Haryana Vet. **52** (December, 2013) pp 26-29

Research Article

EFFECT OF PROCESSING WHITE SORGHUM ON DIFFERENT PHYSICAL PARAMETERS OF BROILER DIET

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Received: 08.10.2013; Accepted: 12.12.2013

ABSTRACT

An experiment was conducted to determine the effect of grinding sorghum through different hole sized sieves before and after roasting on physical parameters of broiler diets. Soaked white sorghum grains were dry heated (roasted, 225±25^{0}C for 45-60 seconds) in an iron pan having Yamuna sand and salt as heat transfer medium. The particle size of sorghum grains was reduced by a country made hammer mill using 2 and 3 mm hole sized screens. The production rate (kg/h) was 2564.1 and 2955.7 for raw sorghum ground through 2 and 3mm sieve as compared to1408.5 and1892.7 for roasted sorghum ground through 2 and 3mm sieve. Significantly lower (P<0.05) time consumption was observed in raw sorghum ground through 2 and 3 mm sieve compared to roasted. Sorghum ground through 3 mm sieve consumed less (P<0.05) electricity for grinding as compared to 2 mm sieve. Heating significantly (P<0.05) increased the electricity consumption in both 2 and 3 mm sieves. The effect of sieve sizes was non-significant on the particle size of starter as well as finisher rations; however, the values were numerically higher for 3mm sieve. Addition of whole grains in the diet significantly (P<0.05) increased the particle size. The number of particles per gram were significantly higher (P<0.05) in roasted ground sorghum based diets. The surface area (cm^2/g) was lowest (P<0.05) in the diets having 100% intact sorghum grains both in starter as well as finisher rations followed by the diets having 50% intact sorghum grains. Modulus of fineness was higher (P<0.05) in the diets having whole grains as compared to other treatments.

Key words: Grinding, energy consumption, particle size, sorghum

Grinding is the most common method of feed processing. It reduces particle size thereby increasing surface area for action of digestive enzymes. Processing of raw materials is necessary for improving feed efficiency, e.g. producing more meat, milk or eggs at a lower cost (Sihag *et al.,* 2010). Coarse grinding has been reported to improve the apparent metabolizable energy in wheat based diet, but not in maize based diet (Amerah *et al*., 2007). Parsons *et al.* (2006) reported that fine grinding of maize decreased the efficiency of nitrogen, lysine retention, better feed efficiency and higher feed intake during evaluation of different corn particle sizes (781 950, 1042, 1109 and 2242 μm) in broiler diets, whereas weight gain was not affected. Wondra *et al*. (1995) studied the effect of a wider range of particle sizes in maize (ranging from 100 to 400 μm) and observed a 1.3% increase in gain: feed for every 100 μm reduction in particle size of the maize.

Sihag and Sihag (2012) reported that the energy consumption was 263, 715, 1025 and 1730% more as the screen size decreased from 3 to 2; 4 to 2; 5 to 2 and 6 to 2 mm. The screen size also affected (P<0.05) the time consumption/throughput. Reducing the hammer mill screen size from 6 mm to 2 mm reduced (P<0.05) average particle size with all five screens (1859, 1678, 1361, 1123 and 945 μm). Therefore, this experiment was planned to determine the effect of grinding sorghum through 2 and 3 mm hole sized sieves at 50 and 100% replacement levels in broiler diets.

MATERIALS AND METHODS

Twenty liter of water was sprinkled uniformly over 100 kg of sorghum grains and was kept for 24 hrs. Soaked sorghum grains were dry heated at 225±25^{0}C for 45-60 seconds in an iron pan using Yamuna sand and salt as heat transfer medium. The particle size was reduced by a country made hammer mill using 2 and 3 mm hole sizes screen. The hammer mill had sieves of 2.5±0.14 kg weight and 47×35.5×0.3 cm (length×breadth×thickness) dimensions. The dimensions of hammer were 9.9×2.38×0.5 cm (length×breadth×thickness) with 1 cm hole on both ends and weighing 100±2.5 g. Total number of holes in 2 mm and 3 mm sieves were 2618 and 2326, respectively. The hammer mill was fitted with a cuboidal roller/rotor

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(28.8 cm shaft length) having provisions for fitting 96 hammers. Twenty four hammers (6 on each side adjusted alternately) were fitted in the roller.

Thirteen rations were prepared as per BIS (1992) specification. The formulated rations were: T_1=maize based ration grounded through 3 mm sieve, T_2=50% maize replaced with sorghum ground through 2 mm sieve, T_3=100% maize replaced with sorghum ground through 2 mm sieve, T_4=50% maize replaced with sorghum ground through 3 mm sieve, T_5=100% maize replaced with sorghum ground through 3 mm sieve, T_6=50% maize replaced with whole sorghum, T_7=100% maize replaced with whole sorghum, T_8=50% maize replaced with roasted sorghum ground through 2 mm sieve, T_9=100% maize replaced with roasted sorghum ground through 2 mm sieve, T_{10}=50% maize replaced with roasted sorghum ground through 3 mm sieve, T_{11}=100% maize replaced with roasted sorghum ground through 3 mm sieve, T_{12}=50% maize replaced with intact roasted sorghum and T_{13}=100% maize replaced with intact roasted white sorghum. A row-tap sieve shaker was used to determine the particle size, modulus of fineness and modulus of uniformity. The sieves were arranged in ascending order in such a way that the largest number sieve was used at the bottom and the smallest number at the top. The sample (100 g) was placed on the top sieve and shaken until the weights of each sieve became constant (about 20 minutes). The data was analyzed using factorial CRD design as described by Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

Time consumption was the highest for roasted sorghum ground through 2 mm sieve (4.26 min/q) followed by roasted sorghum ground through 3 mm sieve (3.17 min/q), raw sorghum ground through 2 mm sieve (2.34 min/q) and the lowest for raw sorghum ground through 3 mm sieve (2.03 min/q) (Table 1). Significantly lower ($P<0.05$) time consumption was observed in raw sorghum ground through 2 and 3 mm sieves as compared to roasted sorghum. The time consumption was significantly higher ($P<0.05$) for raw maize (6.12 min/q and 3.48 min/q) compared to raw sorghum (4.26 min/q and 2.34 min/q). The results are in line with those of Sen *et al*. (2011). The production rate (kg/h) was 2564.1 and 2955.7 for row sorghum ground through 2 mm and 3 mm sieve as compared to 1408.5 and 1892.7 for roasted sorghum ground through 2 mm and 3 mm sieve, respectively.

In this study, electricity consumption decreased considerably with an increase of sieve hole size. Electricity consumption was the highest for maize ground through 2 mm sieve followed by 3 mm sieve and was the least for raw sorghum grains ground through 3 mm sieve. Sorghum ground through 3 mm sieve consumed less ($P<0.05$) electricity for grinding as compared to 2 mm sieve. Heating of sorghum grains increased the electricity cost for its grinding in case of both 2 and 3 mm sieves. As a result electricity cost was more for maize ground through 2 mm sieve followed by 3 mm sieve and the lowest for raw sorghum ground through 3 mm sieve. Feed ingredients ground through 3 mm sieve resulted in less electricity cost for grinding as compared to 2 mm sieve. These observations are similar to those of Sen *et al*. (2011) who also reported that electricity consumption and cost decreased with the increase in sieve size and inverse was true for heated grains of pearl millet.

In starter ration (Table 2) highest geometric mean diameter (GMD) was observed in T_{13} (1875 μ) followed by T_7 (1674 μ) and was the lowest in T_8 (675 μ). The effect of sieve size (2 mm and 3 mm) was non-significant on the particle size of starter ration as well as finisher ration (Tables 2 and 3); however, the values were numerically higher for 3 mm sieve. Addition of whole grains in the diet significantly ($P<0.05$) increased the particle size. In finisher ration also GMD was the highest in T_{13} (1995 μ) followed by T_7 (1442 μ) and was the lowest

Table 1

Effects of sieve size and heating on production rate and electricity consumption for grinding sorghum grains

Parameter	Maize (2 mm)	Maize (3 mm)	Raw sorghum grains (2 mm)	Heated sorghum grains (2 mm)	Raw sorghum grains (3 mm)	Heated sorghum grains (3 mm)
Time consumption (min/qtl)	6.27 ± 0.03^f	3.48 ± 0.02^d	4.26 ± 0.02^e	3.17 ± 0.01^c	2.34 ± 0.01^b	2.03 ± 0.01^a
Production rate (kg/h)	956.9 ± 5.25^a	1724.1 ± 8.67^b	1408.1 ± 6.56^c	2564.1 ± 11.24^e	1892.7 ± 9.44^d	2955.7 ± 12.27^f
Electricity consumption (kWh/qtl)	0.93 ± 0.02^e	0.56 ± 0.01^d	0.30 ± 0.00^b	0.42 ± 0.00^c	0.20 ± 0.00^a	0.30 ± 0.01^b

Mean with different superscript in a row for a parameter differ significantly ($P<0.05$)

Table 2
Effect of dietary treatments on particle size, number of particles, modulus of uniformity and modulus of fineness of starter rations

Treatment	Particle size GMD (μ)	Standard deviation	Surface area (cm^2)/gram	Particles/gram	Modulus of fineness
T_1	695^a	2.41^{ab}	97.0^c	76,675^{ab}	4.10^a
T_2	721^a	2.23^a	88.5^{bc}	42,927^{ab}	4.17^a
T_3	814^a	2.28^{ab}	78.4^b	31,328^a	4.39^{ab}
T_4	865^a	2.40^{ab}	77.3^b	41,036^a	4.49^{ab}
T_5	907^a	2.20^a	68.5^b	17,373^a	4.58^b
T_6	1,324^b	2.49^{ab}	54.2^{ab}	28,857^a	5.00^c
T_7	1,674^c	2.39^{ab}	39.8^a	5,309^a	5.29^c
T_8	675^a	2.63^b	107.3^d	170,562^b	4.10^a
T_9	747^a	2.68^b	99.9^c	153,612^b	4.24^a
T_{10}	684^a	2.59^b	104.8^d	67,875^{ab}	4.08^a
T_{11}	686^a	2.79^b	102.7^c	85,664^{ab}	4.06^a
T_{12}	1,494^b	2.07^a	40.4^a	13,363^a	5.24^c
T_{13}	1,875^c	3.31^c	34.8^a	2,533^a	5.62^d

Figures with different superscript in a column differ significantly ($P<0.05$)

T_1=maize based ration grounded through 3 mm sieve; T_2=50% maize replaced with sorghum ground through 2 mm sieve; T_3=100% maize replaced with sorghum ground through 2 mm sieve; T_4=50% maize replaced with sorghum ground through 3 mm sieve; T_5=100% maize replaced with sorghum ground through 3 mm sieve; T_6=50% maize replaced with whole sorghum; T_7=100% maize replaced with whole sorghum; T_8=50% maize replaced with roasted sorghum ground through 2 mm sieve; T_9=100% maize replaced with roasted sorghum ground through 2 mm sieve; T_{10}=50% maize replaced with roasted sorghum ground through 3 mm sieve; T_{11}=100% maize replaced with roasted sorghum ground through 3 mm sieve; T_{12}=50% maize replaced with intact roasted sorghum; T_{13}=100% maize replaced with intact roasted white sorghum.

in T_9 (656 μ) (Table 3). In starter ration, number of particles per gram were the highest in T_8 (170562) and the lowest in T_{13} (2533). However, in finisher ration, the number of particles per gram were highest in T_9 (261231) and lowest in T_{13} (2370). The number of particles per gram were significantly higher ($P<0.05$) in roasted ground sorghum based diets. This might be because of increased surface area of grains due to roasting and loss of moisture during roasting.

The surface area (cm^2/g) was the lowest ($P<0.05$) both in starter as well as finisher rations having 100% intact sorghum grains followed by the rations having 50% intact sorghum grains (Tables 2 and 3). The surface area (cm^2/g) was the highest (107.3) in the starter diets having 50% raw sorghum grains ground through 2 mm sieve, however, in finisher ration the surface area was the highest (119.5) in the diet having 50% row sorghum grains ground through 3 mm sieve. The surface area (cm^2/g) varied from 34.8 to 107.3 in starter ration and 32.5 to 119.5 in finisher ration. Modulus of fineness was higher ($P<0.05$) in the diets having whole grains compared to other treatments either ground through 2 mm or 3 mm sieve size.

It may be concluded from this study that inclusion level of sorghum in the diets and its grinding through 2 or 3mm hole sized sieves had no significant effect on the particle size of the diets. Therefore by using 3mm sieve in place of 2mm sieve production rate of plant can be increased and simultaneously energy consumption can be decreased.

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Table 3
Effect of dietary treatments on particle size, number of particles/g, modulus of uniformity and modulus of fineness of finisher rations

Treatment	Particle size (μ)	Standard deviation	Surface area (cm^2) / gram	Particles / gram	Modulus of fineness
T_1	782^{ab}	2.56^{ab}	90.3^{c}	$83{,}279^{ab}$	4.28^{ab}
T_2	737^{a}	2.62^{ab}	98.6^{cd}	$148{,}118^{bc}$	4.18^{ab}
T_3	772^{ab}	2.61^{ab}	94.2^{cd}	$128{,}207^{bc}$	4.24^{ab}
T_4	785^{ab}	2.65^{b}	91.3^{c}	$96{,}913^{ab}$	4.37^{abc}
T_5	793^{ab}	2.87^{b}	88.4^{c}	$66{,}972^{ab}$	4.58^{c}
T_6	893^{bc}	2.79^{b}	86.1^{c}	$25{,}304^{ab}$	4.41^{b}
T_7	$1{,}442^{d}$	3.09^{c}	60.8^{b}	$120{,}301^{bc}$	4.96^{d}
T_8	742^{ab}	2.35^{a}	88.0^{c}	$168{,}369^{c}$	4.21^{a}
T_9	656^{a}	2.84^{bc}	119.5^{e}	$261{,}231^{c}$	3.98^{a}
T_{10}	741^{ab}	2.51^{ab}	94.1^{c}	$87{,}524^{ab}$	4.20^{a}
T_{11}	698^{a}	2.85^{bc}	112.8^{de}	$11{,}974^{a}$	4.08^{a}
T_{12}	$1{,}041^{c}$	3.01^{c}	80.1^{bc}	$7{,}891^{a}$	4.64^{c}
T_{13}	$1{,}995^{e}$	2.32^{a}	32.5^{a}	$2{,}370^{a}$	5.51^{e}

Figures with different superscript in a column differ significantly ($P<0.05$)

T_1=maize based ration grounded through 3 mm sieve; T_2=50% maize replaced with sorghum ground through 2 mm sieve; T_3=100% maize replaced with sorghum ground through 2 mm sieve; T_4=50% maize replaced with sorghum ground through 3 mm sieve; T_5=100% maize replaced with sorghum ground through 3 mm sieve; T_6=50% maize replaced with whole sorghum; T_7=100% maize replaced with whole sorghum; T_8=50% maize replaced with roasted sorghum ground through 2 mm sieve; T_9=100% maize replaced with roasted sorghum ground through 2 mm sieve; T_{10}=50% maize replaced with roasted sorghum ground through 3 mm sieve; T_{11}=100% maize replaced with roasted sorghum ground through 3 mm sieve; T_{12}=50% maize replaced with intact roasted sorghum; T_{13}=100% maize replaced with intact roasted white sorghum.

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