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Effect of Dietary Substitution of Wheat Bran with Dried Brewer's Spent Grains on Performance and Economics of Growing Crossbred Pigs

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ABSTRACT

Background: Brewers spent grains (BSG), may offer a suitable cheap replacer for traditional feedstuffs. The present study investigated the effect of dietary substitution of wheat bran with BSG on performance and production economics of crossbred grower pigs.

Methods: The current study was conducted during March, 2022 to September, 2022 on sixty crossbred pigs (28 male + 32 female) that were randomly divided into four groups and allotted to dietary treatment replacement by 0% (T_0), 25% (T_1), 50% (T_2) and 100% (T_3) dried BSG against conventional wheat bran in pig ration.

Result: Results indicated significant (P<0.05) improvement in the total body weight gain and average daily gain (ADG) in both male and female crossbred pigs in groups T_0, T_1 and T_2 when compared against T_3. The performances of the both female and male pigs were significantly (P<0.05) lower when dietary levels of BSG were increased up to 100 % (T_3). Group T_3 had significantly (P<0.01) lower carcass traits as compared to the other groups. The feed cost/kg live weight gain in T_2 was significantly (P<0.05) lower than the control group in both the sexes. In conclusion, crossbred pigs can tolerate up to 50% substitution of wheat bran with BSG which is also cost-effective.

Key words: Carcass trait, Crossbred pigs, Dried brewer's spent grains (BSG), Reproductive performance, Wheat bran.

INTRODUCTION

Brewers waste also known as brewer's grain or spent grain, is a solid waste from the brewery industries. Being a major byproduct of the brewery industry, it is reported to be comparatively cheap and rich in the B-vitamins, unidentified growth factors (UGA), digestible energy and crude protein (CP) (NRC, 1979). Brewers dried grains/brewer's spent grains (BDG/BSG) has been utilized as an ingredient in various livestock feeds. It is easily available and cheap in the North-Eastern Himalayan region due to abundance of local brewery industries. There is wide variability in the proximate composition of BDG depending on the brewery that produced it. It is necessary to ascertain how well pigs might digest and derive nutrients from diets based on high doses of BSG. Owing to the significant amount of BSG produced annually from the ever-expanding brewery industries, current low market value, increasing environmental awareness and the recognition that BSG may represent a nutritionally valuable co-product, efforts should be increasingly focused on valorisation of this agro-industrial by-product. To the authors best knowledge, the optimum inclusion levels of BSG in the conventional pig ration replacing wheat bran without affecting the production dynamics and the farm economics has been lightly looked upon by the scientific community in particular. Moreover, studies are scarce in regard of the cost-effectiveness of BSG in lieu of wheat bran in the conventional pig ration. Keeping this in mind, the present study was conducted with an objective to evaluate the effect of dietary substitution of wheat bran with BSG at different levels on performance and production economics of crossbred grower pigs.

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MATERIALS AND METHODS

Current study was carried out in the Livestock Farm, ICAR RC for NEH Region, Umiam, Meghalaya from March, 2022 to September, 2022. A total of sixty 75% inherited (Hampshire X Khasi local) male (28 Nos.) and female (32 Nos.) crossbred pigs aged around two months old, average body weight 10.30±0.28 and 10.42±0.40kg, respectively were selected

and randomly divided into four groups. The pigs were allotted four dietary treatments *i.e*. replacement of conventional wheat bran by 0% (Control), 25% (T_1), 50% (T_2) and 100% (T_3) dried BSG in their ration. The BSG used in the experiment was procured from the brewery industries located in and around the state of Meghalaya, India. The BSG was sundried and grounded prior to its incorporation in the compounded ration. The feeding trial was carried out for 210 days.

Proximate principles and gross energy (GE) of the dried BSG were determined using standard procedures (AOAC, 2007). All rations were made isonitrogenous and isocaloric by adjusting the levels of BSG against wheat bran as per NRC (1998) recommendation. All analysis were performed in duplicate for 12 samples and were presented on dry matter (% DM) basis.

The body weight gain was recorded at the start (60 day) and at the end (270 days) feeding trial. The average daily weight gain (ADG; g/day) during the trial period was calculated by dividing the body weight gained by the number of days in that particular period. In the female crossbred pigs, reproductive performance *viz*., age at puberty (days), age at 1st mating (days), age at 1st farrowing (days) and subsequent litter size at birth (Nos.) were recorded. The growth performance in males were recorded at similar intervals as the female pigs. At the end of the experiment, four representative male pigs of each treatment were randomly slaughtered for carcass quality. The parameters *viz*., weight at slaughter, carcass weight, carcass length, dressing percentage and back fat thickness (BFT; cm) were recorded.

The economics of feeding dried BSG against wheat bran in the different treatment groups were calculated. For economic analysis parameters such as average feed intake (g/day), feed conversion ratio (FCR), feed cost/kg ration (Indian rupees; (Rs) and feed cost/kg live weight gain (Rs) in both sexes were assessed.

Blood sample was collected from the anterior vena cava using 10 mL syringe at the onset of the feeding trial and once in every fortnightly interval and serum samples were separated for estimation of different biochemical parameters namely total proteins (g/100 mL), glucose (mg/100 mL), cholesterol (mg/100 mL), urea (mg/100 mL) and creatinine (mg/100 mL) using commercially available kits (Bioline Diagnostics, Delhi, India).

Experimental data obtained were expressed as Mean±S.E and analysed using Analysis of Variance (ANOVA) followed by post hoc comparison test (Snedecor and Cochran, 1994), employing Statistical package for Social Sciences programme version 23 (IBM SPSS).

RESULTS AND DISCUSSION

Chemical composition of dried brewer's spent grains (BSG)

The result on the chemical composition of dried BSG is presented in Table 1. Ngodigha *et al*. (1994) reported higher DM (%) of 89-92% in brewers dried grain (BDG) when fed at graded levels (0%, 5%, 10%, 15%, 20% and 25%) replacing equivalent levels of maize-soybean. The CP (%) content derived in our study were in close proximation with the reports of Dung *et al*. (2002) who reported a higher CP of 31% in BSG; but are lower than the value of 19.68 (%) reported by Madubuike and Obidimma (2009). The CF (%) content were at par the values reported by Amaefule *et al*. (2006); Imonikebe and Kperegbeyi (2014). They reported fibre content of BSG ranges from 11.3 to 21%. The EE (%) content were slightly higher than the reported values (Ngodigha *et al*., 1994; Madubuike and Obidimma, 2009 and Weldemariam, 2017). The TA (%) content was higher than the values reported by Imonikebe and Kperegbeyi (2014). Similar to our findings, higher TA (%) content of 9.26% has been reported by Ngodigha *et al*. (1994). The NFE (%) content were lower than the values reported by Ngodigha *et al.* (1994) and Imonikebe and Kperegbeyi (2014) who reported higher values of 45.62% and 50.06%, respectively. Numerous studies on the proximate composition of BSG have revealed that it is an excellent source of dietary fibre, protein, ash and fat (Farcas *et al*., 2014). Robertson *et al*. (2010) opined that the nutrient composition of BSG varies according to the types of barley, malting and mashing conditions as well as type of adjuncts used during processing.

Ingredient and nutrient composition of grower pig ration (% DM basis)

The estimated CP (%), CF (%) and ME (kcal/kg) of the grower pig ration replaced with 0, 25, 50 and 100% dried BSG are presented in Table 2. In our study, the nutrient composition of diets used at various levels of BSG incorporation showed increased CP and CF content but decreased ME at all levels except at 100%. Jørgensen *et al*. (1996) reported that BSG is high in protein and level of protein increased to an increase in BSG which is in agreement with the findings of our study. The most important factor which may influence the digestibility of protein is high fibre as contained in BSG and fibre content also increased with increasing BSG incorporation levels as evident from our findings.

Growth and reproductive performances in female grower pigs

The effect of feeding dried BSG (0-100% DM basis) on growth and reproductive performances of female crossbred

Table 1: Chemical composition of dried brewer's spent grains (BSG) (% DM basis).

Parameters	BSG (n=12)[1]
Dry matter (DM)	57.41±1.26
Crude protein (CP)	28.34±2.34
Crude fibre (CF)	20.84±1.03
Ether extract (EE)	9.00±0.57
Total ash (TA)	7.78±0.78
Nitrogen free extracts (NFE)	34.04±1.47
Gross energy (Kcal/kg)	2865±4.05

[1]*n=Number of observation.

pigs are presented in Table 3. Results indicated that there was significant (P<0.05) improvement in the final body weight gain, average daily gain (ADG) and total body weight gain of crossbred pigs, fed ration where 50 % wheat bran was replaced with BSG (T_2) in comparison to the control, T_1 and T_3. The animals fed ration T_2 attained early puberty than T_0, $T_1$and T_3, respectively. The FCR and feed cost/kg live weight gain were significantly (P<0.05) lower in T_2 when compared to T_0, T_1 and T_3.

The ADG (g/d) increased with increasing level of dried BSG in T_1 and T_2 in comparison to control but significantly (P<0.05) reduced in T_3 when compared to other groups. Diets

Table 2: Ingredient and nutrient composition of grower pig ration (% on DM basis).

Ingredient composition (%)	T_0 (Control)	T_1 (25% BSG)	T_2 (50% BSG)	T_3 (100%BSG)
Maize	55.00	55.00	55.00	55.00
Wheat bran	19.00	14.25	9.50	-
Brewery waste[1]	0.00	4.75	9.50	19.00
Ground nut cake	13.50	13.50	13.50	13.50
Soybean meal	10.00	10.00	10.00	10.00
Mineral mixture[2]	2.00	2.00	2.00	2.00
Salt	0.50	0.50	0.50	0.50
	100	100	100	100
		Calculated		
CP (%)	16.15	17.95	18.98	19.20
CF (%)	13.18	14.23	15.81	17.65
DM (%)	81.05	73.12	63.20	41.23
ME (kcal/kg)	3209	3120	3089	3341
		Estimated		
CP (%)	16.90	17.86	18.01	19.76
CF (%)	13.29	14.90	15.22	18.85
DM (%)	83.56	70.31	61.90	39.08
ME (kcal/kg)	3296	3226	3198	3378

All rations were prepared considering protein-energy requirement as per BIS standard.

[1]T_0- 0% dried brewers spent grains (BSG) inclusion against wheat bran in grower pig ration, T_1-25% dried brewers spent grains (BSG) inclusion against wheat bran in grower pig ration, T_2- 50% dried brewers spent grains (BSG) inclusion against wheat bran in grower pig ration, T_3- 100% dried brewers spent grains (BSG) inclusion against wheat bran in grower pig ration. Other ingredients (Maize and Ground nut cake) were adjusted as per BIS standard.

[2]The mineral mixture contained per kg the following vitamins and minerals-7,00,000 IU Vit A, 70,000 IU VitD_3, 9600mg Zn, 6000 mg Mg, 1500 mg Mn, 1500mg Fe, 1200 mg Cu, 100 mg Nicotinamide, 325 mg I, 250mg Vit E, 1000 mg DL-Methionine, 150 mg Co, 100 mg K, 5.9 mg Na, 25.5% Ca, 12.75% P, 0.72% S.

CP- Crude protein, ME- Metabolizable energy.

Table 3: Performance of female crossbred pigs fed dried brewer's spent grain (BSG) replacing wheat bran.

Parameters	T_0 (Control)	T_1 (25%BSG)	T_2 (50% BSG)	T_3 (100% BSG)
		Growth performances		
[1] Initial body weight (kg) at 60 days	10.42±0.40	10.66±0.43	10.25±0.32	10.32±0.25
[2] Final body weight (kg) at 270 days	73.17^a±0.28	75.00^b±0.29	78.45^c±0.41	65.60^d±0.57
Total body weight gain (kg)	62.75^a±0.21	64.32^b±0.46	68.20^c±0.30	55.28^d±0.75
[3] ADG (g/d)	300^a± 3.15	310^b±1.17	325^c±1.48	263^d±1.15
		Reproductive performances		
Age at puberty(days)	256.50^a±2.90	259.67^a ±3.07	244.33^b±2.04	263.67^c± 3.00
Age at first mating (days)	278.83^a±2.90	281.00^a±3.20	265.33^b±2.00	284.83^a ± 2.90
Age at first farrowing (days)	392.00^a±3.00	395.33^a±3.40	379.50^b±2.10	399.17^a±2.80
Litter size at birth (No)	7.83±0.50	8.17±0.60	8.33±0.40	7.83±0.60

[a,b,c,d] Means for different groups in the same row having different superscript differ significantly(P<0.05).

[1] Initial body weight (kg) recorded at 60 days.

[2] Final body weight (kg) recorded at 270 days.

[3] ADG- Average daily gain- Body weight gain/No. of days

T_2 and T_3 had the highest and lowest ADG, respectively. Current results are not in agreement with the report of Imonikebe and Kperegbeyi (2014). They reported that ADGs were not different when up to 30% level BSG was fed to weaner and grower pigs. In contrary, Yaakugh *et al*. (1990) found that ADG decreased linearly with corresponding increase in the levels of BSG attributable to their higher dietary CF intake. As also evident from our findings, CP and CF content increased in the different treatments with increased incorporation levels of BSG. Pigs on T_3 ration consumed little BSG due to high CF and low DM content, which tended to reduce feed intake and digestibility, in turn leading to low intake as well as lower performance. Lowest ADG in group T_3 could be attributed to the fact that at 100% BSG incorporation as a replacement for wheat bran might have reduced the palatability of the ration due to high CF content of the diet which interfered with nutrient availability and digestibility.

Significantly lower reproductive performance in group T_3 might be due to higher CF content at 100% BSG incorporation resulting in decreased feed intake creating protein-energy imbalances and subsequently lowering the performance. Optimally at 50% BSG (T_2) inclusion significantly improved the reproductive performance suggesting that at this inclusion rate there was no compromise in the energy intake of pigs resulting in better performance. The high fibre content of BSG, which rises in parallel with BSG incorporation into the ration, is the most significant factor impacting the digestion of protein. Grower pigs have difficulty in digesting high fibre feeds which can be compensated by formulating of a ration with higher CP content. With the current findings, we hypothesized that the digestibility and nutrient availability in T_3 was optimal than rest rations but it is to be confirmed with further trials.

Growth and carcass quality in male grower pigs

The effect of replacement of dried BSG (0-100% DM basis) with wheat bran on growth, carcass quality and production economics of male crossbred pigs are presented in Table 4. Results indicated that there was significant ($P<0.05$) improvement in the ADG in T_2 as compared to T_0, T_1 and T_3. However, the total body weight gain did not differ significantly ($P>0.05$) in control, T_1 and T_2. However, significant ($P<0.05$) improvement was noted in T_2 when compared against T_3. The FCR was significantly ($P<0.05$) lower in T_2 when compared against T_3. The feed cost/kg live weight gain was significantly ($P<0.05$) lower in T_2 when compared to ~~the~~ other groups. The carcass weight was found to be significantly ($P<0.05$) higher in T_2 as compared to control and T_3. BFT was inversely proportional to the levels of BSG in the ration. The BFT was significantly ($P<0.05$) higher in T_2 as against T_3.

The total body weight gain and ADG were significantly lower in T_3 as against T_0, T_1 and T_2. T_2 group performed better with regards to the recorded growth parameters. Lower performance of T_3 group might be due to higher concentration of non-starch polysaccharides and some tannins in dried BSG which interfere with the feed utilization inhibiting the absorption of essential nutrients and digestive enzymes *in-vitro* and *in-vivo*, thereby decreasing the efficiency of feed utilization. It has been reported that feeding behaviour and feed intake has high correlation with body weight gain, especially at the finishing stage in pigs (Carco *et al*., 2018). The adaptation to the feed is very crucial, where livestock needs to be given at least six weeks before commencement of the study (Pollman *et al*., 1979). We reported a significant reduction in total body weight gain of the pigs fed ration comprising 100% BSG (high in fibre content) in comparison to the groups with lower inclusion levels.

There were no significant differences in the carcass parameters studied except in carcass weight (kg) and BFT (cm). The carcass weight showed an increasing trend in T_1 and T_2 than the control group. A highly significant decrease in carcass weight in T_3 as compared to other groups might be due to lower body weight gain of the pigs due to lower

Table 4: Performance of male crossbred pigs fed dried brewer's spent grain (BSG) replacing wheat bran.

Parameters	Control	T_1 (25% BSG)	T_2 (50% BSG)	T_3 (100% BSG)
		Growth performances		
[1] Initial body weight (kg) at 60 days	10.30±0.28	10.58±0.37	10.33±0.25	10.35±0.25
[2] Final body weight (kg) at 298 days	80.25^{a}±0.88	81.12^{a}±0.99	82.23^{a}±0.97	69.67^{b}±0.98
Total body weight gain (kg)	69.95^{a}±0.78	70.53^{a}±0.72	71.90^{a}±0.93	59.32^{b}±0.76
[3] ADG (g/d)	296^{a}±4.23	308^{ac}±8.10	318^{bc}±3.04	249^{d}±3.24
		Carcass traits		
Weight at slaughter (kg)	81.60^{c}± 0.42	83.23^{ac}±0.65	83.93^{ac}±0.82	68.67^{b}±0.88
Carcass weight (kg)	54.67^{c}±0.48	56.60^{a}±0.75	57.07^{a}±0.30	45.54^{b}±0.39
Carcass length (cm)	81.67±0.88	83.67±0.88	81.67±0.88	80.33±1.20
Dressing percentage (%)	67.00±0.58	68.00±0.58	68.00±0.58	66.33±0.88
[4] BFT (cm)	2.64^{ac}±0.05	2.60^{a} ±0.04	2.58^{a}±0.05	2.45^{b}±0.06

[a,b,c,d] Means for different groups in the same row having different superscript differ significantly ($P<0.05$).

[1] Initial body weight (kg) recorded at 60 days.

[2] Final body weight (kg) recorded at 270 days.

[3] ADG- Average daily gain- Body weight gain/No. of days.

[4] BFT- Back fat thickness.

digestibility in the gut due to corresponding increment in the levels of fibre in the diet. The BFT was inversely proportional to increasing levels of dried BSG in the diets. This suggests that pigs fed with increased levels of dried BSG used much of their feed energy for muscle tissue rather than fat deposition. Amaefule *et al*. (2006) observed a similar trend when they fed pigs with high levels (30, 35 and 40%) of brewers' dried grain diets in the humid tropics. Darkwa *et al.* (2013) also observed similar trend when growing pigs were fed with dried brewers' spent grains (DBSG) supplemented with an exogenous enzyme. They observed that BFT was inversely proportional to the levels of brewers' dried grain in the diets.

Production economics

The production economics in terms of average feed intake (g/day), FCR, feed cost/kg ration (Rs) and cost of production on feed basis (Rs) has been depicted in Table 5. A significantly ($p<0.05$) lower FCR was recorded in T_2 in comparison to T_0 and T_3 in female pigs. Ration T_3 recorded the highest FCR among the different treatments. Similar results were reported for male pigs whereby ration T_3 had significantly ($P<0.05$) higher FCR than rest treatments. The cost of production on feed basis was significantly ($P<0.05$) lower in T_2 in comparison to the other groups in both the sexes.

The feed cost decreased with increased incorporation of dried BSG (optimally at 50%) in the conventional ration for feeding crossbred pigs in both sexes. Rijal *et al*. (2009) reported a reduction of feed cost when up to 20% BSG substitution was used for crossbred weaner pigs without any adverse effect on performance. With substitution of BSG above 20% in the diet, they observed an increment per kg feed cost. This is not in agreement with our study where 50% replacement was found to be much more economical in terms of lower FCR and feed cost/kg ration than the other groups (T_0, T_1 and T_3). Furthermore, Amaefule *et al*. (2006) observed that inclusion of BSG (dry) up to 35% had the highest profit but above 35% BSG reduced the net profit. Current results are not in agreement with the results of this study, where feeding 50% BSG to crossbred pigs gave higher returns than T_1 (25% BSG) and T_3 (100% BSG). The inconsistency in findings may be due to difference in study design. In their study dried BSG replaced maize partially and all diets were fortified with bone meal. In our study, the net gain per kg production was highest in the group T_2 for both females (Rs 11.74) and males (Rs 12.13). From the results, it can be concluded that inclusion of brewery waste at 50% level proved to be effective in reducing feed cost by Rs 11.74 in females and Rs 12.13 in males. Similar findings were reported by many authors at different levels of inclusion in the grower finisher ration of pigs (Zhu *et al*., 2010). Amaefule *et al*. (2006) and Imonikebe and Kperegbeyi (2014) reported that FCR did not differ in weaned pigs fed on diet where up to 35% BSG (dry) replaced maize were used. This is not in agreement with the results of the current study. The difference could be an effect of partially replaced maize with BSG in the four diets in their study, while in this our dried BSG replaced conventional wheat bran.

Table 5: Production economics of crossbred grower pigs fed ration replacing dietary wheat bran with dried brewers spent grains (BSG) at different level.

Parameters	Female				Male			
	T_0 (Control)	T_1 (25% BSG)	T_2 (50% BSG)	T_3 (100% BSG)	T_0 (Control)	T_1 (25% BSG)	T_2 (50% BSG)	T_3 (100% BSG)
Average feed intake (g/d)	1190.71±45.91	1210.59±46.20	1253.09±46.42	1157.19±45.47	1188.40±50.50	1206.50±50.40	1240.40±50.80	1164.60±50.50
FCR[1]	3.97^{a}±0.04	3.91^{ab}±0.05	3.86^{b}±0.03	4.40^{c}±0.04	4.02^{ba}±0.06	3.94^{a}±0.10	3.90^{a}±0.04	4.67^{b}±0.06
Feed cost/kg ration (Rs)	30.25	29.16	28.07	25.88	30.25	29.16	28.07	25.88
Cost of production on feed basis (FCR × cost of feed/kg (Rs)	120.09^{a}	114.01^{b}	108.35^{c}	113.87^{bd}	121.60^{a}	114.89^{b}	109.47^{c}	120.85^{d}
Net gain per kg production (Rs)	-	6.08	11.74	6.22	-	6.71	12.13	0.75

^{a,b,c} Means for different groups in the same row having different superscript differ significantly ($P<0.05$).

[1] FCR- Feed conversion ratio- Total feed consumed/ Animal weight gain.

Rs- Indian Rupee.

Table 6: Serum metabolites of growing crossbred pigs fed ration replacing wheat bran with dried brewers spent grains (BSG).

Parameters	T_0 (Control)		T_1 (25% BSG)		T_2 (50% BSG)		T_3 (100% BSG)	
	Male	Female	Male	Female	Male	Female	Male	Female
Total protein (g/100 ml)	7.06±0.86	6.58±0.50	6.90±0.80	6.60±0.46	6.94±0.84	6.58±0.60	6.98±0.90	6.64±0.70
Glucose (mg/100 ml)	116.26±1.38	113.60±0.40	118.26±1.78	112.50±0.50	117.24±1.56	111.96±0.70	118.80±1.86	112.46±0.76
Cholesterol (mg/100 ml)	125.86±1.80	123.20±0.36	130.16±1.76	122.80±0.46	132.10±1.86	121.98±0.70	128.68±1.90	122.50±0.56
Urea (mg/100 ml)	12.90±0.86	12.61±0.60	13.10±0.90	12.88±0.50	13.70±0.84	13.00±0.60	12.98±0.78	12.78±0.60
Creatinine (mg/100 ml)	0.90±0.08	0.78±0.06	0.88±0.09	0.77±0.05	0.82±0.07	0.78±0.04	0.94±0.08	0.79±0.05

Means for different groups in the same row did not differ significantly (P>0.05).

Serum metabolites profile

The serum metabolite profile *viz*., total protein, glucose, cholesterol, urea and creatinine levels in both female and male crossbred pigs in the different treatment groups are depicted in Table 6.

In the current study the increasing level of dried BSG did not significantly affect the levels of total protein, glucose, cholesterol, urea and creatinine levels in both female and male crossbred pigs. The reported values were within the physiological ranges for pigs. Similar findings were recorded by Boontiam *et al*. (2022) when pigs were fed brewers grain meal (BGM) supplemented diets at 10% and 20% levels.

CONCLUSION

It is concluded that crossbred pigs can tolerate up to 50% dietary substitution of wheat bran with dried BSG without compromising their growth, blood biochemical parameters and reproductive performance. The incorporation of dried BSG in the compounded rations of crossbred pigs resulted in the reduction of feed cost in both the sexes. Therefore, widespread usage of locally produced feedstuffs like BSG would facilitate further growth of the piggery business especially in the traditional pig holder production systems for nutritional security and livelihood improvement. Economically, 50% level of dried BSG incorporation in the ration of grower crossbred pigs is cost effective and should be encouraged in areas where by-products of the brewery industry are readily available and affordable.

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Conflict of interest

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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