Rice straw, cassava by-products and tree legumes provide enough energy and nitrogen for liveweight maintenance of Brahman (Bos indicus) cows in Indonesia

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Rice straw, cassava by-products and tree legumes provide enough energy and nitrogen for liveweight maintenance of Brahman (*Bos indicus*) cows in Indonesia

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Abstract. The aim of this experiment was to test the effectiveness of two diets in increasing liveweight (LW) and body condition score (BCS) of Brahman cows in Indonesia. Diets were based on rice straw, with additional energy and nitrogen (N) provided in the form of onggok (a cassava by-product) plus urea or a tree legume. Thirty mature, non-pregnant, non-lactating Brahman crossbred cows (288 kg LW, BCS 2/5) were allocated to one of two treatment groups. Cows were kept in individual pens for 21 weeks and offered one of two diets; (1) urea-supplemented rice straw *ad libitum* plus 10 g onggok DM/kg LW.day, or (2) untreated rice straw *ad libitum* plus 5 g onggok DM/kg LW.day and 5 g *Gliricidia sepium* DM/kg LW.day. The urea supplement provided no advantages over using locally available N sources such as gliricidia, with both supplement types meeting the rumen-degradable N requirements of the cows. Cows on both diets gained weight at a similar rate (0.19 kg/day) for the first 15 weeks of the experiment. Liveweight gain in Weeks 16–21 was only 0.04 kg/day, despite an increase in total feed intake and energy content of the diets compared with Weeks 1–15. Liveweight of cows stabilised during Weeks 16–21 at 304 kg, BCS 2.2. While our results demonstrate that Brahman cows can maintain LW on rice straw-based diets, they may not be able to maintain a BCS sufficient for good reproduction rates (i.e. BCS 3 or higher on 1–5 scale). Better quality diets containing higher levels of energy are required for cows to gain and maintain a suitable BCS.

Additional keywords: body condition score, beef cattle, gliricidia, onggok.

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Introduction

Cattle are an important source of income for smallholder farmers in Indonesia, and farmers typically manage between one and two adult cows, plus their offspring, in a labour-intensive cut and carry system (Hanifah *et al*. 2010; Priyanti *et al*. 2012). The major beef cattle breeds kept by smallholder farmers in Indonesia are the local Bali (*Bos javanicus*) and Ongole (*Bos indicus*) breeds, but imported breeds such as Brahman (*Bos indicus*), Simmental and Limousin (*Bos taurus*) have been introduced with the aim of improving productivity (Kementan–BPS 2012). Imported cattle breeds are most common in the regions of Java and Sumatra, which are also the focus of the domestic beef herd (Kementan–BPS 2012). Brahman cows and heifers imported from Australia are distributed to villages through schemes primarily instigated by the Indonesian government or private sector.

Reproductive performance of Brahman cows kept by smallholder farmers in Indonesia has generally been poor. Yuwono and Sodiq (2010) and Tambunan et al. (2013) reported problems such as high calf mortality, long postpartum anoestrous periods, extended calving intervals and low calving rates. In both papers, the authors attributed the problems to inadequate nutrition, and subsequent poor body condition score (BCS) of the cows.

Cattle kept by smallholder farmers in Indonesia are typically fed low quality diets based on crop residues such as rice straw (*Oryza sativa*) (Hanifah *et al*. 2010). Rice straw alone does not provide sufficient energy or protein for maintenance of liveweight (LW) (McLennan *et al*. 1981), but any supplements need to be cost effective, easily accessible and practical to be adopted by farmers (Owen and Jayasuriya 1989).

Cassava (*Manihot esculenta*) by-products have huge potential to be used as animal feed in Indonesia. In 2012, Indonesia harvested ~24 million tonnes of cassava from 1.1 million ha, making it the fourth largest crop in the country after oil palm (*Elaeis guineensis*), rice and sugarcane

(*Saccharum* spp.) (FAO 2013). Cassava production is focussed around Java and southern Sumatra, which coincides with the location of the majority of the Brahman cattle herd. Cassava in Indonesia is mostly grown for industrial production of flour, starch and tapioca, but many smallholder farmers also grow cassava for human consumption. By-products and residues from cassava include leaves, peels and onggok. Onggok is the fibrous component left after starch has been extracted from the tuber. The nutritive value of onggok is variable, depending on the methods used for starch extraction, but it is generally considered to be a high energy feed suitable for consumption by ruminants, pigs and poultry. As an example, Aro and Aletor (2012) reported values of 1% crude protein, 3% ash, 41% neutral detergent fibre (NDF), 18% acid detergent fibre (ADF) and 11 MJ of metabolisable energy (ME)/kg DM in unfermented onggok. Djazuli and Bradbury (1999) measured the cyanide content of a range of cassava by-products from Java and Lampung, and found the cyanogens concentration of onggok to be 9 ppm, which is below the level of toxicity for ruminants (Kumar 1992). Fed in conjunction with a protein source such as tree legumes (e.g. *Gliricidia sepium*), onggok is potentially a high quality, cheap and readily available energy supplement for cattle kept by smallholder farmers.

The aim of this experiment was to test the effectiveness of two village-based diets in increasing the weight and BCS of Brahman cows. The diets were based on rice straw, with energy provided in the form of onggok and nitrogen (N) from urea or a tree legume.

Materials and methods

Animals and experimental design

Thirty mature, non-pregnant, non-lactating Brahman cross cows [288 ± 8.21 kg (s.e.m) LW, BCS 1.9 ± 0.07 on a 1–5 scale] were purchased from local markets and traders. Cows were randomly allocated to one of two treatment groups (n = 15/treatment) of similar average LW and housed in individual pens at the Beef Cattle Research Institute, Grati, East Java, Indonesia. The experiment consisted of a 3-week adaptation period where cows were introduced to the pens and experimental diets, followed by a 21-week experimental period.

All procedures were reviewed and approved by the University of Queensland Animal Ethics Committee in accordance with the Australian Code of Practice for the Care and Use of Animals for Scientific Purposes.

Diets and feeding

Cattle in both groups were fed rice straw *ad libitum* plus an energy and N supplement. The amount of rice straw offered each day was calculated as 110% of the previous week's average daily intake. Nitrogen was provided as either urea or gliricidia, with additional energy in the form of onggok. Cows in group SO+U (straw, onggok + urea) were offered onggok at 10 g DM/kg LW.day plus a urea supplement at 0.2 g DM/kg LW.day. The urea supplement consisted of urea and ammonium sulfate mixed to provide a N : S ratio of 10 : 1. The daily supplement amount was dissolved in 500 mL of water and sprayed onto the rice straw as it was fed. Cows in group SO+G (straw, onggok + gliricidia) were fed onggok at 5 g DM/kg LW.day plus gliricidia at 5 g DM/kg LW.day. One animal in the SO+G group did not consume enough of the supplement to maintain weight and was removed from the experiment. Data from this animal is not included in any analyses. The composition of feeds offered in each period of the experiment is shown in Table 1. Diets were not balanced for N or ME.

The amount of feed offered to the cows was calculated according to designated treatment every week after the cows were weighed. Feed was prepared 1 day in advance. Cows were fed at 0800 hours each morning after any feed remaining from the previous day was collected and weighed. The feed troughs were not big enough to contain the entire daily ration, so rice straw and gliricidia were added to the trough every hour until the entire ration was fed out at ~1500 hours. Onggok was fed in two portions each day, at ~0900 hours and 1400 hours. Animals had free access to fresh drinking water at all times.

All feed was purchased from local traders. Rice straw was grown in irrigated paddies, dried standing in the field, and delivered to the research station once each week. Fresh gliricidia was delivered daily. Onggok was delivered in three batches during the experiment.

Sampling procedures and measurements

Feed intake was measured daily for the duration of the experiment. Subsamples of feed offered were collected each day and dried at 60°C for 48 h to determine DM content. Dried samples of each feed were bulked for each week and ground to pass through a 1-mm screen in a Retsch GmBH 5657 HAAN mill (Retsch-Allee, Haan, Germany). Organic matter was determined by combusting samples at 600°C for 3 h in a NEY M-525 Series II furnace (Yucaipa, California, USA) (AOAC 1984). Nitrogen was analysed using the Kjeldahl technique (AOAC 1984). Ash-free NDF and ash-free ADF were measured according to the technique described by Goering and Van Soest (1970). Amylase is not used in this method, and is not readily available in Indonesia. Amylase is not necessary for feed samples low in starch (Cherney *et al*. 1989). However, cassava by-products potentially contain large amounts of starch, so NDF and ADF were not presented for these samples. Residues of each feed type for each cow were bulked each week and a subsample was taken to determine DM as described above.

Digestibility of the diets was determined by total faeces collection on four separate occasions, during Weeks 5, 8, 11 and 18 of the experimental period. Faeces were collected from the floor of each animal's pen over 24 h for 7 consecutive days.

Table 1. Chemical composition of feed offered to cows (mean ± s.e.m.)

	Rice straw	Onggok	Gliricidia
Dry matter (g/kg)	408 ± 28.6	900 ± 9.7	236 ± 7.6
Organic matter (g/kg DM)	766 ± 3.4	695 ± 40.3	899 ± 2.0
Crude protein (g/kg DM)	57 ± 1.8	33 ± 2.7	225 ± 9.6
Ash-free neutral detergent fibre (g/kg DM)	648 ± 7.8	–	410 ± 10.7
Ash-free acid detergent fibre (g/kg DM)	450 ± 9.3	–	364 ± 8.7

Daily faecal output for each animal was weighed, mixed and a 10% subsample collected and stored at −20°C. At the end of the week, subsamples were thawed and bulked for each animal. Subsamples of the bulked samples were dried at 60°C for 72 h to determine DM content. The dried samples were ground and organic matter was determined using the same protocol as for the feed samples.

Cows were weighed weekly before feeding and BCS (1–5) was determined visually.

Data analyses

Equations from CSIRO (2007) were used to estimate the ME content of the diets (M/D, MJ/kg DM) and ME required for maintenance (ME_m, MJ/kg $LW^{0.75}$.day);

$$M/D = 0.169\ OMD - 1.986,$$
$$\text{where OMD is organic matter digestibility } (\%)$$

$$ME_m = \{1.2 \times [0.26 \times LW^{0.75}\ \exp(-0.03\ A)]/k_m + 0.09\ MEI\}/LW^{0.75},$$

where LW is liveweight (kg), A is age (years, with a maximum value of 6), k_m is the net efficiency of use of ME for maintenance (0.02 × M/D + 0.05) and MEI is total ME intake (MJ).

The Large Ruminant Nutrition System (LRNS) version 1.0.30, which is based on the Cornell Net Carbohydrate and Protein System (Fox *et al*. 2004), was also used to calculate ME_m and ME content. Ruminal N balance was also estimated using the LRNS.

Linear regression of ME intake (based on CSIRO equations) on daily LW gain was used to estimate the ME_m observed in the experiment. This method was also used to estimate the weight of 1 BCS unit, by regression of change in LW over change in BCS for each animal.

Liveweight gain during the experiment was plotted using split-line regression (GENSTAT 15th edition, VSN International, Hemel Hempstead, UK). Student's *t*-tests were used to identify differences in parameters measured between the two treatments (unpaired) and time periods (paired).

Results

Effect of diet

There was no significant difference in average daily LW gain or change in BCS between the two diets (Table 2). Over the entire experimental period, average daily LW gain of all cows was 0.14 kg/head.day and cows gained an average of 0.3 BCS units.

There was no significant difference in total DM intake, ME intake or rice straw intake between cows fed the two different diets (Table 2). Cows in the SO+G group had higher gliricidia and lower onggok intakes as formulated than did cows in the SO+U group. The SO+U diet had higher OMD than did SO+G (P = 0.01). The ME content of the diets estimated using the LRNS were similar for both diets (6.6 and 6.7 MJ/kg DM for the SO+U and SO +G diets, respectively), and lower than the values estimated using the equations in CSIRO (2007) (Table 2).

Both diets met the rumen-degradable N requirements of the cows. Ruminal N balance as calculated by the LRNS model was 114% and 115% of daily requirements for the SO+U and SO+G diets, respectively.

Effect of time

Liveweight of cows increased until Week 15 of the experiment, then reached a plateau at 304 kg, BCS 2.2 (Fig. 1). Average daily LW gain during the first 15 weeks of the experiment was 0.19 kg/head.day and weight of 1 BCS unit was estimated to be 36 kg. Based on these values, it would take a Brahman cow ~189 days to gain 1 BCS on the two diets tested.

Intake of onggok, gliricidia and total DM were higher in Weeks 16–21 than 1–15 (Table 2, $P < 0.001$). The OMD, ME content of the diets and ME intake were also higher in the second part of the experiment.

ME for maintenance

Regression of ME intake over LW predicted ME_m of 0.84 MJ/kg $LW^{0.75}$.day. This was much higher than the average value predicted by the CSIRO equation, 0.47 MJ/kg $LW^{0.75}$.day. Average ME_m predicted by the LRNS was 0.62 MJ/kg $LW^{0.75}$.day.

Table 2. Mean feed and water intake, digestibility, metabolisable energy (ME) intake, liveweight (LW) gain and change in body condition score of mature Brahman cows fed rice straw and onggok plus urea (SO+U) or gliricidia (SO+G), and of all cows during Weeks 1–15 and 16–21 of the experiment

Means within rows within diet or time followed by different letters are different at P = 0.05

	Diet			Time		
	SO+U	SO+G	s.e.m.	Weeks 1–15	Weeks 16–21	s.e.m.
Total intake (g DM/kg $LW^{0.75}$.day)	99.8	106.2	2.51	100.9a	107.8b	1.92
Rice straw intake (g DM/kg $LW^{0.75}$.day)	67.0	74.5	2.36	70.5	70.8	1.79
Onggok intake (g DM/kg $LW^{0.75}$.day)	32.7a	18.6b	1.36	24.7a	28.8b	1.07
Gliricidia intake (g DM/kg $LW^{0.75}$.day)	–	13.2	0.64	5.6a	8.2b	1.00
Organic matter digestibility (g/kg DM)	645a	623b	4.8	622a	673b	5.0
ME content (MJ/kg DM)[A]	8.9a	8.5b	0.08	8.5a	9.4b	0.09
ME intake (MJ/kg $LW^{0.75}$.day)[A]	0.89	0.91	0.021	0.86a	1.02b	0.021
Liveweight gain (kg/day)	0.13	0.15	0.027	0.19a	0.04b	0.026
Change in body condition score (1–5 scale)	0.33	0.29	0.076	0.33a	–0.02b	0.050

[A]ME content and ME intake were calculated using the equations in CSIRO (2007).

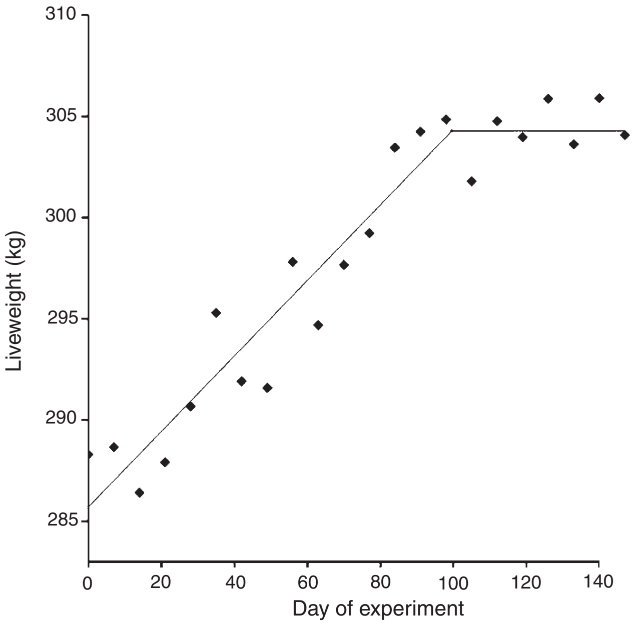

Fig. 1. Split-line regression of average liveweight of cows fed rice straw *ad libitum* plus onggok and urea or gliricidia.

Discussion

Average daily LW gain of cows fed rice straw and onggok was lower than expected, and it would take Brahman cows over 6 months to gain 1 BCS unit on the diets tested. This result suggests that increasing BCS quickly to reduce the postpartum anoestrous interval, and hence calving intervals, is difficult within village-based systems. It also casts some doubt over the usefulness of onggok as an energy supplement for cattle kept by smallholder farmers, at least at the levels consumed in this experiment.

Good BCS is important for cows to maintain reproductive function, and a BCS of 3 or higher on the 1–5 scale is usually targeted in beef cattle (e.g. Short *et al*. 1990). Jenkins and Ferrell (2007) demonstrated that cows will reach a stable weight, BCS and ME_m after a period of feeding a fixed DM or ME intake (g DM or MJ ME/day). In our experiment, the LW and BCS of cows reached a plateau at 304 kg and a BCS of 2.2. This means that while Brahman cows can maintain weight on a rice straw-based diet, they may not be able to maintain a BCS sufficient for good reproduction rates. Our result is similar to that of Syahniar *et al*. (2012), who reported that feeding rice straw *ad libitum*, supplemented with tree legumes at up to 22 g DM/kg $LW^{0.75}$.day was enough to maintain the weight of mature Ongole cows with average BCS of 2.6 (also 1–5 scale). This is an important demonstration of the concepts advanced by Jenkins and Ferrell (2007), whereby if intake is fixed at a given amount by physical regulation of intake, as most likely occurred with rice straw given various supplements, then it will support a level of weight but that weight and consequent BCS may not be adequate for reproduction. Presumably if a better diet was formulated to achieve a higher fixed intake then a higher weight and BCS would be achieved. Thus a target BCS for reproduction will require a certain level of ME intake to be achieved, higher than can be achieved by rice straw alone or with moderate levels of supplements readily available in Indonesia.

An important result from this experiment is that there was no advantage in using urea instead of gliricidia as a source of N for the cows. Both supplements comfortably met the daily rumen-degradable N requirements of cows. Tree legumes such as gliricidia, *Leucaena leucocephela* and *Sesbania grandiflora* provide a cheap and locally available source of crude protein and ME for livestock throughout the year, including the dry season. They can be planted as living fences around the farmer's house or animal pens, where they can be harvested easily with little labour cost. In comparison, urea is expensive and farmers may consider it a risky supplementation option because the amount of urea fed needs to be carefully controlled or mortalities can occur.

Interestingly, there was no difference in total supplement intake, ME intake or LW gain between the two diets, despite significantly higher levels of onggok being consumed in the SO+U group. This suggests that the ME content of the onggok used in this experiment was lower than we anticipated and similar to that of the gliricidia. The quality of the onggok fed to cows in this experiment was highly variable, and the average ash content from our analysis (30% DM) was much higher than values previously reported in the literature. The high ash content of the onggok was attributed to contamination with soil. Cassava is a root crop, and cassava tubers might not always be washed thoroughly before processing, leaving some soil material in the remaining by-products. In addition, some processors dry onggok by leaving it on the ground exposed to sunlight, presenting more opportunities for contamination (Sari *et al*. 2013). Finally, it is possible that some traders dilute onggok with sand or other material to take advantage of good feed prices. The onggok used in this experiment was purchased from local feed traders, and can be assumed to be of similar quality to that available to smallholder farmers.

The ME_m of Brahman cows in this experiment was estimated to be 0.84 MJ/kg $LW^{0.75}$.day. This is higher than that predicted using the CSIRO equations [0.47 MJ/kg $LW^{0.75}$.day, CSIRO (2007)] or the LRNS (0.62 MJ/kg $LW^{0.75}$.day). Differences between the values may be partially explained by differences in the estimated ME content of the diets. When the energy content predicted by the LRNS was used instead of the CSIRO ME values to estimate observed ME_m through regression, the average ME_m decreased to 0.63 MJ/kg $LW^{0.75}$.day. Although there may have been small errors in our measurement of OMD, the equations from CSIRO (2007) are more likely to be the reason ME content was overestimated. The OMD of the diets would need to be ~500 g/kg DM for the CSIRO equations to output an ME content similar to that of the LRNS. This is very different to our average measured OMD of 634 g/kg DM, and lower than published values for OMD of untreated rice straw fed without supplementation [for example, Syahniar *et al*. (2012), 531 g/kg DM]. There may also be issues with the calculation of net efficiency of use of ME for maintenance (k_m). CSIRO (2007) state that their equation may not be valid for diets with ME content of less than 7 MJ/kg DM since data from low quality feeds were not used in deriving their equations.

Syahniar *et al*. (2012) also reported that the CSIRO equations underestimated the ME_m of cattle fed rice straw-based diets compared with values derived from the LRNS or estimated through regression. Both the LRNS and CSIRO equations account for breed, weight, age, sex and physiological state. However, the CSIRO equation may not fully account for current BCS or energy expended by animals coping with high environmental temperatures.

Conclusions

The results from our experiment demonstrate that Brahman cows can maintain LW on a rice straw and onggok-based diet with the provision of N in the form of urea or tree legumes. However, these diets do not provide sufficient ME for cows to gain LW quickly or maintain a BCS sufficient for good reproduction rates (i.e. BCS 3 or higher on a 1–5 scale). The nutritive value of onggok was lower than expected, but reflects the quality of feed available to smallholder farmers in Indonesia. Better quality diets, containing higher levels of ME, are required for cows to gain and maintain a good BCS in smallholder farming systems.

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References

AOAC (1984) 'Official methods of analysis.' 14th edn. (Association of Official Analytical Chemists: Washington, DC)

Aro SO, Aletor VA (2012) Proximate composition and amino acid profile of differently fermented cassava tuber wastes collected from a cassava starch producing factory in Nigeria. *Livestock Research for Rural Development* **24**, Article #40.

Cherney DJR, Patterson JA, Cherney JH (1989) Use of 2-ethoxyethanol and á-amylase in the neutral detergent fiber method of feed analysis. *Journal of Dairy Science* **72**, 3079–3084. doi:10.3168/jds.S0022-0302(89)79461-3

CSIRO (2007) 'Nutrient requirements of domesticated ruminants.' (CSIRO Publishing: Melbourne)

Djazuli M, Bradbury JH (1999) Cyanogen content of cassava roots and flour in Indonesia. *Food Chemistry* **65**, 523–525. doi:10.1016/S0308-8146(98)00218-0

FAO (2013) 'FAOSTAT.' (Food and Agriculture Organisation of the United Nations: Rome) Available at http://faostat.fao.org [Verified 15 May 2014]

Fox DG, Tedeschi LO, Tylutki TP, Russell JB, van Amburgh ME, Chase LE, Pell AN, Overton TR (2004) The Cornell net carbohydrate and protein system model for evaluating herd nutrition and nutrient excretion. *Animal Feed Science and Technology* **112**, 29–78. doi:10.1016/j.anifeedsci.2003.10.006

Goering H, Van Soest P (1970) 'Forage fibre analyses (apparatus, reagents, procedures and some applications). Handbook No. 379.' (US Department of Agriculture: Washington, DC)

Hanifah VW, Priyanti A, Mahendri IGAP, Cramb RA (2010) A comparison of feeding management practices of beef cattle smallholders in lowland and upland sites in East Java. In 'Proceedings of the 5th international seminar on tropical animal production: community empowerment and tropical animal industry'. (Eds KA Santosa, A Wibowo, B Guntoro, DR ZoBell, ER Orskov, E Sulastri, IGS Budisatria, M Lund, R Akashi, Soeparno, SPS Budhi, T Suzuki, Widodo, Y Opatpatanakit) pp. 189–195. (Faculty of Animal Sciences, Universitas Gadjah Mada: Yogyakarta, Indonesia)

Jenkins TG, Ferrell CL (2007) Daily dry matter intake to sustain body weight of mature, nonlactating, nonpregnant cows. *Journal of Animal Science* **85**, 1787–1792. doi:10.2527/jas.2006-678

Kementan–BPS (2012) 'Rilis Hasil Akhir PSPK 2011.' (Kementerian Pertanian, Badan Pusat Statistik: Jakarta)

Kumar R (1992) Anti-nutritional factors, the potential risks of toxicity and methods to alleviate them. In 'Legume trees and other fodder trees as protein sources for livestock'. (Eds A Speedy, P Pugliese) pp. 145–160. (FAO: Rome)

McLennan SR, Wright GS, Blight GW (1981) Effects of supplements of urea, molasses and sodium sulfate on the intake and liveweight of steers fed rice straw. *Australian Journal of Experimental Agriculture and Animal Husbandry* **21**, 367–370. doi:10.1071/EA9810367

Owen E, Jayasuriya MCN (1989) Use of crop residues as animal feeds in developing countries. *Research and Development in Agriculture* **6**, 129–138.

Priyanti A, Hanifah VW, Mahendri IGAP, Cahyadi F, Cramb RA (2012) Small-scale beef cattle production in East Java, Indonesia. In 'Proceedings of the Australian Agricultural and Resource Economics Society annual conference'. (AARES: Fremantle, WA)

Sari M, Warji , Novita DD, Tamrin (2013) Mempelajari karakteristik tepung onggok pada tiga metode pengeringan yang berbeda. *Jurnal Teknik Pertanian Lampung* **2**, 43–48.

Short RE, Bellows RA, Staigmiller RB, Berardinelli JG, Custer EE (1990) Physiological mechanisms controlling anestrus and infertility in postpartum beef cattle. *Journal of Animal Science* **68**, 799–816.

Syahniar TM, Antari R, Pamungkas D, Marsetyo , Mayberry DE, Poppi DP (2012) The level of tree legumes required to meet the maintenance energy requirements of Ongole (*Bos indicus*) cows fed rice straw in Indonesia. *Animal Production Science* **52**, 641–646.

Tambunan RD, Suminah, Mayberry DE, Fordyce G, Poppi DP (2013) Reproductive performance of Brahman cows kept by smallholder farmers in Indonesia. In 'Proceedings of the Northern beef research update conference'. p. 184. (North Australian Beef Research Council: Cairns, Qld)

Yuwono P, Sodiq A (2010) Brahman cross development in village breeding centre of the *Sarjana Membangun Desa*: pitfall and a lesson learned. *Journal of Animal Production* **12**, 156–162.