b±0.78	71.69^b±0.92	4.02**
CP	13.56^e±0.23	13.71^e±0.27	15.48^d±0.28	20.03^c±0.35	22.12^b±0.68	30.31^a±0.72	2.01**
EE	4.77^a±0.37	5.17^a±0.13	4.51^a±0.12	4.43^a±0.29	3.39^b±0.24	3.34^b±0.10	1.08**
CF	1.55±0.11	1.60±0.06	1.45±0.16	1.39±0.04	1.33±0.09	1.28±0.05	NS
NFE	78.73^a±1.01	78.12^a±0.92	77.17^a±0.74	72.77^b±0.77	71.86^b±1.05	63.85^c±1.29	4.24**
Total ash	1.39±0.08	1.40±0.02	1.39±0.03	1.38±0.05	1.30±0.03	1.22±0.21	NS
Ca (mg/100 g)	84.33±2.67	85.33±3.00	85.01±5.67	81.33±6.01	78.67±2.73	73.67±2.33	NS
P (mg/100 g)	480.67±6.69	481.33±6.96	478.00±8.39	474.33±14.84	471.00±12.17	466.67±9.13	NS

Each figure is an average of 3 observations; a, b, c, d, e values in a row with different superscripts differ significantly (P<0.01); NS, nonsignificant.

Table 2. Effect of reconstitution and urea treatments on DM loss pH, lactic acid, starch, total and reducing sugars of *bajra* grain

Parameters	Treatments						CD
	T_1	T_2	T_3	T_4	T_5	T_6	
DM loss (%)	–	1.64^{c}±0.15	0.39^{e}±0.03	2.31^{c}±0.08	2.88^{b}±0.05	3.85^{a}±0.04	0.38**
pH	6.04^{d}±0.01	4.33^{e}±0.02	7.53^{c}±0.06	9.01^{b}±0.01	9.09^{ab}±0.01	9.14^{a}±0.02	0.12**
Lactic acid (%)	0.39^{b}±0.02	2.21^{a}±0.07	ND	ND	ND	ND	0.32**
Starch (%)	66.36^{a}±1.20	65.77^{a}±1.73	64.65^{a}±3.33	63.20^{ab}±0.66	60.06^{ab}±0.66	55.48^{b}±2.11	8.13**
Total sugars (%)	2.34^{d}±0.02	2.97^{c}±0.04	3.98^{b}±0.03	4.25^{a}±0.11	4.33^{a}±0.03	4.10^{a}±0.10	0.29**
Reducing sugars (%)	0.46^{d}±0.02	0.60 c±0.01	0.72^{b}±0.01	0.87^{a}±0.02	0.92^{a}±0.01	0.87^{a}±0.02	0.07**

Each figure is an average of 3 observations; a, b, c, d, e values in a row with different superscripts differ significantly (P<0.01); ND, Not detectable.

by Stock *et al.* (1991). The lactic acid in urea treated grain was not detectable; this might be due to the alkaline pH in these treatments and presence of ammonia in free form. Starch in T_1, T_2, and T_3 was significantly (P<0.01) higher than the content in T_6.The decrease in starch of grain due to different treatments may be attributed to its conversion to sugars. Reconstitution increased (P<0.01) total and reducing sugar contents in *bajra* grain. The results are in line with the results reported by Kishore *et al.* (1993) and Singh and Lohan (1998). Total and reducing sugar contents increased due to urea treatments and the values were higher (P<0.01) than the values in $T_1$and T_2. Among urea treatments, total and reducing sugar contents were significantly (P<0.01) higher in T_4, T_5 and T_6 than that in T_3, the differences among T_4, T_5 and T_6 were nonsignificant.

The losses of urea nitrogen in urea treated grain are presented in Table 3. The losses of urea nitrogen in urea treated grain during incubation period of 21 days was minimum (P<0.01) in T_3 followed by T_4 and was maximum (P<0.01) in T_6, while the differences between T_3 and T_4 and between T_4, and T_5were nonsignificant. The losses increased with an increase in urea level in grain. Small losses of urea nitrogen during incubation period are in line with Ørskov *et al.* (1974, 1979) who reported minimal losses of nitrogen from urea treated grain after 5 to 6 months of storage and besides, Russell *et al.* (1988) reported no loss of nitrogen from urea treated milo during storage. The urea nitrogen losses after incubation followed by 24 hr aeration, 48 hr aeration and drying in oven for 48 hr at 50°C were significantly (P<0.01) higher in T_5 followed by T_4 and T_6 and were minimum (P<0.01) in T_3. The nitrogen losses increased with the increase in urea level except in T_6. This might be due to the reason that when the grain was treated at higher level of urea (10%) and low level of moisture (28%) the whole of urea could have not been hydrolysed and hence resulted in less urea nitrogen losses. Ghate and Belanski (1981) reported that moisture content of grain influences the rate of urea hydrolysed. It is revealed from the data presented that most of the urea nitrogen present in the form of ammonia was removed from grain within 24 h aeration, there was only a small increase in urea nitrogen loss when the grain were aerated for 48 hr. The urea nitrogen loss at 48 hr aeration and at 48 hr oven drying at 50°C are almost at par, this indicated that almost all the free ammonia is removed from grain within 48 hr aeration. Large losses of urea nitrogen during aeration are in line with the large losses during the first week after reconstitution reported by Russell *et al.* (1988).

The results to the effect of reconstitution and urea treatments on visible fungal growth are presented in Table 4. Up to 5 days after aeration no fungus was visible on aerated grain in any of the treatments. The fungus growth was more

Table 3. Loss of urea nitrogen in urea treated *bajra* grain

Treatments	Initial nitrogen (%)			Urea nitrogen loss (%)			
	Bajra grain	Urea	Total	During incubation	24 h aeration	48 h aeration	48 h oven drying at 50°C
T3	2.17	0.46	2.63	0.44^{c}±0.11	28.26^{c}±1.06	33.04^{c}±1.64	33.26^{c}±1.69
T4	2.17	1.84	4.01	1.20^{bc}±0.09	39.19^{b}±1.05	42.88^{b}±1.46	43.76^{b}±1.50
T5	2.17	2.76	4.93	1.45^{b}±0.16	45.80^{a}±0.96	49.02^{a}±1.52	50.40^{a}±1.58
T6	2.17	4.60	6.77	2.17^{a}±0.31	37.41^{b}±0.35	40.61^{a}±0.23	41.78^{b}±0.43
CD				0.90**	4.30**	6.04**	6.40**

Each figure is an average of 3 observations; a, b, c values in a column with different superscripts differ significantly (P<0.01); T_1, T_4, T_5 and T_6 are 1, 4, 6, and 10% urea treated groups, respectively.

Table 4. Effect of processing on visual fungal growth in *bajra* grain at room temperature (16 to 20°C) and RH (60 to 70%)

Days after aeration	Treatments					
	T_1	T_2	T_3	T_4	T_5	T_6
1 to 5th	–	–	–	–	–	–
6th	–	+	–	–	–	–
7th	–	++	–	–	–	–
8th	–	++	–	–	–	–
9th	–	+++	+	–	–	–
10th	–	+++	+	–	–	–
11th	–	++++	+	–	–	–
12th	–	++++	+	–	–	–
13th	–	++++	++	–	–	–

–No growth; +, less visible; ++, visible foci (clearly visible); +++, sporadic visible (prominent); ++++, highly visible (very prominent).

and early in reconstituted grain, where fungus appeared on sixth day, clearly visible on seventh day, was prominent on ninth day and spread allover the surface on eleventh day after aeration. In T_3 fungus appeared on ninth day and was clearly visible on 13th day after aeration. In T_1, T_4, T_5 and T_6 there was no visible fungus growth up to 13 days aeration. The observations clearly indicated the antifungal action of urea through alkaline pH. Similar were the observations made by Bolhast *et al.* (1973), Russell *et al.* (1988) and Singh and Lohan (1998).

Observation on the effect of reconstitution and urea treatments on the temperature of *bajra* grain revealed that on the first day of incubation the ambient temperature was 16°C while the temperature in treatments T_1, T_2, T_3, T_4, T_5 and T_6 was 17, 30, 22,19, 19 and 18°C, respectively. Temperature in T_1 increased due to respiration of grain. In T_2 the moisture level was 28% that increased the rate of respiration and hence the temperature, but in T_3, T_4, T_5 and T_6 in spite of the higher moisture content (28%) the rise in temperature was not at the level of T_2, this might be due to urea treatment. This showed, urea treatment was effective in reducing temperature rise in grain after reconstitution. The steady decline in grain temperature on second day onwards might be due to the depletion of oxygen that restricted the respiration of the grain. The higher temperature in reconstituted grain as compared to urea treated grain from third day onward might be due to higher anaerobic microbial activity at acidic pH as compared to alkaline pH. Similar results were reported by Russell *et al.* (1988) that urea treatment was effective in reducing temperature rise after reconstitution.

Reconstitution of *bajra* grain increased (P<0.01) the nitrogen solubility, irrespective of the solvents used (Table 5). Similar results were reported by Billings (1972), Danley and Vetter (1974), Walker and Lichtenwalver (1977), Stock *et al.* (1991) and Singh and Lohan (1998) by using different solvents.

Table 5. Effect of processing on nitrogen solubility (%) in different solvents

Solvents	Treatments						CD	Mean±SE
	T_1	T_2	T_3	T_4	T_5	T_6		
Distilled water	19.17^{e}±0.23	43.94^{d}±0.65	45.66d±0.64	48.88c±0.61	59.49b±0.67	68.63a±0.53	3.04**	47.63c±6.86
Bicarbonate-	32.01^{d}±0.45	58.69^{c}±0.74	61.19^{c}±0.39	64.78^{c}±1.04	74.37^{b}±0.99	85.72^{a}±2.36	6.31**	62.79^{b}±7.37
Mc Dougall's	40.97^{d}±0.87	69.20 c±0.79	71.38^{c}±0.57	73.31^{c}±0.82	80.03^{b}±0.90	92.07^{a}±0.85	4.27*	71.16^{a}±6.92
Mean±SE	30.72^{e}±6.33	57.58^{d}±7.33	59.41^{c}±7.48	62.32^{c}±7.16	71.29^{b}±6.13	82.14^{a}±7.00	3.35**	X2.37**

Each figure is an average of 3 observations; a, b, c, d, e values in a row with different superscripts differ significantly (P<0.01); X=CD of the same column; a, b, c values in the same column with different superscripts differ significantly (P<0.01).

It can be concluded that the increased level of lactic acid, sugars and nitrogen solubility due to reconstitution may lead to better digestion and improved utilization of the *bajra* grain. Mixing urea with grain acts as a preservative and prevents mould growth. The possibilities of using urea treated *bajra* grain as a concentrate in ruminants need to be explored.

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