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project

Profitable feeding strategies for smallholder cattle in Indonesia

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prepared by	Karen Harper and Dennis Poppi
co-authors/ contributors/ collaborators	Cuk Tri Noviandi, Ali Agus, Gunawan, Simon Quigley, Kieren McCosker, Kusmartono, Marsetyo, Moh. Takdir, Dahlan Dahlanuddin, Tanda Panjaitan, Kasmiyati, Achmad Subagio
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Contents

1 Acknowledgments

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2 Executive summary

Indonesia aims to increase beef production to meet increasing demand. Smallholder farmers account for most of the cattle production within Indonesia and their participation in supply and value chains offers a pathway out of poverty. Farmers usually formulate cattle feed rations based on cheapest feed cost inputs, resulting in low growth rates (about 0.2-0.5 kg per day) of cattle in villages and in small to medium scale feedlots. Growth rate can only increase if metabolizable energy (ME) content of the ration can be increased, and crude protein (CP), neutral detergent fibre (NDF) and mineral requirements are met. Therefore, feed formulation needs to be based on a combination of the most cost-effective and feed efficient diets.

Each region in Indonesia has a different range of feed resources, both on farm and purchased feeds, thus there is a need to customise diets for different regions in Indonesia. In addition, there is a large range of high energy food processing wastes that could be incorporated into cattle diets but there are limited data on the benefits of using these ingredients in cattle diets. The prices and availability of ration ingredients vary markedly and so a flexible system of ration formulation is required to take advantage of local price fluctuations.

Project LPS/2013/021 - Profitable feeding strategies for smallholder cattle in Indonesia, investigated rations that promote high live weight gain and low feed for gain conversion (FFG, kg feed/kg gain). Specific objectives of this project were:

1. Develop robust treatment processes for removal of HCN from under-utilised by-products of cassava and preparation as a tradeable feed source for cattle
2. Devise simple, cost-effective feed rations with a lower feed for gain conversion (low FFG) than those currently used for reproduction and fattening of cattle
3. Conduct participatory on farm and small to medium scale feedlot best bet interventions of feed mixes
4. Analyse the costs and benefits of the interventions and their adoption by small-scale producers and document the economic and social impacts on households and household members.
5. Strengthen capacity of local scientists, including postgraduate students, to conduct farmer relevant research and farmers and feed companies to make sound business decisions.

The project formed a partnership with Universities and Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian (BPTP) in Indonesia and the University of Queensland and Northern Territory Department of Industry, Tourism and Trade (NT DITT) in Australia.

There was a mix of controlled experiments on station at the Universities of Gadjah Mada (Yogyakarta), University of Brawijaya (Malang), University of Mataram (Lombok) and Tadulako University (Palu) and village based experiments with participating farmers. High energy based resources were identified in each region so that each location utilised different feeds and cattle breeds. Simple feed ration formulations were developed and tested at each site to achieve high liveweight gain with a cost structure that increased profit and daily income. Outputs of each of the controlled experiments were evaluated in participatory village based experiments conducted by the local Balai Pengkajian Teknologi Pertanian (BPTP). The village sites were used for monitoring animal liveweight, testing interventions and conducting capacity building

Many high energy ingredients identified were products of cassava (whole tuber, cassava powder (gaplek), peels, tips and bagasse (onggok) as there are few high energy

ingredients available at village level. Some cassava products, such as the peel are especially high in HCN. The Jember University and the University of Queensland were involved in developing robust treatment processes for the removal of HCN. It was found that HCN can be removed by drying to be safely incorporated into local diets and the parameters of drying (time etc) were established. Some aspects of silage production were established.

A Least Cost Ration (LCR) formulator (ACIAR LCR) using a solver program within excel, and a least cost ration formulator mobile phone android App (Beef-upp) have been developed for use across industry to allow users to modify ration formulations for local circumstances considering cost and feed availability. The spreadsheet is designed for users with a nutritional background while the mobile phone app is designed for use by entrepreneurial farmers, co-operatives and small commercial feed companies. Both least cost formulators formulate and alter rations quickly as circumstances change. The application of these principles has led to two-fold increases in income over feed cost (IOFC) for farmers.

Importantly the project also identified the potential for readily available high metabolisable energy feed ingredients to be incorporated into diets and the limits to inclusion.

The main outputs of the project were:

- Development of an ACIAR LCR and Beef-upp App to formulate and evaluate rations to promote high live weight gain.
- Rations that utilised different local ingredients which varied from site to site based on availability and cost
- An increase in IOFC when these rations were applied either as a supplement or preferably as a total mixed ration (TMR). IOFC increased from IDR1500 in the worst current systems to IDR42000 in the best systems where IOFC were higher when TMRs were used and fed to high levels. There was a higher risk because of the higher cost outlay for feed. IOFC varied with regions and breeds but the highest IOFC was achieved with Euro x Ongole bulls fattened in East Java using all purchased feed. Development of systems based on home grown cassava and tree legumes had the greatest potential to increase IOFC and also regional output of beef. IOFC was more sensitive to TMR feed costs and level of feeding than to sale price of bulls.
- The realisation that whole cassava tubers can be incorporated into rations at low cost especially if combined with tree legumes as a protein source. There is no need for processing other than some drying of the product.
- The responses by Euro x Ongole, Ongole and Bali bulls to the rations were similar but that once high growth rates were achieved then Euro x Ongole and Ongole bulls outperformed Bali bulls. The IOFC were however similar. Results from Brahman weaner cattle in Australia were similar.
- Village based co-operatives or agribusiness can use the ACIAR LCR or Beef-upp App and in two cases developed a feed formulation and mixing business based within a village.
- The upper level of inclusion of any cassava product was determined to be 40%.
- Rice bran composition and quality varied markedly across sites reflecting the changing processing methods of rice. Onggok (cassava bagasse) also varied in quality reflecting the higher extraction of starch in new processing methods.
- HCN was best removed by at least a 24 hour sun drying procedure. Ensilage had variable results depending on how much drying occurred prior to ensiling, and cassava part to be ensiled. A small drying period (<24 hrs), ensilage for at least 4

weeks and aeration (at least an hour) prior to feeding and inclusion at a maximum of 40% of the TMR would be a safe standard operating procedure. Samples should be tested for HCN prior to feeding.

- Increased capacity of scientists, both senior and junior level.

3 Background

The Indonesian government has placed a high priority on self-sufficiency in beef production where domestic beef supply is currently unable to meet consumer demand. Livestock production accounts for about 30% of agricultural GDP in the eastern provinces of Indonesia. The major concentration of cattle in Indonesia is in East Java, Central Java and Yogyakarta which, together with Bali, Nusa Tenggara Barat (NTB) and Nusa Tenggara Timur (NTT), account for approximately 57% of the total cattle herd in Indonesia. The majority of cattle in Indonesia are raised by 4.2 million smallholder farmers and landless producers, with an increasing number of small to medium scale feedlots. The Indonesian priority for the beef sector is to increase the number and improve the reproductive efficiency of breeding cows and improve the growth and fattening of cattle. Project LPS/2013/021 was developed to address and support these Indonesian cattle priorities.

Though there is substantial trade in cattle feedstuffs, the growth rates of cattle in villages and in small to medium scale feedlots are low (about 0.2-0.5 kg per day, depending on breed). Diets are based on the cheapest available feed rather than a combination of the most cost-effective and feed efficient diets. This is mainly because there is a lack of understanding of the benefits of improved diets (i.e. increased growth rates and decreased cost/weight gain), the aversion to risk and no tools for formulating a simple diet based on nutritional principles. A 'best-bet' diet intervention in a previous ACIAR project has shown that growth rates of 0.9 kg per day could be achieved in Ongole bulls and this greatly increased the financial return from IDR 15,770 to IDR 24,180 per day per bull. Furthermore, there is a large range of high energy food processing wastes that could be incorporated into cattle diets but there are limited data on the benefits of using these ingredients in cattle diets. While a lot of basic research has been done, there is a need to customise diets for different regions in Indonesia as each region has a different range of feed resources – both on farm and purchased feeds. There are three constraints to improving the situation:

1) Developing simple, cost-effective diets for different locations in Indonesia using locally available (on-farm and purchased) ingredients
2) Developing a feed calculator to make it simple to replace ingredients in local diets depending on what is available / cheap at any one time.
3) Often, energy is a key limiting factor in local diets but there are products such as cassava and its by-products that could be used, provided we find ways of safely incorporating them into local diets.

This project was developed from the conclusions of LPS/2008/038 where the profit advantage of a better diet was clearly demonstrated but the lack of response curve relationships and a formal ration formulation system inhibited further development of suitable feed rations. A scoping meeting with Indonesian livestock researchers held at Gadjah Mada University in June 2015 discussed the need for research on cost-effective cattle diets and identified the following key research questions:

- What high energy based resources are available, as energy is a key limiting factor in local diets? There are products such as cassava and its by-products that could be used, provided we find ways of safely incorporating them into local diets.
- What robust treatment procedures of by-products are needed and how may they be developed to ensure the by-products are safe to use, in particular removal of HCN from cassava waste?
- What simple feed ration formulations can be developed that achieve high liveweight gain with a cost structure that increases profit and daily income?

- What simple ration formulator system is required to be able to substitute feed ingredients based on local availability and cost, and how might this be developed for use by advisors and commercial enterprises?
- What are the constraints to adoption of new feeding systems?
- What are the economic and social outcomes of the proposed interventions?

The project formed a partnership with Universities and Balai Teknologi Pertanian (BPTP) in Indonesia and the University of Queensland and Northern Territory Department of Industry, Tourism and Trade in Australia. The project firstly needed to identify the potential for readily available high ME feed ingredients to be incorporated into diets. Controlled experiments on-station at collaborative universities aimed to optimise the use of local ingredients to achieve high live weight gains in each region utilising local breeds of cattle. Participatory village based trials in each region evaluated the outputs from the controlled experiments and managed by the Balai Pengkajian Teknologi Pertanian (BPTP). Developing simple flexible ration formulation tools, is important for use across industry to allow users to develop modified formulations for local circumstances considering cost and feed availability. Figure 1 outlines the overall co-ordination of the project partners.

The overall goal of the project was to improve the profitability of beef cattle production of small-scale beef producers through the development of simple cost-effective feed rations.

The project is of benefit smallholders, landless cattle producers and small-medium scale feedlots by improving reproduction and growth of cattle. The project focussed on growth of bulls, but the same principles can be applied to maintain body condition score in cows. Based on previous research, growth rates can be doubled and profit from cattle production increased by 53%. At the national level, improved reproductive performance and higher growth rates will improve the number and quality of cattle available for slaughter. The project also aimed to build capacity of a new generation of ruminant nutritionists across Indonesia who will be skilled in farmer relevant research to facilitate the continued development of local cattle production systems.

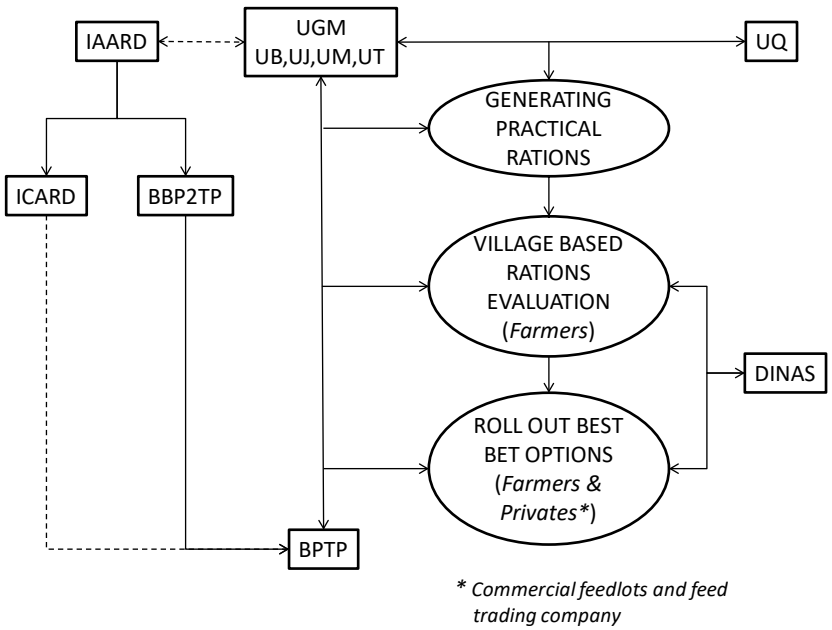

Figure 1. Role of each parties to achieve project outputs

4 Objectives

Specific objectives were:

Objective 1. ***Develop robust treatment processes for removal of HCN from under-utilised by-products of cassava and preparation as a tradeable feed source for cattle.***

Activities

- The Jember University conducted three experiments. **Experiment 1** investigated the effect of wilting and sun drying of sweet and bitter varieties of cassava leaves, stems, tuber and peel on HCN content. **Experiment 2** evaluated the linamarin content in the tuber of a range of cassava varieties. **Experiment 3** investigated the elimination of HCN compounds from various parts of cassava plants with silage fermentation with wilting and EM4 which is a microorganism/inoculum commonly used in Indonesia to promote low pH silage.
- A series of three experiments at The University of Queensland investigated the rate of disappearance of Hydrocyanic Acid (HCN). **Experiment 1** investigated drying or silage processing of various cassava plant parts. **Experiment 2** investigated the use of additives (limestone, sugar) and pre-wilting when ensiling cassava leaves on HCN content. **Experiment 3** further investigated the influence of wilting and additives of sugar, limestone ($CaCO_3$) or urea in cassava leaf silage on HCN content.
- Further research was conducted at The University of Queensland to develop a HCN kit so that feed samples can be accurately measured for HCN to ensure safe feeding. Previous kits were expensive and utilised a very small amount of sample which was not necessarily indicative of the feed eaten by the animal. Our aim was to develop a cost effective kit that utilised a larger sample in the analysis of HCN.
- To examine digestibility of cassava tubers, The University of Queensland compared in vitro digestion under conditions of cassava tubers with or without supplements of grain or protein meals.
- Laboratory analysis was undertaken on 120 samples of rice bran collected across Indonesia. All samples were subsampled and analysed at UQ, Beef Cattle Research Institute (BCRI) Grati and the University of Gadjah Mada for chemical analysis.

Objective 2. ***Devise simple, cost-effective feed rations with a lower feed for gain conversion than those currently used for reproduction and fattening of cattle.***

Activities

- Two least cost ration formulations systems were devised at The University of Queensland.
- There were four University sites completing eight feeding experiments in Indonesia over the course of the project. In addition, in Katherine, NT, cassava tuber was included in a range of diets to Brahman cross steers to develop diets applicable to live export cattle and those destined for local meatworks. At each regional site a full inventory of locally available feeds was made to include them in the ration formulator. These controlled experiments all aimed at developing response curves to develop optimum level of inclusion and boundaries to inclusion for ingredients under test. The feeds included whole tuber, cassava powder (gaplek) cassava bagasse (onggok) and cassava peels as energy sources and tree

legumes, various protein meals, soybean hulls and wheat pollard as protein sources. The ACIAR LCR excel spreadsheet was used to create rations.

Objective 3. ***Conduct participatory on farm and small to medium scale feedlot best bet interventions of feed mixes.***

Activities

- Ten village trials were undertaken across four target regions over a three year period. These village trials were conducted by the regional BPTP in collaboration with the regional University and Dinas Peternakan. Diet combinations from the university experiments were tested on farm. Farmers were provided with access to data as it was collected, allowing them to track live weight performance and predict turn-off time / live weight/ age and economic modelling to assist with business decisions. Associated with these village trials were outreach and field days within the village as well as in surrounding villages.

Objective 4. ***Analyse the costs and benefits of the interventions and their adoption by small-scale producers and document the economic and social impacts on households and household members.***

Activities:

- Livelihoods analysis involved survey of farmers at the commencement of the village trials. Surveys described: numbers, age, occupations, level of education and gender roles.
- A survey describing the use of various feeds for cattle production was also undertaken across the experimental regions.
- Economic analysis was performed for the village rations for each site and some controlled experiments. This provided data on daily IOFC and therefore potential profitability of supplementation.

Objective 5. ***Strengthen capacity of local scientists including postgraduate students to conduct farmer relevant research and farmers and feed companies to make sound business decisions.***

Activities

- Ten Junior scientists and 1 Junior researcher were employed and supported to complete postgraduate degrees, primarily Master's degrees, at the Universities conducting the research. The project funds the research as part of the project activities at University sites and the village sites where BPTP closely aligned to regional Universities to ensure these trials also had a student enrolled in a postgraduate program. Undergraduates were also involved in some universities for honours projects.
- To ensure junior scientists acquire technical skills, workshops were conducted by senior scientists (Indonesian and Australian). There were 4 workshops over the project and subject matter included: experimental design, blocking, statistical analysis, measuring feed intake, excel spreadsheet use, biochemistry of HCN, and application of the least cost ration formulator.
- Farmer field days and training workshops were held in all regions on a regular basis. Central Sulawesi had bi-monthly meetings and workshops for participating farmers, Malang had monthly meetings and field days and Yogyakarta had weekly participating farmer meetings. The University of Gadjah Mada held five farmer

workshops on feed formulation. Number of participants for field days and workshops ranged from 20 to 440. The NTB region hosted farmers for demonstrations during all the feeding trials.

5 Methodology

Methodology

This project targeted five Indonesian research areas distributed across different cattle breeds and different agricultural systems thus providing different alternative feed resources. The sites were in Yogyakarta, East Java (Malang and Jember), Nusa Tenggara Barat (NTB, Lombok and Sumbawa) and Central Sulawesi (Palu) (Figure 2).

In **Yogyakarta,** our project focused on Ongole (Bos indicus) cattle. Gliricidia forests are near and available and protein meals and cassava are readily available. Cattle producers are generally smallholders or landless, with cattle tethered at the farmer's house or in a group kandang. A kandang is a group housing system with farmers responsible for their own bulls. Ongole bulls and Euro x Ongole bulls (Bos taurus x Bos indicus) are the main breeds.

Malang (East Java) is a region of high cattle numbers with farmers having little access to land. This area has access to a wide range of feeds and due to local large commercial feedlots has access to a large range of agricultural by-products. There is a mixture of small feedlots (>10 head) and smallholders (<10 head, usually 1-5 bulls). There are kandangs in some villages. Ongole bulls and Euro x Ongole bulls are the main breeds.

Jember (East Java) is a major intensive agricultural cropping region (cassava and tobacco). Jember University has a recognised food technology laboratory for processing cassava and analysis of HCN.

NTB Lombok and Sumbawa region has larger land areas for farmers. Leucaena and other tree legumes dominate rations but also corn is grown locally. By-products can be expensive to source. Bali cattle (Bos javanicus) are the main breed.

Palu (**Central Sulawesi**) has larger land areas and can grow a number of crops with gliricidia widely available. Corn is widely grown and harvested for sweet corn and as such has a higher quality corn stover than is usual. Many by-products available in Java are not as common in this area and are expensive. Bali cattle and Ongole cattle are the main breeds in this region.

Figure 2. Map of Indonesia with red dots indicating location of research nodes.

Australian research sites involved the University of Queensland, Gatton Campus and Katherine Research Station, NT DITT Northern Territory. A key Australian domestic policy is the development of northern Australia which specifically identifies the need to improve cattle production and supply chains to meet the Asian beef market. Katherine research

station grew cassava as a feed resource for Brahman cattle. The University of Queensland grew a bitter cassava variety (sourced from Katherine) and used it in experiments related to removal of HCN. It was also the site for development of some laboratory procedures and analysis of rice bran samples from Indonesia. The ACIAR LCR and Beef-Upp app were developed here using local IT expertise.

Across these sites we conducted a series of experiments designed to either:

- provide safe and effective feeds for use in rations (8 experiments)
- devise simple cost-effective rations for cattle fattening in controlled, university trials (11 animal feeding experiments)
- examine these “best bet” rations, devised in the controlled university experiments, in locally relevant village systems (10 experiments).

In the villages, costs and benefits of supplemental interventions and their adoption by smallholder farmers was analysed.

Strengthening the capacity of local scientists and farmers was an important activity throughout all experiments. Junior scientists employed in the project received training in managing projects and technical skills in data analysis. All were enrolled in a postgraduate degree and most have completed their degree requirements at the current date. Farmers involved in the village trials had free animal health checks, had access to scales for cattle weighing and received some free feed supplements. Farmers involved in the village trials, and those interested in its outcomes, were also able to attend meetings and field days.

Table 1. outlines the list of experiments, locations and year in which it was conducted. Experiments were prioritised at the annual meeting. Animal experiments followed a similar experimental procedure and group training at the start ensured the same protocols and quality assurance procedures were followed by each group. Experiments analysing the procedures to provide safe cassava products were conducted early within the project and continued for two years. University controlled experiments were prioritised to provide best bet diets for village trials. The development of the least cost formulators was also prioritised so as to provide a means to devise rations and assess them for their nutritive value. Rations for each experiment were based on a combination of availability and cost of ingredients for a region and what was formulated by the ACIAR LCR. We also tested some diets that had previously been successfully used within a region. The animal feeding experiments are organised by site rather than by activity number in the document as this made it more logical to outline the experiments at a site and the methodology, results and discussion relating to each experiment given the large number of feeding experiments and sites. The experimental number code thus differs from the original proposal.

Only brief descriptions of methodology, results and major points of discussion are outlined here. More detail can be found in published papers or reports in the Appendix.

Table 1. Summary of experimental activities conducted in the project aligned to research focus activities across Indonesia and Australia.

Obj #	Experimental Activity	Location	Year
1 Processing and feed quality experiments			
1.1	Exp 1 Drying and silage based procedures for removing HCN from cassava products	Series of experiments at **Jember University and The University of Queensland** University of Jember – variety trial University of Jember – plant parts trial University of Jember – probiotics and wilting University of Queensland- silage and drying plant parts	2017-2019

		University of Queensland – silage additives 1 University of Queensland – silage additives 2 University of Queensland – in vitro energy and protein interactions	
1.2	Exp 2 Variability in onggok composition (including HCN content) and develop colour chart for rapid assessment of soil addition	All sites: samples collected and analysed for HCN and ash. Colour chart was not developed owing to changes in onggok production. University of Queensland – HCN kit developed	2017-2019
1.3	Exp 3 Variability in rice bran composition	The University of Queensland, University of Gadjah Mada and BCRI Grati	2019-2021
Objective 2: Devise simple cost-effective feed rations with higher feed conversion efficiency (low Feed for Gain conversion) than those currently used for reproduction and fattening of cattle. ***Objective 3. Conduct participatory on farm and small to medium scale feedlot best bet interventions of feed mixes.***			
	Exp 4 Develop a least cost ration formulator	The University of Queensland	2019-2021
Animal experiments Animal experiments are organised by site rather than activities in the proposal. This listing refers to the collation of Objectives 2-3 in the proposal. Experiments are given a number so that they are more easily followed and referenced.			
	Yogyakarta		
	Experiment 5 Live weight gain response curve of Ongole and bulls to variable levels of gaplek and protein meal	University of Gadjah Mada. Response curve established	2018
	Experiment 6 Live weight gain response of Ongole bulls to rations varying in ME content and level	University of Gadjah Mada. Originally this experiment was a live weight gain response curve of Ongole bulls to increasing level of onggok and cassava tops, but sufficient cassava tops could not be sourced, and the experiment was changed to examining the response to ME content and level.	2019-20
	Experiment 7 Live weight gain response of Ongole bulls fed a commercial concentrate or various combinations of gaplek and wheat pollard.	University of Gadjah Mada. Originally this experiment was to study the response in Body condition score of cows at calving and 100d post-calving to a least cost ration supplement. It was decided with ACIAR approval that this was a lower priority than some of the questions emerging from experiments at other sites. Thus, the experiment was changed to looking at various combinations of gaplek and wheat pollard given local interest from farmers and also to compare to a known commercial feedlot ration.	2020-21
	Experiment 8 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Yogyakarta	BPTP Yogyakarta Village experiment. Live weight gain response of Ongole bulls to various formulated combinations using current feeding system (CFS) or supplemented with various combinations of gaplek, copra meal and gliricidia leaf meal.	2018
	Experiment 9 Live weight gain response of Ongole bulls to least	BPTP Yogyakarta Village experiment. Live weight gain response of Ongole bulls to various formulated combinations using current feeding system (CFS) or	2019

	cost ration formulation and protein meal sources in villages in Yogyakarta	supplemented with various combinations of gaplek, soybean hulls, copra meal, gliricidia leaf meal. The combinations and some ingredients were different to 2018 experiment.	
	Experiment 10 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Yogyakarta	BPTP Yogyakarta Village experiment. Live weight gain response of Ongole bulls to various formulated combinations using current feeding system (CFS) or supplemented with various combinations of gaplek, soybean hulls, PKC, peanut husks and gliricidia leaf meal either pelleted or as a meal. Processing method was studied in this experiment.	2020
	Malang		
	Experiment 11 Live weight gain response curve of Euro Xbred bulls to variable levels of dried cassava chips and protein meals	University of Brawijaya. Response curves of Euro Xbred bulls to levels of inclusion of dried cassava chips and copra meal and PKC as protein meal sources.	2018
	Experiment 12 Live weight gain response curve of Euro Xbred bulls to variable levels of cassava peel silage and protein meals	University of Brawijaya. Response curves of Euro Xbred bulls to levels of inclusion of cassava peel silage and copra meal and PKC as protein meal sources.	2019
	Experiment 13 Live weight gain response of Euro Xbred bulls to new ration formulations at Malang	BPTP Malang. Live weight gain response of Euro Xbred bulls in response to current feeding system (CFS) with 1 or 2 %W commercial concentrate mix OR 1 or 2 %W supplement of UB Best Bet ration of gaplek, PKC and copra meal.	2018
	Experiment 14 Live weight gain response of Euro Xbred bulls to new ration formulations at Malang	BPTP Malang. Live weight gain response of Euro Xbred bulls in response to CFS with UBrawijaya best bet formulation, CFS with commercial mix, CFS with local research diet, CFS with local feedlot diet (Santos).	2019
	Lombok and Sumbawa		
	Experiment 15 Live weight gain response curve of Bali bulls to increasing level of cassava chips with Leucaena based rations	University of Mataram. Live weight gain response curve to increasing levels of cassava chip with Leucaena based rations established.	2018
	Experiment 16 Live weight gain response curve of Bali bulls to increasing levels of cassava chips or onggok with Leucaena based rations	University of Mataram. A comparison of the live weight gain response curve of Bali bulls to increasing levels of cassava chips or onggok with Leucaena based rations	2019
	Experiment 17 Live weight gain response curve of Bali bulls sourced from low (with low body condition score (BCS)) or high (with high BCS) rainfall regions of NTB	BPTP NTB Sumbawa. The live weight gain response of Bali bulls sourced from different regions of Sumbawa with rations made of gaplek and Leucaena at different levels.	2018
	Experiment 18 Live weight gain response of Bali bulls to cassava, cassava peels, corn or commercial complete feed to Leucaena feeding systems	BPTP NTB Sumbawa. Compared the live weight gain response to supplementation with cassava chips, cassava peels and corn or commercial complete concentrate mix to a leucaena based diet for Bali bulls.	2019
	Experiment 19 Live weight gain response of Bali bulls to increasing energy content through cassava,onggok, corn or rice bran to Leucaena feeding systems	BPTP NTB Sumbawa. Compared various strategies to increase the ME content of rations by formulations using cassava, onggok, corn grain and rice bran	2020

	Palu Central Sulawesi Experiment 20 Live weight gain response curve of Ongole and Bali bulls to increasing level of gliricidia and ground cassava powder	Tadulako University and BPTP Central Sulawesi. The response curve of live weight gain of Ongole and Bali bulls to increasing levels of a supplement mix of cassava powder and gliricidia	2018
	Experiment 21 Live weight gain response of Ongole and Bali bulls to rations formulated by the ACIAR LCR based on cost and availability of local ingredients	Tadulako University and BPTP Central Sulawesi. Supplement rations formulated in different combinations using rice bran and gliricidia, rice bran and PKM, cassava and gliricidia or cassava and PKM.	2019
	Katherine, Northern Territory Experiment 22 Live weight gain response curve of Brahman steers to increasing level of cassava tubers with soybean meal or cavalcade hay at Katherine, NT, Australia	This developed a response curve of live weight gain of Brahman steers to increasing levels of cassava tuber and decreasing protein source	2020
SOSEC studies			
4.1	Economic analysis of smallholder systems and small commercial feedlots at regional village sites	All sites	2018-2021
	Livelihoods analysis of smallholder systems at regional village sites	All sites with UGadjah Mada as lead agency	2018

5.1 Processing and feed quality experiments

Objective 1

5.1.1 Experiment 1

Jember University experiments

5.1.1.1 Effect of drying and wilting process on HCN content of cassava plant parts.

Processing methods of chopping, drying, wilting and fermentation were tested and compared in their ability to reduced hydrogen cyanide (HCN). The HCN content analysis was assessed using picric paper method. HCN content was measured in cassava tubers using six cultivars. Kaspro, malang-6, and malang-4 are bitter cultivars, while ketan, cimanggu, and mentega are sweet cultivars. These vary in HCN content, higher in the bitter varieties which are used for starch extraction.

5.1.1.2 Linamarin Content in Tuber of Some Cassava (Manihot esculenta) Cultivars.

The purpose of this experiment was to analysis the concentration of linamarin and lotaustralin on cassava tubers from several cultivars - Malang 4, Malang 6, Kaspro, Ketan, Cimanggu and Mentega. Linamarin compounds were identified on LC-MS/MS with an optimum mass to charge ratio (m/z) 265 at retention time 0.92 to 1.32 min, whereas lotaustralin compound with m/z 279 had an optimum retention time of 1.34 to 1.45 min.

Furthermore, linamarin content was calculated by spiking method using glucose as standard, so the linamarin content was expressed as ppm equivalent of glucose (peg).

5.1.1.3 Elimination of HCN Compounds from Various Parts of Cassava Plants with Silage Fermentation.

Parts of cassava plants (leaves, stems, tuber with peel) were chopped and wilted for 24 hours, then fermented both spontaneously and with the use of EM4 microorganisms for 0, 7, 14 and 21 days. The process was carried out on a simple fermenter with anaerobic conditions. The observed variables included water content, total Lactic Acid Bacteria (LAB), pH value, nitrogen level and HCN acid level. Analysis of HCN acid was carried out by spectrophotometric (UV-VIS) method at a wavelength of 510 nm.

The University of Queensland experiments

5.1.1.4 The rate of disappearance of Hydrocyanic Acid (HCN) from cassava plant parts under drying or silage processing methods

Cassava cultivar MAus7 was grown at The University of Queensland, Gatton Campus, Australia. The experiment was a 2x3 factorial (two processing treatments with three plant part types) in a completely randomised design. After harvesting, tubers were washed, and peels removed. Peels, peeled tubers and foliage (top 50 cm) were chopped to 1-2 cm using a super-chipper (Cox, Australia). Cassava parts were immediately either ensiled using vacuum bags (Johnson et al. 2005) or sun-dried. Samples were analysed in triplicate at each of the following time-points: 0, 1, 3, 7, 10, 14, 17, 21, 24 and 28 days, with foliage silage further tested at 9 months. At each time-point, samples were analysed for dry matter, HCN using the picrate paper kit method (Bradbury et al. 1999), and pH for silages. An acceptable limit of HCN in Indonesia is 40 mg HCN/kg DM (Damardjati et al. 1993).

5.1.1.5 Making safe silage from cassava leaves

For this research the use of wilting and commonly used additives were used as treatments before ensiling cassava leaves using vacuum packing (Johnson, Merry et al. 2005). For this experiment, cassava leaves of cultivar MAus 7 were harvested and subjected to 12 treatments with 2 levels of wilting (wilt and no wilt) and 6 different additives (Control, 4% sugar,1% limestone, 1% limestone and 4% sugar, 3% limestone ($CaCO_3$), and 3% limestone and 4% sugar). For the wilted treatments, samples were wilted 16 hours prior to ensiling while the non-wilted were ensiled immediately. At 3 time points (zero time, 20 days and 12 weeks), HCN was analyzed for each treatment.

5.1.1.6 Investigating the influence of wilting and additives of sugar, limestone, urea in cassava leaf silage on hydrogen cyanide content.

The aim of this research was to further investigate ensiling chopped cassava leaves under a series of controls and additive treatments and how these influence the release of HCN. The primary aim was to reduce these HCN levels below safe limits (10ppm) reported by the Food and Agriculture Organisation (FAO) using ensiling. From 5.1.1.5 it was found that chopping and wilting was effective in reducing HCN content, but this experiment further investigated the use of alkali treatments in the early release of HCN before ensiling. For adequate release of HCN, pH needs to be between pH 5 – 6 (Nambisan 2011). The amount of additive was on an as fed basis. The sugar was incorporated to encourage the proliferation of lactic acid producing bacteria during the ensiling process and to offset the alkalinity of the limestone ($CaCO_3$) and urea. This research involved harvesting, chopping and then mixing cassava with a series of controls and additive treatments.

The pH and HCN was measured before ensiling and after a 4 week period of ensiling.

5.1.1.7 In vitro feed experiment assessing the degradability of DM and NDF with various energy and protein supplement combinations.

An in vitro experiment compared the dry matter and neutral detergent digestibility of Rhodes grass supplemented with various combinations of energy and protein supplements. Samples were set up in individual 50mL flasks. The basal forage (Rhodes grass) was set at 20 % of the ration and the energy sources (i.e. Cassava, corn or wheat) were added at levels of 35, 45, 55 or 65 %. The remaining proportion (45, 35, 25, 15 %) corresponded to the protein sources (i.e. cassava tops or soybean). Urea, dissolved in water, was added in different proportions so that all treatments had the same CP concentration (being the diet with the highest CP the reference: Wheat 35/Soybean 45, equal to 26.8 % CP).

5.1.2 Experiment 2. Variability in onggok composition and development of HCN kit

Over the last few years, onggok has not been readily available, the processing method has changed and the need for a colour chart was no longer appropriate. Instead, onggok was analysed in experiments, where used, to determine variability in the product.

The need for a HCN kit was identified and has been developed by UQ. Indonesian feed samples were sent to Jember University for HCN assessment The method used was the picric acid method (Bradbury et al. 1999). At The University of Queensland, this methodology was also used but through a kit form developed by the Australian National University (ANU) http://biology-assets.anu.edu.au/hosted_sites/CCDN/five.html. This kit is quite costly, and a very small sample size is required and therefore gave a high standard error as different plant parts have variable HCN content. As such we devised a new kit that can be made in any lab that has access to cassava. Our new kit has been used successfully in our laboratory and our aim is to utilise a larger sample tissue size of 500 -1000 mg. The kit needs to be further refined for wider use especially within Indonesia.

5.1.3 Experiment 3. Variability in rice bran composition

Reports emerged of wide variation in rice bran composition related to changing processing methods in Indonesia. Rice bran samples (120) were collected throughout Indonesia by our collaborators. A sampling and labelling protocol was provided to all partners involved in collection.

All rice bran samples were taken to the University of Gadjah Mada, split into three to be distributed to BCRI Grati, The University of Queensland and kept at University of Gadjah Mada for analysis. A material transfer was arranged for transportation and analysis in Australia.

Scope of area of where rice bran samples were collected

Rice bran was collected in North Sumatra, throughout Java, Sulawesi and in the NTB region of Indonesia.

Chemical analysis

Dried rice bran samples were ground to pass through a 2 mm screen. Feed samples were then analysed for DM, organic matter (OM), ether extract and bulk densities according to AOAC (1995). At the University of Queensland, the CP content was determined using Leco (928 series macro determinator, LECO). The content of ash-free neutral detergent fibre (aNDFom) and ash-free acid detergent fibre (ADFom) of the feed was measured according to the technique described by Goering and Van Soest (1970) adapted for the Ankom fibre analyser, ash-free neutral detergent fiber (NDFom) and indigestible NDFom (iNDFom) (Harper and McNeil 2015) at the School of Agriculture and Food Sciences, University of Queensland, Gatton Campus, Queensland. The samples were analyzed for iNDFom using long-term (10 days) in vitro fermentation. This procedure is based on a

fermentation procedure described by Goering and Van Soest (1970), adapted for use with Ankom filter bags using ANKOM Daisy incubators. Samples were analysed using (Daisy ANKOM method, two stage rumen fluid pepsin procedure to determine dry matter digestibility (DMD), organic matter digestibility (OMD) and digestible organic matter in the DM (DOMD) (Minson 1984, Holden 1999).

5.2 Devising a simple cost-effective feed ration

5.2.1 Experiment 4. Developing a least cost ration formulator

Two formulators were developed at The University of Queensland.

ACIAR LCR spreadsheet

A least cost ration (LCR) excel spreadsheet with solver program was created in 2018. This was developed from a basic prototype from the Murray State University USA (Alyx Shultz pers. comm.) which was customised for Indonesian feeding systems and modified to facilitate use.

The ACIAR LCR was utilised in devising rations in most of the 2019 and 2020/21 animal experiments (noted in the activity chart) over the last two years of the project for testing and formulating experimental rations. This spreadsheet is designed for users with a nutritional understanding with regard to animal nutrient requirements, feed intake (total and palatability issues), controlled feeding (avoiding slug feeding), potential anti-nutritive issues including excess starch and HCN. A successful training day in July 2019 instructed all the junior scientists on how to effectively use this tool. Based on feedback from users the ACIAR LCR has been regularly updated to provide appropriate information and remove points of confusion in its application.

Beef-upp

The second formulator was an android mobile phone app. At the end of 2019, the Beef-upp app was developed and available free on google play. This app was developed in conjunction with UQ postgraduate students in the School of Information Technology and Electrical Engineering. This app creates a least cost ration for various breeds of Indonesian bulls based on energy and protein requirements. The success of the app is due to its simplicity in formulating rations for energy and protein only and then putting nutritional safeguards within the app to allow for safer but effective feeding. This app is designed for users without a background in nutrition. It is aimed at safe and effective feeding.

5.3 ANIMAL EXPERIMENTS

The broad outline of all animal experiments done under controlled feeding conditions on site or in farmer collaborative experiments in village were outlined in Table 1. Location of sites were outlined there. Only brief descriptions of methodology, results and major points of discussion are outlined here. More detail can be found in published papers or reports in the Appendix. All sites followed a similar experimental protocol established at the start of the project and reviewed at annual meetings. A workshop to establish these protocols and a QA procedure for data collection and analysis was conducted at the start of the project.

Experiment 5 Live weight gain response curve of Ongole bulls to variable levels of gaplek and protein meal at University of Gadjah Mada

This study aimed to determine the optimum ratio of gaplek and palm kernel cake (PKC) offered to Ongole bulls with rice straw offered at a low level as a roughage source. Dry matter (DM) intake, organic matter (OM) intake, and average daily gain (ADG) was measured. Fifteen Ongole bulls aged 1 to 1.5 years with initial body weight (BW) of 200 ± 20 kg were equally allocated to three dietary treatments. Each dietary treatment included

5 g rice straw DM/kg BW.day as a roughage source to maintain rumen function and treatment rations offered *ad libitum*: T1 (87.5% gaplek + 12.5% PKC), T2 (75% gaplek + 25% PKC), and T3 (62.5% gaplek + 37.5% PKC). All diets included 2 g urea/kg gaplek and all bulls were offered 30 g/head/day of a mineral mix (Agromix Booster) to ensure adequate rumen degradable N and minerals.

Experiment 6 Live weight gain response of Ongole bulls to rations varying in ME content and level at University of Gadjah Mada

Originally, this experiment was to investigate the liveweight gain response curve of Ongole bulls to increasing levels of onggok and cassava tops but due to the unavailability of cassava tops, this experiment was changed and designed to investigate the effects on cattle growth of varying concentrations and proportions of ME and CP in the diet, with rations formulated using the LCR tool. This experiment aimed to answer a fundamental question about nutrient supply – what target ME /CP requirement should we be aiming for, utilising regionally relevant supplements (based on price and supply). The change was approved by ACIAR and discussion at the annual general meeting. Liveweight gain of Ongole bulls fed rations formulated to provide different ME content or different ME intake was determined. Bulls were fed a fixed quantity of rice straw to maintain rumen function, and a concentrate formulated to contain 10 or 12 MJ ME/kg DM *ad libitum* (10MJAL and 12MJAL respectively) or the 12 MJ ME/kg DM ration fed at an equivalent ME intake on a liveweight basis as the bulls fed the 10 MJ ME/kg DM ration (12MJR).

Experiment 7 Live weight gain response of Ongole bulls fed a commercial concentrate or various combinations of gaplek and wheat pollard at University of Gadjah Mada.

Originally this experiment was to study the response in Body condition score of cows at calving and 100d post-calving to a least cost ration supplement. It was decided with ACIAR approval that this was a lower priority than some of the questions emerging from experiments at other sites. Thus the experiment was changed to looking at various combinations of gaplek and wheat pollard given local interest from farmers and also to compare to a known commercial feedlot ration. University of Gadjah Mada has developed a high quality feed supplement (HQFS). Cassava and wheat pollard are two local feed sources which could be used in formulating rations. The ACIAR LCR was used to formulate rations from these local ingredients and compared to a commercially produced concentrate (HQFS). Twenty four Ongole bulls were randomly allocated based on fasted live weight. There were fed one of three rations: 1) a commercial high concentrate ration (HQFS) + rice straw (5g/kg.day) 2) gaplek (50%) + wheat pollard (50%) + rice straw (5g/kg W.day) 3) High gaplek (91.7%) + molasses (5%) + urea (3.3%) + rice straw (5g/kg W.day).

Experiment 8 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Gunungkidul Regency, Yogyakarta

This study compared the live weight gain of Ongole bulls that used Current Feeding System (T_0) with those obtained with feed supplementation (T_1, T_2, T_3 and T_4) at levels of 1(T1,T2) and 2(T3, T4)%W.day. Supplementation feed for T_1 and T_3 treatments consisted of 50% dried cassava, 25% copra meal and 25% palm kernel cake, whereas T_2 and T_4 treatments used 50% dried cassava, 25% copra meal and 25% soybean hulls. Fifty Ongole bulls with initial body weight around 200 kg at 12 to 18 months old were used in this experiment. Bulls divided into 5 treatments, so each treatment used 10 bulls. Bulls were kept in individual pen by 50 farmers, 20 farmers in Banaran Village and 30 farmers in Bleberan Village. The experiment was conducted for 12 weeks (April 28 to July 22, 2018).

Experiment 9 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Gunungkidul Regency, Yogyakarta

This study compared the live weight gain of Ongole bulls that used Current Feeding System (T_0) with those obtained with feed supplementation. All supplements were fed at 1%W.day and used gliricidia leaf meal (GLM), soybean hulls (SBH), copra meal (CM) and gaplek. GLM was produced by farmers on site by drying and grinding the product. The supplements were T1 (50% gaplek, 25% SBH, 25% CM), T2 (50% gaplek, 25% SBH, 25% GLM), T3 (50% gaplek, 25% CM, 25% GLM).

Experiment 10 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Gunungkidul Regency, Yogyakarta

This study compared the live weight gain of Ongole bulls that used Current Feeding System (T_0) with those obtained with feed supplementation. All supplements were fed at 1%W/d and used gliricidia leaf meal (GLM), soybean hulls (SBH), copra meal (CM), palm kernel cake (PKC), peanut hulls (PH) and gaplek. GLM was produced by farmers on site by drying and grinding the product and in some treatments pellets were made of the supplement. T0 CFS, T1 (25%GLM, 25%SBH, 50% gaplek), T2 Pellet (25%GLM, 25%SBH, 50% gaplek), T3 Pellet (50% GLM, 25%SBH, 25%gaplek) T4 Pellet (50%GLM, 5%SBH, 10% PH, 15%PKC, 20% gaplek), T5 (50%GLM, 5%SBH, 10% PH, 15%PKC, 20% gaplek).

Experiment 11 Live weight gain response curve of Euro x Ongole bulls to variable levels of gaplek and protein meals at University of Brawijaya, Malang

Thirty growing Euro x Ongole bulls were used in a randomised block design consisting of 5 treatments with 6 animal replications/treatment. All treatments used 20% corn stover as a roughage source and 80% of a concentrate mixture that contained 30, 40, 50, 60 or 70% cassava meal (powder) with the remainder being a mixture (1:1 DM basis) of copra meal and PKC. The composition of cassava meal was 2.13.% CP and 7.3% NDF, copra meal (24.6 % and 50.7%), PKC (17.7% and 66.9%) and corn stover (9.5% and 56.9%) respectively. Urea was added at 2% (DM basis) to the cassava meal. A mineral mix was added at 2.0% of total ration.

Experiment 12 Live weight gain response curve of Euro x Ongole bulls to variable levels of cassava peel silage and protein meals at University fo Brawijaya, Malang

An experiment evaluated the effect of using cassava peel silage (CPS) at the various inclusion levels on the live weight gain (LWG) of crossbred Euro X Ongole bulls (269 ±8.9 kg). Thirty bulls were allocated in a completely randomized block design with six

blocks based on initial live weight (LW) and five treatments based on level of CPS. All treatments used 20% corn stover as a roughage source and 80% of a concentrate mixture that contained 30, 40, 50, 60 or 70% CPS (estimated DM basis) with the remainder being a mixture (1:1 DM basis) of copra meal and PKC. Urea was added at 2% (DM basis) to the CPS. A mineral mix was added at 2.0% of total ration.

Experiment 13 Live weight gain response of Euro x Ongole bulls to new ration formulations at Malang

The experiment was conducted to determine the growth of Euro x Ongole bulls fed on a cassava by-product-based diet and local concentrate. Fifty cross bred bulls aged of 1.5 - 2 years were used in this study. The bulls were divided into five groups; they were offered 1% and 2% W local concentrate (T1 and T2), 1% and 2% cassava-based diet (T3 and T4) and current feeding system (CFS) by farmers (T0) as control. Local concentrate was bought from Blitar while cassava-based diet contained 50% cassava, 25% copra meal and 25% PKC. No interventions were made to the CFS. However, some farmers in T0 not only used local forages and agricultural by-products such as rice bran and pollard bran as a feed, but they also added local concentrate the same as used by T1 and T2 farmers.

Experiment 14 Experiment 14 Live weight gain response of Euro X Ongole bulls to new ration formulations at Malang

This experiment aimed to determine the growth of crossbred bulls fed a range of supplemented diets using local products and comparing them to the current traditional feeding system. This work was conducted in Kucur village, Dau sub-district, Malang. Fifty cross bred bulls aged between 1.5-2 years were allocated into five treatments; cassava-based diet by recent ACIAR-UB experiment (T1), commercial concentrate (T2), YaYa diet (T3), Santos diet (T4) and current feeding system (CFS) by smallholder farmers (T0) as the control. Cassava-based diet (T1) consisted of 50% cassava, 25% copra meal (CM) and 25% PKC. Local concentrate (T2) was bought from local cooperative in Malang. Yaya diet (T2) consisted of 30% cassava, 20% corn cob, 20% copra meal, 20% palm kernel cake and 10% rice bran. Santos diet (T4) consisted of 40 % corn cob, 20% PKC, 20% rice bran and 20% wheat pollard. Control treatment (T0) was a supplement of 1 kg wheat pollard a day which was the general current feeding system by local smallholders.

Experiment 15 Live weight gain response curve of Bali bulls to increasing level of cassava chips with Leucaena based rations in Lombok

The objective of this experiment was to determine the ratio of leucaena and cassava that resulted in the best cattle growth rate and feed for gain ratio. Thirty Bali bulls (30) (with initial live weight of 164±1.8 kg (mean ± se) were allocated to one of six experimental treatments in randomized block design. Bulls were held in individual stalls and had access to experimental diets and water ad libitum. The diets were 20% rice straw + 80% leucaena hay + mineral mix (A), 20% rice straw + 65% leucaena hay + 15% whole cassava tuber chip + mineral mix (B), 20% rice straw + 50% leucaena hay + 30% cassava chip + mineral mix (C), 20% rice straw + 35% leucaena hay + 45% cassava chip + mineral mix (D), 20% rice straw + 20% leucaena hay + 60% cassava chip + mineral mix (E), and 20% rice straw + 5% leucaena hay + 75% cassava chip + mineral mix (F). Leucaena and cassava were ground using a hammer mill with screen size of 5 mm. The ground leucaena hay and cassava chip were mixed daily and offered ad lib. Rice straw was fed at 0.5% LW. The trial had to be stopped at day 77 as those on the highest level of cassava lost weight. Starting from day 78, animals from treatments A, D and F were retained for another 77 days and fed diet D (the best diet).

Experiment 16 Live weight gain response curve of Bali bulls to increasing levels of cassava chips or onggok with Leucaena based rations in Lombok

Forty male Bali cattle with initial live weight (LW) of 112 ± 7.1 kg and around 18 months of age were assigned into 10 treatment groups. Each treatment group was offered *ad libitum* leucaena mixed with either cassava chips or cassava pulp (onggok) included at levels of 0, 15, 30, 45, 60% on an approximate dry matter basis. All diets included rice straw provided at 0.5% LW/day and urea at 2% of cassava chip or cassava pulp on a dry matter basis.

Experiment 17 Live weight gain response curve of Bali bulls sourced from low (with low body condition score (BCS)) or high (with high BCS) rainfall regions of NTB Sumbawa

The objective of this study was to examine the response to a high quality ration of low and high body condition score (BCS) bulls sourced from regions with inadequate and adequate feed supply resulting in different BCS. Farmers wanted to know if BCS of bulls bought for fattening affected their results. Forty eight growing Bali bulls were sourced of which 24 had low BCS sourced from a region of inadequate feed supply and low rainfall with initial liveweight of 117.5 ± 13.4 kg and initial BCS of 2.3 ± 0.3 and 24 high BCS bull from a region of adequate feed supply and higher rainfall with initial liveweight of 121.2 ± 11.2 kg and initial BCS of 2.7 ± 0.3. The bulls were fed leucaena *ad libitum* and corn stover at 5 g DM/kg LW as the basal diet and were supplemented with increasing amount of cassava chip (5, 10, 15 g cassava chip DM/kg LW). Live weight gain was monitored.

Experiment 18 Live weight gain response of Bali bulls to cassava, cassava peels, corn or commercial complete feed to Leucaena feeding systems in NTB Sumbawa

The objectives of this study was to examine the live weight gain response of Bali bulls fed on leucaena as a basal diet and supplemented with combinations of cassava, cassava peel, cassava peels- grain corn (1:1) mix or complete feed supplementation. Forty mature Bali bulls with initial liveweight of 171.8 ± 17.1 kg were used in this experiment. The bulls were randomly allotted to five (5) treatments with 8 animals per treatment as a replication. The treatments were corn stover 0.5%W + leucaena *ad libitum* + mineral + salt (Control), Control + cassava chips at 1.0% of BW, Control + cassava peels at 1.0% of BW, Control + cassava peels-grain corn mix at 1.0% of BW and Control + complete commercial feed at 1.0% of BW.

Experiment 19 Live weight gain response of Bali bulls to increasing energy content through cassava, onggok, corn or rice bran to Leucaena feeding systems in NTB Sumbawa

The aim was to provide alternative energy sources in addition to cassava chips to examine strategies to increase the energy content of rations safely and beyond the maximum cassava chip inclusion of 40% found in experiments from the project. The experiment ran from June to November 2020 at Pototano Agriculture Technology Park in West Sumbawa District of West Nusa Tenggara Province Indonesia. A total of 48 growing Bali bulls about 12-18 month of age and 100-150 kg liveweight sourced from West Sumbawa and Sumbawa district were used in this experiment. The bulls were allocated by stratified randomisation on the basis of unfasted live weight and blocked on liveweight into 6 groups and allocated randomly to experimental diets. The treatment diets were:

1) Cassava chip (40%) + leucaena (50%) + corn stover (8.6%) + urea (1.4%),
2) Cassava chip (40%) + corn grain (20%) + leucaena (30%) + corn stover (8.6%) + urea (1.4%),
3) Cassava chip (40%) + rice bran (20%) + leucaena (30%) + corn stover (8.6%) + urea (1.4%),
4) Cassava chip (60%) + leucaena (30%) + corn stover (7.9%) + urea (2.1%),
5) Onggok (60%) + leucaena (30%) + corn stover (7.9%) + urea (2.1%) and
6) corn grain (60%) + leucaena (30%) + corn stover (9%) + urea (1%).

The diets were formulated with the ACIAR LCR system. Cassava was dried ground cassava from East Java and local whole cassava tips (chipped and dried) and Onggok (dried and ground) was obtained from East Java. Other ingredients were locally sourced.

Experiment 20 Live weight gain response curve of Ongole and Bali bulls to increasing level of gliricidia and ground cassava powder in Central Sulawesi

Fifty Bali bulls (initial body weight (W) 157 ± 3.73 kg) were used in a completely randomised block design, with a combination of ground cassava powder and gliricidia (1:1 on estimated DM basis) offered as a supplement at levels of 0, 4, 8, 12 and 16 g DM/kg W.day (d), fed in conjunction with elephant grass given *ad libitum*. The experimental site was at Malonas village (0º30'N to 2º20'S and 119º45'E) to 121º45'E, Donggala district, Central Sulawesi province, Indonesia. There were 10 animal replications per dietary treatment. Drinking water was offered *ad libitum* daily, and measured during weeks 3, 9 and 15 together with measurement of faecal pH. The experiment lasted for 18 weeks, consisting of 2 and 16 weeks, for adaptation and measurement period, respectively.

Fifty Ongole bulls (initial body weight (W) 215 ± 5.1 kg) were used in a completely randomised block design, with a combination of ground cassava powder and gliricidia (1:1 on estimated DM basis) offered as a supplement at levels of 0, 4, 8, 12 and 16 g DM/kg W.day, fed in conjunction with corn stover given *ad libitum*. The experimental site was Sigi village, Donggala district, Central Sulawesi province, Indonesia. There were 10 animal replications per dietary treatment. Drinking water was offered *ad libitum* daily, and measured during weeks 3, 9 and 15 together with measurement of faecal pH. The experiment lasted for 18 weeks, consisting of 2 and 16 weeks, for adaptation and measurement period, respectively.

Experiment 21 Live weight gain response of Ongole and Bali bulls to rations formulated by the ACIAR LCR based on cost and availability of local ingredients in Central Sulawesi

Bali bulls:This research on Bali bulls was carried out on-farm at Malonas village, Central Sulawesi, Indonesia to examine the effect of high level supplementation of by-products formulated for high ME and CP. Feed intake, faecal pH and liveweight gain of Bali bulls was observed. The basal diet was elephant grass, and supplements were rice bran (RB), cassava powder (C), PKM, gliricidia (G) and urea.

Fifty Bali bulls (LW 168±4.48 kg) were housed in individual pens for 18 weeks (2 introductory and 16 experimental) and allocated into five treatments: 1) elephant grass (EG) *ad libitum*, 2) EG offered at 1% W/day, plus 2.5%W/day mixed RB:G, (1:1), 3) EG offered at 1% W/day plus 2.5%W/day mixed RB:PKM (1:1), 4) EG offered at 1% W/day plus 2.5%W/day mixed C:G (1:1), 5) EG offered at 1%W/day plus 2.5%W/day mixed C+urea: PKM (1:1). Faecal pH was measured at weeks 3, 9 and 15.

Ongole bulls: This research was carried out on-farm in the Sigi district, Central Sulawesi, Indonesia to examine the effect of high level supplementation of by-products formulated for high ME and CP. Feed intake, faecal pH and liveweight gain of Ongole bulls was observed. The basal diet was elephant grass, and supplements were rice bran (RB), cassava (C), palm kernel meal (PKM), gliricidia (G) and urea.

Fifty Ongole bulls (LW 186 ± 4.27 kg) were housed in individual pens for 18 weeks (2 introductory and 16 experimental) and allocated into five treatments: 1)elephant grass (EG) *ad libitum*, 2)EG offered at 1% W/day, plus 2.5%W/day mixed RB:G, (1:1), 3)EG offered at 1% W/day plus 2.5%W/day mixed RB:PKM (1:1), 4) EG offered at 1% W/day plus 2.5% W/day mixed C:G (1:1), 5)EG offered at 1% W/day plus 2.5% W/day mixed C+urea: PKM (1:1). Faecal pH was measured at weeks 3, 9 and 15.

Experiment 22 Live weight gain response curve of Brahman steers to increasing level of cassava tubers with soybean meal or cavalcade hay at Katherine, NT, Australia

Ninety *Bos indicus* weaner steers (169 kg average live weight [LW]) were allocated to one of 10 nutritional diets (9 steers/diet). The base cassava mixture included: 97% cassava tuber, 2% urea and 1% trace mineral mix (on a DM basis) and was included at either 31, 38, 45, 55 or 62 % of the diet. The remainder of the diet was either soybean meal or cavalcade hay (*Centrosema pascuorum*) as protein sources. A pen of three animals was considered the experimental unit. Each diet was replicated three times. Cavalcade hay replaced cassava tops as cassava tops were not able to be harvested in sufficient quantity and cavalcade hay is a readily available forage protein hay in the region.

SOSEC studies

There were livelihood and economic analysis done across all sites. Economic analysis focussed on daily Income over Food Costs (IOFC)/bull for each experiment based on local prices for feed and sale of bulls. Livelihood analysis proceeded by survey.

6 Achievements against activities and outputs/milestones

Objective 1: To develop robust treatment processes for removal of HCN from under-utilised by-products of cassava and preparation as a tradeable feed source for cattle.

no.	activity	outputs/ milestones	completion date	comments
1.1	Experiment 1 Drying and silage based procedures for removing HCN from cassava products	Identified procedures to reduce HCN from cassava plant parts	November 2019	3 Jember University experiments and 4 University of Queensland silage/drying experiments were implemented
		Results published as scientific paper and fact sheet prepared		UJ 5 conference papers published UQ 1 published conference paper
1.2	Experiment 2 Variability in onggok composition (including HCN content) (UJ, UGM) Experiment 2 Development of a HCN kit (UQ)	Results published as scientific paper	Dec, 2019	Originally this was an experiment to assess the variability of onggok composition (including HCN content) and to develop a rapid assessment of soil addition. At the commencement of the project it was noted that onggok had not been readily available and the need for a colour chart no longer appropriate. Instead, onggok was analysed in experiments where used. A submission was made to the review team to exclude this experiment. Instead a HCN kit has been developed by UQ. Samples in Indonesia were analysed for HCN at Jember University and requires chemicals which are very difficult to acquire. In Australia, HCN was analysed with a kit from ANU. Analysis was very expensive and utilised a very small sample which led to a high standard error of replicates. We therefore decided to develop a kit that could be made from easy to purchase materials, and could take a larger sample size. Kit developed and used.
		Technical note prepared	Dec 2019	Technical note prepared on the preparation and use of the kit to test for HCN.
1.3	Experiment 3 Variability in rice bran composition (University of Gadjah Mada and UQ)	Collection of rice bran samples were taken across Indonesia and analysed for compositional analysis	Dec 2020	120 samples of rice bran were collected by colleagues to encompass a wide cross section across Indonesia. All samples then went to University of Gadjah Mada and then subsampled. Samples were analysed at UQ, BCRI Grati and University of Gadjah Mada.
		Technical note prepared	Dec 2020	Technical note regarding the variability of the quality of rice bran. Further results on this variability is forthcoming.

PC = partner country, A = Australia

Objective 2: To devise simple cost-effective feed rations with higher feed conversion efficiency (lower feed for gain conversion) than those currently used for reproduction and fattening of cattle.

no.	activity	outputs/ milestones	completion date	comments
2.1	Experiment 4 Develop a simple least cost ration formulator (UQ)	Current systems identified	2018	Available formulators were reviewed and it was found that they were either quite complicated with lots of inputs (some not easily available) or costs were involved.
		Two formulators developed.	2018	**ACIAR LCR**. An LCR excel with a solver addin formulator has been developed and then utilised for each site to evaluate rations for round 2 and 3 experiments. This formulator has been used to formulate high and low ME diets using feeds available. It can create diets using a least cost solver program or can create or evaluate diets without taking costs into consideration. This program has also been used to ensure Ca and P was supplemented when required. **Beefupp** – an android mobile phone app was also developed with the help of IT students at UQ. As opposed to the excel formulator, which is designed for users with nutritional background, the app is well suited to users such as farmers and village entrepeneurs. This app is based on energy and protein only and has inbuilt safeguards such as limiting protein meal and starch use. It also provides warning if the NDF is too low and if the Ca:P ratio incorrect.
		Evaluation and training of formulators		Junior scientists have had a training workshop at the July 2019 meeting. This provides the junior scientists with the skills necessary to teach ACIAR LCR at each site. There have been 6 farmer meetings across Yogyakarta and Malang – both in villages at University sites which have introduced this app to farmers and other next end users. The latest meeting at UGM attracted 430 participants.

In the following outline of activities for the Annex table the Activity number is kept the same but the experiment numbers are changed to align with the new experiment numbers and outline. All experiment numbers now relate to the description given in methodology

2.2	Experiment Live weight gain response curve of Ongole and Xbred bulls to variable levels of onggok and protein meal (UB and University of Gadjah Mada)	Undertaken 2 experiments to develop response curves to dried cassava and protein meals for Ongole and crossbred cattle.	2018	Two feeding trials over two locations, examining responses to protein meals and dried cassava – one on Ongoles, one o**n** Euro x Ongole bulls. **Exp 5 University of Gadjah Mada -** dose response curve of Ongoles **t**esting 5 different combinations of gaplek and PKC **Exp 11 University of Brawijaya**- Liveweight gain response of crossbred Limousin Bulls testing 5 different combinations of dried cassava and PKC and copra meal
		Results published as scientific papers	January 2020	**University of Gadjah Mada** – 3 conference papers. Draft prepared for full paper. **University of Brawijaya** – 2 conference abstracts and 1 full peer reviewed paper in **Animal**
2.3	Experiment Live weight gain response curve of Ongole and Bali bulls to increasing level of tree legume (Tadulako, University University of Mataram)	Undertake 2 experiments to develop response curves to increasing level of tree legume for Ongole and Bali cattle	2018	One of these trials was planned for University of Gadjah Mada however due to palatability issues with Gliricidia, Tadulako University performed this trial, in addition to that planned for University of Mataram Two feeding trials over two locations, examining responses to increasing tree legume – one on Ongoles, one on Bali cattle. **Exp 15 University of Mataram**- – Involved a dose response curve of Bali bulls testing 6 different combinations of leucaena hay and cassava chips. This was expanded at end of experiment to look at compensatory growth of those treatments that gave low live weight gain. **Exp 20 Tadulako University/BPTP Central Sulawesi** - Two on farm experiments examining the effect of increasing level of a combination of ground cassava and gliricidia.
		Results published as a scientific papers	2019-2021	**University of Mataram** – paper in draft **Tadulako University/BPTP Central Sulawesi** - Paper accepted and published in **Animal Production Science** Abstract published for the international conference in Germany **ISRP2019**
2.4	Experiment Live weight gain response curve of Euro X Ongole bulls to increasing level of cassava peels (UB)	Response curve to cassava peels developed.	2019	**Exp 12 University of Brawijaya** - Feeding trial to examine the response of crossbreds to increasing level of cassava peel silage in the diet
		Results published as a scientific papers	2021	Paper submitted to **Animal**. Accepted subject to changes

2.5	Experiment Live weight gain response of Ongole bulls to varying ME diet concentrations (University of Gadjah Mada).	Response curve to onggok and cassava tops developed.	November 2019	Originally this experiment was to develop a response curve of ongole bulls to increasing level of onggok and cassava tops. However this was not commenced due to a feed sourcing and drying issue. Instead, it was of interest to explore the importance of ME concentration to formulate a diet. It can be difficult to formulate for very high ME diets with available concentrates. If similar liveweights could be obtained with slightly lower ME it would aid in our understanding of future formulations. University of Gadjah Mada used the ACIAR LCR to develop two diets varying in ME and measured the liveweight gain response of Ongole bulls. The nutritional treatments were low (10 MJ /kg DM) and high (12 MJ/kg DM) ME diets offered *ad libitum*, and the high ME diet offered at the equivalent ME intake as bulls offered the low ME diet *ad libitum*. The change in emphasis was approved at our annual meeting and ACIAR. **Exp 6 UGM** Live weight gain response of Ongole bulls to rations varying in ME content
		Results published as a scientific papers		Abstract prepared for later publication.
2.6	Experiment Live weight gain response curve of Brahman steers to increasing levels of cassava bulbs with a protein meal as the protein source (NT DITT**)**	Response curve of Brahman cattle to cassava bulbs and tops developed.	Dec 2020	A study was completed at the Katherine Research Facility to measure the liveweight gain response of Brahman steers to increasing levels of cassava tubers with two different protein sources. Soybean meal was chosen as a standard protein meal and cavalcade hay was chosen as a local protein source. This forage protein source was similar in action to the tree legume protein sources used in Indonesia but one which can be grown by farmers in the Northern Territory. **Exp 22 NTDITT** Live weight gain response curve of Brahman steers to increasing levels of cassava tubers with soybean meal or cavalcade hay

		Results published as scientific paper		Results prepared for APS Conference proceedings: McCosker, K., Roberio, G., Mello, H., Quigley, S. P. and Poppi, D. P. (2021). *Feed intake and live weight gain of Brahman steers fed diets containing cassava in the Northern Territory. 33rd Biennial Conference of the Australian Association of Animal Sciences*, Fremantle, WA Australia, 1-3 February 2021. Orange, NSW Australia: Australian Association of Animal Science.
2.7	Experiment Live weight gain response of Bali bulls to cassava as a supplement to a Leucaena based diet (UM)	Combinations tested and best ones identified.	2019	University of Mataram (2019) determine the optimum level of cassava chip or optimum level of onggok to a leucaena based diet for Bali bulls. BPTP NTB used rice bran in Exp 19 (see later) **Exp 16 University of Mataram** Live weight gain response curve of Bali bulls to increasing levels of cassava chip or onggok with Leucaena based rations
		Results published as scientific paper	2021	Paper published in **Livestock Research for Rural Development**

PC = partner country, A = Australia

Objective 3. Conduct participatory on farm and small to medium scale feedlot best bet interventions of feed mixes

no.	**activity**	**outputs/ milestones**	**completion date**	**comments**
3.1	Experiment Live weight gain response of Bali bulls to cassava or rice bran as a supplement to various forage feeding systems (UM and BPTP NTB)	Village evaluation of best bet combination from pen studies at University of Mataram. Combinations tested and best ones identified.	Nov 2020	Experiment determined the live weight gain response of Bali bulls in Sumbawa to combinations of energy sources designed to increase ME content of rations over and above that achievable under the limit of 40% inclusion of cassava products **Exp 19 BPTP NTB** Live weight gain response of Bali bulls to cassava, cassava peels, corn, rice bran or commercial complete feed to Leucaena feeding systems
		Results published as scientific paper		Paper in preparation

3.2	Experiment Live weight gain response of Ongole and Bali bulls to least cost ration formulation and protein meal sources in villages at Central Sulawesi (TU/BPTP and Yogyakarta BPTP	Village based responses to onggok and local protein sources	Central Sulawesi/TU 2019	Four village based experiments were done (2 with Bali bulls and 2 with Ongole bulls) instead of the three village based experiments planned. They examined the response of both breeds to a LCR supplement mix at different levels (Exp 20) and a mix of different supplements designed by the LCR (Exp 21). Live weight gain responses and economic analysis were done. Combinations used rice bran and gliricidia, rice bran and PKC, cassava and gliricidia or cassava and PKC. Diets formulated with ration formulator. **Exp 20 Tadulako University/BPTP Central Sulawesi** Live weight gain response curve of Ongole and Bali bulls to increasing level of gliricidia and whole cassava tuber **Exp 21 Tadulako University /BPTP** Live weight gain response of Ongole and Bali bulls to rations formulated by the ACIAR LCR based on cost and availability of local ingredients
		Results published as scientific paper	2019	**Exp 20** Paper accepted and published in **Animal Production Science** Abstract published for the international conference in Germany ISRP2019 **Exp 21** Junior scientist Wayan Sulendre received an ACIAR travel scholarship to attend TropAg in Brisbane 2019 where he delivered a poster and abstract.
		Farmer education days		Both of these sites have been very active in farmer meetings and farmer field days relating to the outcomes of these trials
3.3	Experiment Live weight gain response curve of Bali bulls sourced from dry (low body condition score bulls) or wet (high body condition score bulls) regions of BPTP NTB	Identify effect of BCS at purchase on live weight gain responses.	July 2018	There was no effect of BCS or region of origin of Bali bulls on the live weight gain response to rations varying in gaplek and Leucaena ratio. **Exp 17 BPTP NTB** Live weight gain response of Bali bulls sourced from low (with low body condition score (BCS)) or high (with high BCS) rainfall regions of NTB
		Results published as scientific paper	ongoing	Paper currently being prepared

3.4	Experiment Live weight gain response of Ongole and Euro cross Ongole bulls to new ration formulations (University of Gadjah Mada /BPTP Yogyakarta and University of Brawijaya/BPTP Malang village and small feedlot sites)		Malang round 1 2018 Malang round 2 2019 Yogyakarta round 2 2019 Yogyakarta round 3 2020	There were two regional sites: Yogyakarta and Malang both operated by local BPTP. All experiments identified combinations that increased live weight gain and IOFC. **Yogyakarta BPTP** Three experiments were done with Ongole bulls. All examined various combinations and use of local resources based on the LCR. One experiment developed a gliricidia leaf meal. One experiment examined and developed a pelleted product. All involved two villages and participating farmers. **Exp 8 BPTP Yogyakarta** Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages. This looked at the use of gliricidia leaf meal. **Exp 9 BPTP Yogyakarta** Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages. This looked at the use of soybean hulls as well as gliricidia leaf meal. **Exp 10 BPTP Yogyakarta** Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages. This looked at various protein sources including gliricidia leaf meal but also developed a pelleted product. **Malang BPTP** Two experiments were done with Euro cross bulls each one in a different village with participating farmers. **Exp 13 BPTP Malang** Live weight gain response of Euro X ongole bulls to new ration formulations at Malang. This looked at LCR formulated supplements with cassava product fed at 1 or 2%W/d under current village feeding systems. An increase in live weight gain and IOFC was found. **Exp 14 BPTP Malang** Live weight gain response of Euro X ongole bulls to new ration formulations at Malang. This looked at LCR formulated supplements with cassava product and a local commercial product. An increase in live weight gain and IOFC was found for some formulations. Some individuals in this village started a feed mixing business based on the best LCR recipe to supply feed to other farmers in the village and also contract mixed for other villages in the region.

		Results published as scientific paper	Ongoing	**Yogyakarta trial publications:** Two papers prepared and submitted to **Animal Production Science** and **Animal Feed Science and Technology**. Site very active in farmer field days. **Malang trial publications** Deni Setiadhi received a ACIAR scholarship and travelled to TropAg 2019 Brisbane. Abstract published **Malang village 2** – presented at 4th animal production international seminar (Oct 2019) Malang. Published - IOP conference series Earth and Environmental Science (2020) vol 478 Malang BPTP very active in village field days.
3.5	Experiment Determining optimal ME for Ongole bull fattening (Ongole UGM/BPTP) and Bali bulls at BPTP NTB	LWG response of Ongole bulls fed a commercial concentrate or various combinations of cassava and wheat pollard	2021	Originally this was Body condition score (BCS) response of cow at calving and 100 days post-calving to least cost ration supplement, however it was decided at the first annual meeting that a stand alone cow/calf experiment was not relevant to the project. A more relevant experiment comparing the LWG of Ongole and Bali bulls to diets fed a commercial concentrate or various combinations of cassava and wheat pollard was designed after ACIAR approval. **Exp 7 University of Gadjah Mada** Live weight gain response of Ongole bulls fed a commercial concentrate or various combinations of gaplek and wheat pollard. The commercial concentrate (UGM) gave the best response but other LCR combinations also resulted in an increase in LWG. **Exp 18 BPTP NTB** Live weight gain response of Bali bulls offered cassava, cassava peels, corn or commercial complete feed to Leucaena feeding systems. This looked at various cheaper cassava products and local ingredients to increase the ME content of rations based on Leucaena. Some of the treatments increased live weight gain markedly and bulls reached live weight gains close to genetic potential.
		Results published as scientific paper		In preparation Five farmer workshops

Objective 4. Analyse the costs and benefits of the interventions and their adoption by small-scale producers, and document the economic and social impacts on households and household members.

no.	activity	outputs/ milestones	completion date	comments
4.1	Activity (15) Economic analysis of small holder systems and small commercial feedlots at regional village sites	Economic analysis of village and small commercial feedlot intervention studies.	2021	All village experiments in all regions completed IOFC comparisons for rations.
		Regional comparisons of economics of cattle production and feed resources and costs for fattening	2019	A survey of the variability of feed costs across regions was undertaken. Costs were incorporated into experiments to obtain IOFC comparisons. All village experiments in all regions completed IOFC comparisons for rations.

		Results published in relevant journal	2019-2021	Asrianto, N., Andarwati, S., Nurtini, S., Putridinanti, A. D., Gunawan, Harper, K. and Poppi, D. (2019). Increased farmer's income through use of cassava as main ingredient of beef cattle concentrate feed in Playen Subdistrict, Gunungkidul, Yogyakarta. The 8th International Seminar on Tropical Animal Production, Yogyakarta, Indonesia, 23-25 September 2019. Yogyakarta, Indonesia: Universitas Gadjah Mada. **Review publications** During the last year of the project as results were being collated across all sites **4 review publications** involving collaborators were published. 1.Outlined the role of energy based supplements, mainly cassava based, in the development of bull fattening systems based on Leucaena (Harper et al. 2019) Trop Grasslands-Forrajes Tropicales. 2. Poppi DP, Gunawan, Antari R, Harper KJ. (2020) Strategies to improve local beef cattle industry supply chains during the pandemic of Covid-19. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner, Bogor 26-27 Oktober 2020. DOI: http://dx.doi.org/10.14334/Pros.Semnas.TPV-2020-p.3-7 3. Dennis P. Poppi, Kusmartono, Kasmiyati, Simon P Quigley, Karen J Harper (2021) Feeding strategies for improving ruminant productivity in the post-COVID 19 pandemic era particularly for small holders. **Indonesian Journal of Animal Science**. Vol 31 DOI: http://dx.doi.org/10.21776/ub.jiip.2021.031.01.11 4. Dennis Poppi, Atien Priyanti, Kusmartono, Marsetyo, Dahlanuddin, Tanda Panjaitan, Karen Harper and Simon Quigley (2021) Moving into more profitable beef production systems. LPVT2021 (International Seminar on Livestock Production and Veterinary Technology). Submitted May 10, 2021. This review outlined for the first time the live weight gain response of different breeds (Euro X Ongole, Ongole, Brahman and Bali bulls) to metabolizable energy intake. It also outlined the use of LCR procedures and some of the results from the suite of experiments just presented. IOFC was analysed for various systems and sensitivity analysis to costs and sale prices established. This provided lessons for local advisors but also national policy makers in the changes which are most likely to lead to higher

				IOFC for an individual farmer and greater regional production of beef.
4.2	Experiment Livelihoods analysis of smallholder systems at regional village sites (University of Gadjah Mada)	Livelihood survey of participating villages.	2018	Initial livelihood survey completed however followup survey was not due to collaborator health and covid19 issues.
		Regional comparisons of role of cattle and feed resources for fattening.	2019	Summary of supplement survey: • Rice bran is widely used across Indonesia as an energy source. • Cassava products are often underutilised for cattle feed, but can be hard to get. • Producers decide on ingredients based on availability and nutritive value. • Tree legumes are very important as an ingredient
		Gender disaggregated data on cattle fattening and breeding activities and influence of changes	x	Final survey not completed due to collaborator health and covid19 issues.
		Constraints to adoption of new strategies.	2021	Constraints to adoption of new strategies surveyed – about to be submitted
		Results published, policy fact sheet prepared	2021	Paper ready to submit A R S Putra, I W Patama, R Agustine, A Astuti, Kasmiyati, C T Noviandi, A Agus and KJ Harper (2021) The willingness to adopt local feed innovation among cattle farmers

Objective 5: Strengthen capacity of local scientists including postgraduate students to conduct farmer relevant research and farmers and feed companies to make sound business decisions.

no.	activity	outputs/ milestones	completion date	comments

5.1	Employ junior scientists	Nine junior scientists employed to conduct experiments.	Oct, 2017	Ten (10) Junior scientists were employed. Ujang Kurniawan left in December 2018 following the Central Sulawesi earthquake and tsunami. He has now been replaced by Syahrul.
5.2	Postgraduate research projects		ongoing	26 research theses projects are listed in Table 6. Most students are graduated but a few students are required to have papers accepted.
5.3	Establish linkages with feed companies, farmer co-operatives and small feedlots where operate at each site		2021	Malang village has formed a cooperative and mini feed mill. They utilise ACIAR LCR to create a supplement, make the supplement and sell to other farmers. Yogyakarta village region make gliricidia meal pellets to sell Yogyakarta village region make a mineral block to sell to other farmers. From 2018 Indobeef team invited to attend annual meetings. From 2018 Teddy Kristedi from PRISMA and ARISA invited to attend annual meetings. From 208 staff of BCRI, Grati invited to attend annual meetings. From 2018 local Dinas Peternakan staff invited to attend annual meetings. 2019 in the Malang meeting was attended by: Mr Ferry Pernama (Marketing division of feed in Multibreeder. Mr Budiarton (Nutritionist at Japfa Co, Ltd) Dr Desianto B. Utomo (HDR from Charoen Phokpand) Mr Didik (animal food producer) Mrs Kundarsih (feed division at dairy cooperative in Malang) Mr Hendris Nugraha (Japfa Comfeed) Mr Victor Budianto (Charoen Phokpand) Mr Amin (Sierad Produce Co LTD

5.4	Farmer visits and field days	Results of on farm and on station work highlighted by farmer visits during experiments at each site.	2021	Palu – 15 extension meetings and workshops Malang- 31 meetings and field trips Yogyakarta – 55 meetings and workshops University of Gadjah Mada – 5 workshops Lombok/Sumbawa- farmers attended demonstrations for each trial
5.5	Annual team meeting and training programs	Project meetings	2021	First project meeting was in May 2017 at University of Gadjah Mada July 2018 first annual meeting at University of Jember attended by the whole team including all JS. July 2019 was the mid semester review at the University of Brawijaya – Malang The 2020 scheduled meeting in Lombok was cancelled due to COVID-19 Final meeting Oct 2021 via zoom.
		Annual Junior scientist and postgraduate training	2017-2019	Four workshops were held for Junior scientists. Two were associated with annual meetings in Malang and Jember. A further one at NTB, and another at Yogyakarta. Details are listed in section 7.2.2.
5.6	Project newsletter and fact sheets	Project newsletter for internal communication	2021	Six newsletters were distributed to the extended team and interested parties, and a further three updates were distributed to the team members.
		Fact sheets on significant project activities	2020	Five factsheets were produced. These were more technical but not appropriate for research papers. These are detailed in section 7.4 and appendix 1

7 Key results and discussion

Objective 1. Developing robust treatment processes for removal of HCN and assessing tradeable feed resources for cattle

Safe removal of HCN by drying and ensiling

Cassava is one of the largest agricultural commodities in Indonesia and plays an important role as a staple food and source of calories. The main products of cassava plants are tubers, however there are by products such as onggkok, foliage, tips and peels, all with high potential as ingredients in a ration.

However, the presence of HCN is one of the factors that limits the use of cassava. In this project, Jember University investigated the concentration of HCN in parts of cassava plants from sweet varieties (Cimanggu, Ketan Mentega), as well as from bitter varieties (Kaspro, Malang-4 and Malang-6). The HCN content in bitter cultivars was higher than sweet cultivars, because the concentration of linamarin and lotaustralin in bitter cultivars was very high. Both types of cyanogen compounds can be eliminated by further hydrolysis enzymatically to become HCN which dissolves in water and evaporates.

To safely and effectively utilise cassava in the rations of cattle, it is important to evaluate sun drying and ensiling techniques to remove HCN and the minimal times required for this processing. Besides being able to potentially eliminate HCN, these processing methods can also increase the shelf life of a product. For this investigation, a range of trials were conducted at both Jember University and the University of Queensland. The picrate paper kit method was used to measure HCN at both the University of Queensland and the Jember University. It is a relatively simple method that can be used in the field and is even more accurate when a spectrophotometer is used to measure the absorbance of the samples (Egan et al.1998) as was the case in the current studies.

There was a timeline reduction of HCN concentration by more than 90%, when sun drying all the cassava parts. In this experiment, sun drying was effective in reducing HCN in roots and foliage to safe levels of 10 mg/kg as recommended by WHO and FAO (Nambisan 2011; Nebiyu & Getachew 2011; Lukuyu et al.2014). However, the peels measured 16 mg/kg HCN dry weight which is above this recommended level. Sun drying cassava roots would effectively reach safe levels within 1-3 days however, it took 24 and 28 days for the foliage and the peels respectively to reach safe feeding levels. The cool season during which this study was conducted could have contributed to the slower drying processes.

Unlike sun drying, the silage treatment of any part of the cassava in this study did not reduce HCN to recommended safe levels. More than 70% HCN was retained in the silage sample particularly the peels and the foliage after 28 days of treatment. The pH values measured in this study were characteristic of good quality silage, with good smell.

This was in contrast with other studies at Jember University which indicated that the percentage of cyanogens retained in fermented foods varied from 0 – 20%. This may have been due to the difference in the ensiling process, or in the pretreatment techniques used prior to ensiling. HCN reduction may be more influenced by pre-treatments such as wilting, chopping and soaking before the actual ensiling process. In the Jember University ensiling experiments, the parts of the cassava plants (leaves, stems, tuber with peel) were chopped and wilted for 24 hours, then fermented with the use of EM4 microorganisms (a commonly used microbial silage starter) for 0, 7, 14 and 21 days. While the pH value in spontaneous fermentation samples with time 0, 7, 14 and 21 days were respectively 5.6, 3.7, 3.7 and 3.0, the pH value in the fermentation sample using EM4 microorganisms reduced pH more quickly with values of 5.3, 3.6, 3.6 and 3.6 in the same timeframe.

Pre- treatments and additives may enhance the destruction of cells subsequently facilitating for the hydrolysis of the cyanogens with the endogenous enzyme leading to the production of HCN. Therefore, in order to effectively reduce the HCN levels in cassava silage, further experiments were undertaken at the University of Queensland to assess the effect of wilting before ensiling and the effects of additives (sugar, limestone, salt, urea) to reduce HCN. Results showed that wilting does initially reduce HCN however the addition of additives did not significantly reduce HCN. Sugar did reduce pH of all treatments but appeared to have a negative effect on HCN reduction.

Summary of processing of cassava to reduce HCN

Care must be taken when ensiling cassava, especially the leaves or peels. Results from the UQ experiment showed that the ensiling process per se does not remove the HCN nor do additives. Wilting prior to ensiling is required to reduce the HCN to safer levels. Addition of water prior to ensiling does reduce HCN with HCN dissolving in the water rather than staying in the plant tissues, however this is not considered good ensiling practice and may lead to clostridial fermentation. It is also important to note that even if there were high levels of HCN in silage, aeration prior to feeding may reduce HCN levels but further research on this, is required.

Drying of cassava plant parts is a much safer option for HCN removal. Tubers without peels is safe for consumption, particularly if dried for 24-48 hours. The actual timeframe required does depend on plant variety, part of plant of interest, as well an environmental conditions. Due to this variation, testing for HCN prior to feeding is vital. Knowing the HCN concentration prior to feeding will allow the combination of cassava with other ingredients so that the HCN level of the entire diet is in a safe range. The finding that a maximum inclusion level of cassava at 40% of the final ration maximises live weight gain will also mean that HCN levels are below the recommended level of HCN for livestock.

Developing a HCN test kit

When feeding cassava, that is not dried, it is vital to analyse the HCN content. This will allow it to be safely incorporated into the diet. Methodology for all HCN analysis was using the picric acid methodology. For the University of Queensland trials, this was via a kit obtained from the Australian National University. This methodology is standard for this analysis but was found to have issues, such as the difficulty in obtaining some chemicals and with regards to the kits, their expense. In addition, it is worth noting that the non-uniformity of the chopped cassava pieces/sizes in this study played a role in the variations within replicate measurements consequently having high standard errors of the mean HCN. The current kit also utilised such a small sample size 100mg which increased the standard error. This project therefore set out to develop a HCN analysis kit which was similar to the ANU derived kit, but utilised a larger sample, and could be made from chemicals that were cheap and available. A technical sheet (appendix 1) describes how to make a kit, and also describes the methodology for its use.

Variability of rice bran

Rice bran has the potential to be utilised in cattle feed rations throughout Indonesia. It is relatively cheap and has good energy content. According to Department of Agriculture, the availability of rice bran is up to 5.5 million ton/year (Laksmi and Budijanto, 2016). Rice bran results from the outer layer of broken rice skin consisting of pericarp (SNI 3178: 2013). To define rice bran, we also need to define rice polish because these two matters are often considered as the same. Coarse bran is called rice bran and fine bran is called polish bran. Husk is the outer shell covering the rice seeds. The processing of rice and generation of rice bran has changed and farmer feedback at the start of the project suggested that there was a lot more variation depending on the method used. The quality of rice bran anecdotally has changed from when the early studies were done. We therefore sampled a wide cross-section of rice bran from across areas of Indonesia ensuring our sites were in the samples.

Around 120 rice bran samples were collected and subsampled for analysis. Rice bran samples were analysed in Indonesia and at the University of Queensland using standard wet chemistry methodology of forages. CP ranged from 3.5 - 14% CP, ME from 3-13 MJ ME/kg DM.

This variability of nutritional content makes it especially hard to formulate a ration designed for a particular live weight gain. It was hoped that bulk density (either tapped or loose) which indicates quality would correlate to ME or crude protein however this was not apparent in this study. A good NIR relationship was established for estimating CP and dry matter digestibility and highlighted that NIR procedures could be used within Indonesia with satisfactory wet chemistry calibrations. Portable devices are now being used internationally and provide another opportunity for rapid analysis.

Report of this analysis is found in Appendix 2.

Objective 2. Devising simple cost effective feed rations for fattening cattle

LCR systems

This project aimed to develop simple, reliable least-cost ration (LCR) formulators for farmers, farmer advisers, co-operatives, agri-business, small scale feed-lotters, feed processors and extension staff to easily assess and compare available feed additive options in their region on both efficacy and cost. This project has developed two least cost ration formulators. A least cost ration formulator based on an excel solver program (available on request from karen.harper@uq.edu.au) and an android app called “Beef-upp” which is available for free on google play.

ACIAR LCR

The More-Beef project has developed an LCR aimed for researchers with a nutritional background. The aim of this formulator is to develop a formulation based on a range of nutrients. ACIAR LCR is an excel spreadsheet using the solver addin. This LCR has a feed database which can be added to or modified. Any number of nutrient requirements can be inputted for LCR calculation. The excel spreadsheet is linked to the feed database so that a drop bar with the feeds appears for a feed selection and then automatically fills in the nutrient cells. Up-to-date prices of each feed can be added manually. There are five tabs that are linked to a single spreadsheet and so a number of different rations (may relate to villages, seasons, animal types) can be included and compared. Results are in both dry matter and as fed. Consideration must be given to results for palatability, overall nutrient and mineral balance. Limits are placed on maximum level of inclusion of some ingredients eg cassava products are set a maximum inclusion level of 40% based on the results of the current project.

Beef-upp – an android app for least cost rations – free on google play.

Beef-upp app was developed by the More-Beef team in collaboration with a postgraduate IT group from the University of Queensland. Beef-upp is an android app for least cost ration formulation, freely available on google-play. The success of this app is based on simplicity. Formulations are based on energy and protein however once a diet is formulated, the final major nutrient composition is provided. This app is developed for a range of users, in particular producers, leader groups, co-operatives and small feedlots. Beef-upp has a number of nutritional safe-guards to reduce palatability issues and to reduce the chance of a nutritional or mineral imbalance. Least cost formulations are presented in both an as fed and a dry matter basis. Feedback from testing is leading to some modifications to the current version.

CONTROLLED ANIMAL TRIALS

The following list of experiments aligns with the experiment numbers outlined in the methodology. An overall summary of the feeding experiments and their outcomes appears at the end of this list.

Experiment 5 Live weight gain response curve of Ongole and bulls to variable levels of gaplek and protein meal at University of Gadjah Mada

Ongole bulls offered the highest proportion of gaplek (87.5%) grew significantly slower (0.10±0.12 kg/day) than bulls offered the other four treatments (0.31±0.1, 0.38±0.1, 0.41± 0.1 and 0.39 ± 0.1 kg/day for 75, 62.5, 50, 37.5% gaplek inclusion respectively with no significant difference in LW gain of bulls fed these other diets. Bulls offered 62.5% gaplek had significantly higher DM intake (20.3 g DM/kg LW.day; $P<0.05$) with no significant difference in DM intake of bulls fed these other diets. It was concluded that inclusion of a very high gaplek content in the concentrate portion of the ration (~90% in T1) reduced total feed intake and LW gain.

Published for ISTAP

Muzaki M.S., Latiefah S., Agus A., Noviandi C.T,, Astuti, A., Quigley S., and Poppi D. (2019) Feed intake and average daily gain of ongole crossbred bulls in response to different inclusion levels of gaplek and palm kernel cake. Proceedings for 8th International Seminar on Tropical Animal Production - ISTAP September 22-25, 2019, Yogyakarta.

Latiefah S., Noviandi C.T., Agus A., Utomo R., Quigley S. and Poppi D.(2019). Rumen fermentation characteristics of ongole crossbred bulls in response to different inclusion levels of gaplek and palm kernel cake. Proceedings for 8th International Seminar on Tropical Animal Production - ISTAP September 22-25, 2019, Yogyakarta. Institute of Physics Publishing.https://doi.org/10.1088/1755-1315/387/1/012117

Experiment 6 Live weight gain response of Ongole bulls to rations varying in ME content and level at University of Gadjah Mada

Liveweight gain of Ongole bulls fed rations formulated to provide different ME content or different ME intake was determined. Bulls were fed a fixed quantity of rice straw to maintain rumen function, and a concentrate formulated to contain 10 or 12 MJ ME/kg DM *ad libitum* (10MJAL and 12MJAL respectively) or the 12 MJ ME/kg DM ration fed at an equivalent ME intake on a liveweight basis as the bulls fed the 10 MJ ME/kg DM ration (12MJR). Bulls fed the 10MJAL treatment had a higher liveweight gain (0.5 +/- 0.05 kg/day) than bulls fed the 12MJR treatment (0.28 +/- 0.05 kg/day) with bulls fed the 12MJAL treatment intermediate (0.39 +/- 0.05 kg/day) and not significantly different to either of the other two treatments. The results were unexpected and the hypothesis that a higher ME content diet would result in a higher ME intake and liveweight gain was rejected. Complete consumption of rice straw occurred with no difference between treatments (5.1 g DM/kg LW.day). Bulls fed the 10MJAL treatment had a significantly higher concentrate intake (18.2 +/- 0.7 g DM/kg LW.day) than bulls offered the 12MJAL (14.2 +/- 0.7 g DM/kg LW.day) and 12MJR (12.2 +/- 0.7 g DM/kg LW.day) treatments with no significant difference in concentrate intake between the latter two treatments. The estimated ME content of the three diets (based on a mean of two 7-day measurement periods of total diet digestibility) were lower (8.2, 8.5 and 8.1 +/- 0.2 MJ ME/kg DM for 10MJAL, 12MJAL and 12MJR respectively) than the theoretical formulation based on a combination of book values and the LCR formulation and did not differ significantly between treatments. The significantly higher total DM intake of bulls fed the 10MJAL treatment (22.9 +/- 0.65 g DM/kg LW.day) compared to bulls fed the 12MJAL (19.4 +/- 0.65 g DM/kg LW.day) and 12MJR (17.4 +/- 0.65 g DM/kg LW.day) treatments resulted in a significantly higher total ME intake by these bulls (44, 36 and 29 +/- 2.6 MJ ME/day). The lower than expected ME content of the diets, and hence ME intake, is likely a function of the lower than expected intake of concentrates across all treatments resulting in a

higher than anticipated proportion of the low ME rice straw (5.8 MJ/kg DM; Feedipedia) in the total ration which would have diluted the ME supplied in the form of the concentrates. It was expected that concentrate intake would exceed 20 g DM/kg LW.day (or 80% of the total ration) however actually intakes, particularly of the 12MJ/kg DM concentrate were much lower (14 g DM/kg LW.day). The reasons for the lower than expected concentrate intakes are unknown but may have been partly related to the feeding procedures and the possibility of sub-acute ruminal acidosis, although no data is available to directly support this. The 10 MJ and 12 MJ concentrates were formulated with the same ingredients in different proportions and included gaplek (36 v 40%), rice bran (9 v 15%), palm kernel cake (17 v 30%), copra meal (0 v 15%), corn cobs (35 v 0%) and urea (2 v 0%). The main differences were the higher proportion of corn cobs and the lower proportion of palm kernel cake and copra meal in the 10 MJ ration, and it is possible the different proportions of these ingredients may have affected palatability (corn cobs) or rumen function (protein meals with potentially higher lipid content) and subsequently intake.

Experiment 7 Live weight gain response of Ongole bulls fed a commercial concentrate or various combinations of gaplek and wheat pollard at University of Gadjah Mada.

Growth of Ongole bulls fed a commercial concentrate or various combinations of cassava and wheat pollard was measured. University of Gadjah Mada has developed a high quality feed supplement (HQFS). Cassava and wheat pollard are two local feed sources which could be used in formulating rations. The ACIAR LCR was used to formulate rations from these local ingredients and compared to a commercially produced concentrate (HQFS).

The three rations and associated liveweight gains (LWG) were:

• a commercial high concentrate ration + rice straw (5g/kg W/day): LWG 0.99 kg/d

• Gaplek (50%) + wheat pollard (50%) + rice straw (5g/kg W/day): LWG 0.70 kg/day

• Gaplek (91.7%) + molasses (5%) + urea (3.3%) + rice straw (5g/kg W.day): LWG 0.26 kg/day

This experiment has recently been completed and not yet fully analysed. The commercial University of Gadjah Mada concentrate ration gave the highest response. Using gaplek (50%) and wheat pollard (50%) gave an acceptable LWG response but as shown in previous experiments in the More Beef project the high gaplek treatment (91.7%) even when balanced for rumen degradable N requirement with urea gave a very low LWG response.

Experiment 8 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Gunungkidul Regency, Yogyakarta

This study compared the live weight gain of Ongole bulls that used C*urrent Feeding System* (T_0) with those obtained by feed supplementation (4 treatments, T_1, T_2, T_3 and T_4). Supplement feed for T_1 (1%W/day) and T_3 (2%W/day) treatments consisted of 50% dried cassava, 25% copra meal and 25% palm kernel cake, whereas T_2 (1%W/day) and T_4 (2%W/d) treatments used 50% dried cassava, 25% copra meal and 25% soybean hulls. Gain of bulls (kg/head.day) in treatments T_1, T_2, T_3 and T_4 were 0.61, 0.82, 0.68 and 0.74, respectively, higher ($P<0.01$) than T_0 (0.43). Feed supplementation of 1% W/day using 50% dried cassava, 25% copra meal and 25% soybean hulls gave the highest increase in live weight gain of Ongole bulls.

Experiment 9 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Gunungkidul Regency, Yogyakarta

The control group (R_0) was provided the current feeding system (CFS) fed *ad libitum*, and supplement treatments consisted of CFS fed *ad libitum* + 1% Liveweight (on approximate DM basis)/day of three different concentrate supplement diets (R_1, R_2 and R_3). R_1 concentrate contained 50% gaplek, 25% copra meal (CM) and 25% soybean hulls (SBH), R_2 was 50% gaplek, 25% Gliricidia leaf meal (GLM) and 25% SBH and R_3 was 50% gaplek, 25% CM and 25% GLM.

The live weight gain of bulls (kg/head) in the treatments R_0, R_1, R_2 and R_3 were 0.31; 0.75; 0.61 and 0.62 kg/day respectively. The daily income over food costs (IOFC)/bull of treatments R_1, R_2 and R_3 were double that of control (R_0). It was concluded that GLM can replace the use of SBH and CM in a cassava based supplement and increase the income of farmers in this district.

This paper was submitted to **Animal Production Science**

Experiment 10 Live weight gain response of Ongole bulls to least cost ration formulation and protein meal sources in villages in Gunungkidul Regency, Yogyakarta

Gliricidia sepium leaf meal (GLM), gaplek, soybean hulls (SBH), peanut husks (PH) and palm kernel cake (PKC) in various combinations were processed as a mash or a pellet to produce a concentrate supplement diet (CSD) for Ongole crossbred bulls in a village fattening system in Indonesia. Bulls were given the current feeding system (CFS) *ad libitum* (T_0/control) and CFS *ad libitum* + 1% live weight (on approximate DM basis) of five different CSD (T_1, T_2, T_3, T_4 and T_5). Treatments were: T_1 (CFS + CSD mash: 25% GLM + 25% SBH + 50% gaplek), T_2 (CFS + CSD pellet: 25% GLM + 25% SBH + 50% gaplek), T_3 (CFS + CSD pellet: 50% GLM + 25% SBH + 25% gaplek), T_4 (CFS + CSD pellet: 50% GLM + 5% SBH + 20% gaplek + 10% PH + 15% PKC) and T_5 (CFS + CSD mash: 50% GLM + 5% SBH + 20% gaplek + 10% PH + 15% PKC).

CSD supplementation significantly ($P < 0.05$) increased dry matter intake and average daily gain of PO bulls without affecting the feed to gain ratio. There were no differences in the live weight gain between CSD treatments despite a difference in crude protein (CP) content (9 vs 13% CP) between high and low gaplek inclusion levels (25% vs 50%) and inverse GLM inclusion or mash vs pelleted processing method. This suggested that the response was due primarily to increased ME supply rather than CP supply. Daily income over feed cost was highest in T_5 treatment (38% higher than the control) which was formulated to provide the lowest cost of CSD ration.

Pelleting the supplement did not improve the performance of bulls, GLM and gaplek could be used effectively at high levels (50%) and a least cost ration approach was most effective in increasing the daily income over food cost for smallholders fattening bulls.

This paper was submitted to **Animal Feed Science and Technology**

Experiment 11 Live weight gain response curve of Euro X Ongole bulls to variable levels of gaplek and protein meals at the University of Brawijaya, Malang

DM intake of crossbred bulls declined curvilinearly ($y=2.556+0.2435x-0.003131x^2$, where x is percentage of gaplek inclusion in concentrate meal) with a similar decline in average daily gain (ADG) ($y=0.4283 + 0.05326x - 0.000379x^2$). With increasing gaplek inclusion bulls grew at 1.27. 1.35, 1.05, 0.76 and 0.30 kg/day at gaplek inclusion of 30, 40, 50, 60 and 70% respectively. Cyanic acid (HCN) concentration of gaplek used in this study was 20.7 ppm which is considered safe. DM digestibility was 76, 72, 73, 70, and 69% and NDF

digestibility was 70, 63, 59, 46, and 42%, respectively for low to high cassava inclusion. Rumen parameters (pH 6.34 - 6.91, ammonia 73 - 94 mg N-NH_3/L and VFA concentration 84.8-152.1 mmoles/L with the molar percentage of propionic acid varying from 32-39 molar %) were significantly different between treatments (P<0.05), but all values were within a normal range. It can be concluded that the use of 40% cassava meal in the concentrate mixture (or 32% of the final ration) was an optimum level for ADG (1.35 kg/day). HCN was low and not considered to limit intake and average daily gain.

This trial is published in **Animal**

Retnaningrum, S., Kusmartono, , Mashudi, Harper, K.J. and Poppi, D.P. (2020). Formulating rations with cassava meal to promote high live weight gain in crossbred Limousin bulls. **Animal**, 15 (2) 100125, 1-7. doi: 10.1016/j.animal.2020.100125

Experiment 12 Live weight gain response curve of Euro X Ongole bulls to variable levels of cassava peel silage and protein meals at the University of Brawijaya, Malang

The combination of cassava peel silage (CPS) (with 2% urea of the CPS) and protein meals significantly affected LWG with the highest values obtained at levels of 30 and 50% inclusion of CPS (1.16 - 1.35 kg/day) ($P < 0.05$). Polynomial analysis of LWG data revealed the optimal LWG is theoretically achieved at 37% CPS with a LWG (1.31 kg/day) however LWG was similar from 30 to 50S inclusion levels and then declined. There was little significant difference at CPS inclusion levels of 30 - 60%, for dry matter intake (DMI) which ranged from 2.3 - 2.6% LW, organic matter (OM) digestibility (77.8 - 81.6%), feed for gain ratio (FFG) (6.56 - 7.56 kg DM/kg LWG) and feed cost of gain (Indonesia rupiah (IDR)/kg LW 18612 – 21398). At a high (70%) level of CPS inclusion, these values were markedly depressed particularly when compared to the optimal inclusion level of CPS. Feed treatments did not affect rumen pH, ammonia (NH_3-N), concentration or molar percentage of volatile fatty acids (VFA) or protozoal population ($P < 0.05$). Rumen pH measured three hours after morning feed, ranged from 6.7 to 6.8 and NH_3-N ranged from 14.1 - 19.3 mg NH_3-N/dl. It was concluded that inclusion of CPS was optimal at 37% but for practical ration formulation, inclusion up to 50% mixed with protein meals and urea and 20% corn stover maximized LWG and profitability of the production system. These results were very similar to those obtained in Experiment 11 using gaplek.

This paper is submitted in **Animal**

Experiment 13 Live weight gain response of Euro X Ongole bulls to new ration formulations at BPTP Malang

The experiment was conducted to determine the growth of crossbred bulls fed on a cassava by product based diet and local concentrate. Fifty cross bred bulls aged of 1.5 - 2 years were used in this study. The bulls were divided into five groups; they were offered 1% and 2% local concentrate (T1 and T2), 1% and 2% cassava-based diet (T3 and T4) and current feeding system (CFS) by farmers (T0) as control. Local concentrate was bought from Blitar while cassava-based diet contained 50% cassava powder, 25% copra meal and 25% palm kernel cake. No interventions were made to the CFS. However, some farmers in T0 not only used local forages and agricultural by-products such as rice bran and wheat pollard as a feed, but they also added local concentrate the same as used by T1 and T2 farmers. The average daily gains were 1.13 kg/head.day (T0), 1.09 kg/head.day (T1), 1.38 kg/head.day (T2), 0.8 kg/head.day (T3) and 1.23 kg/head.day (T4). The study found that local concentrates promoted high average daily gain and that traditional feeding systems (CFS) performed well especially when farmers saw other farmers feeding better diets and getting better results. The best results compared closely with the experimental results from the University of Brawijaya experiments.

Experiment 14 Live weight gain response of Euro X Ongole bulls to new ration formulations at BPTP Malang

This experiment aimed to determine the growth of crossbred bulls fed a range of supplemented diets using local products and comparing them to the current traditional feeding system. This experiment was conducted in Kucur village, Dau sub-district, Malang. Fifty cross bred bulls were allocated into five treatments; cassava-based diet by recent ACIAR-UB experiment (T1), commercial concentrate (T2), YaYa diet (T3), Santos diet (T4) and current feeding system (CFS) by smallholder farmers (T0) as the control. Cassava-based diet (T1) consisted of 50% cassava, 25% copra meal (CM) and 25% palm kernel cake (PKC). Local concentrate (T2) was bought from local cooperative in Malang. Yaya diet (T2) consisted of 30% cassava, 20% corn cob, 20% copra meal, 20% palm kernel cake and 10% rice bran. Santos diet (T4) consisted of 40 % corn cob, 20% palm kernel cake 20% rice bran, and 20% wheat pollard. Control treatment (T0) was 1 kg wheat pollard a day which was the general current feeding system supplement by local smallholders.

The experiment found that cassava-based diet (T1) supplementation showed the highest live weight gain compared to the other diets. The average daily gain for each treatment was T0=0.84±0.34, T1=1.08±0.25, T2=0.87±0.21, T3=0.85±0.27, T4=0.78±0.16.

Paper published as a conference series below:

D Setiadi, Kusmartono, Kasmiyati, Mashudi, A Z Zakariya, K J Harper and D P Poppi 2020 The Weight Gain and Growth of Crossbred Bulls Fed Locally Inspired Supplements Compared with Current Feeding Systems in Village Smallholdings in Malang, East Java. **The 4th Animal Production International Seminar IOP Conf. Series: Earth and Environmental Science** 478 (2020) 012037IOP Publishing doi:10.1088/1755-1315/478/1/012037

Experiment 15 Live weight gain response curve of Bali bulls to increasing level of cassava chips with Leucaena based rations in Lombok

The diets were 20% rice straw + 80% leucaena hay + mineral mix (A), 20% rice straw + 65% leucaena hay + 15% cassava chip + mineral mix (B), 20% rice straw + 50% leucaena hay + 30% cassava chip + mineral mix (C), 20% rice straw + 35% leucaena hay + 45% cassava chip + mineral mix (D), 20% rice straw + 20% leucaena hay + 60% cassava chip + mineral mix (E) and 20% rice straw + 5% leucaena hay + 75% cassava chip + mineral mix (F). The LWG during the first 77 days were 0.49±0.06, 0.54±0.06, 0.58±0.12, 0.68±0.06, 0.38±0.06 and -0.11±0.06 kg/day for the animals fed diets A, B, C, D, E and F respectively. The corresponding organic matter digestibility values were 0.52±0.01, 0.56±0.02, 0.63±0.01, 0.67±0.01, 0.71±0.02 and 0.70±0.01 respectively. The trial had to be stopped at day 77 as those on the highest level of cassava lost weight. Starting from day 78, animals from treatments A, D and F were retained for another 77 days and fed diet D (the best diet). The LWG during the second 77 days were 0.31±0.05, 0.40±0.04 and 0.42±0.06 kg/day for animals previously fed diets A, D and F respectively. In conclusion, the best LWG was reached when diet D (45% cassava chip and 35% Leucaena hay) was fed. Feeding diet D to the animals previously fed diet F (and lost weight) did not result in marked compensatory gain. Cassava chip could be used as a supplement to extend limited amounts of Leucaena available in the Leucaena feeding systems being developed in NTB.

Experiment 16 Live weight gain response curve of Bali bulls to increasing levels of cassava chips or onggok with Leucaena based rations in Lombok

Each treatment group was offered *ad libitum* leucaena mixed with either cassava chips or cassava pulp (onggok) included at levels of 0, 15, 30, 45, 60% on an approximate dry matter basis. Including cassava chip up to 30% of the ration increased total daily dry matter intake from 24.1 g/kg LW to 29.3 g/kg LW. The dry matter intake with onggok was

lower than with cassava chip at all levels of inclusion. Consequently, the live weight gain was generally higher with cassava chip. The equations for the response of the live weight gain (kg/d) in relation to level of cassava chip or onggok inclusion were quadratic with values higher for cassava chip inclusion. The inclusion of cassava chip resulted in a higher live weight gain response most likely due to the higher starch content. The maximum live weight gain was achieved at a level of inclusion of 47.5% for the cassava chip and 28% for onggok. Feeding higher amounts than these optimal levels significantly decreased feed intake and live weight gain.

Paper published in **Livestock Research for Rural Development**

Luh Ade Kariyani, Dahlanuddin, Tanda Panjaitan, Karen Harper, Dennis Poppi, Ryan Aryadin Putra (2021) Effect of increasing levels of cassava chips and cassava pulp in the Leucaena based diets on feed intake and live weight gain of male Bali cattle. Livestock Research for Rural Development. 33 (9).

Experiment 17 Live weight gain response curve of Bali bulls sourced from low (with low body condition score (BCS)) or high (with high BCS) rainfall regions of NTB Sumbawa

The objective of this study was to understand the response of low and high body condition score (BCS) bulls sourced from regions with inadequate and adequate feed supply (based on rainfall) to a better quality diet. Twenty four growing Bali bulls from a region of high rainfall and 24 Bali bulls from a region of low rainfall were each fed 4 treatments: control (leucaena *ad libitum* and corn stover at 5 g DM/kg LW), control plus supplements with increasing amounts of cassava chips (5, 10, 15 g DM/kg LW). Cassava chip supplementation increased liveweight gain of both low and high BCS. The live weight gain of low and high BCS bull fed only on leucaena and cornstover was 0.37±0.16 kg/day and cassava chip supplementation at 15 g/kg LW.day increased live weight gain to 0.47±0.11 kg/day . However, increasing level of cassava chip supplementation had no further response on growth. The live weight gain of low or high BCS bulls to increasing cassava chip supplementation was not different. The highest liveweight gain of low BCS bulls was 0.47 ± 0.11 kg/day with cassava chip supplementation of 15 g/kg LW.day and not different to cassava chip supplementation of 5 and 10 g/kg LW.day while the highest liveweight gain of high BCS bulls was 0.49 ± 0.08 kg/d with cassava chip supplementation of 5 g/kg LW.day and not different to cassava chip supplementation of 10 and 15 g/kg LW.day. Cassava chip supplementation increased total dry matter intake. It was concluded that cassava chips could be effectively added to a total Leucaena based ration to increase live weight gain and extend the use of limited amounts of Leucaena. The regional source of bulls for fattening was not important.

Experiment 18 Live weight gain response of Bali bulls to cassava, cassava peels, corn or commercial complete feed to Leucaena feeding systems of NTB Sumbawa

The treatments were corn stover 0.5%W + Leucaena *ad libitum* + mineral + salt (Control), Control + cassava chips at 1.0% W, Control + cassava peels at 1.0%W, Control + cassava peels-grain corn (1:1) mix at 1.0%W and Control + complete commercial feed at 1.0%W. Liveweight gain over 10 weeks of bulls on rations of control were 0.49 ± 0.13 kg/d and treatment supplement rations (1%W) of cassava chips were 0.50 ± 0.13 kg/day, cassava peels 0.44 ± 0.07 kg/day, cassava peels and grain corn mixture 0.64 ± 0.10 kg/day and complete feed were 0.57 ± 0.11 kg/day. Cassava chips and cassava peels could be successfully used as a supplement to extend the use of limited amounts of Leucaena but could not increase live weight gain any further. The supplement mixture of cassava chip and corn gain significantly ($P<0.05$) increased live weight gain over all treatments including the use of a commercial complete feed. The live weight gain values for the mixture of corn grain and cassava chip supplement approached the genetic potential of Bali bulls assumed to be approximately 0.65 kg/day.

Submitted to **Livestock Research for Rural development Journal.**

Objective 3 participatory on farm and small to medium scale feedlot best bet interventions of feed mixes.

Experiment 19 Live weight gain response of Bali bulls to increasing energy content through cassava, onggok, corn or rice bran to Leucaena feeding systems of NTB Sumbawa

The study was conducted to measure the live weight gain response of Bali bulls to various energy supplement sources when fed to Leucaena. The aim was to provide alternative additional energy sources to add to cassava chips given the results of Experiment 18. Cassava inclusion up to 40% has been shown to be a maximum inclusion level in most experiments of the More Beef project.

Table 2. Liveweight gain in Bali Bulls subject to various treatments.

Treatment	**Live weight gain kg/day**
Cassava chips (CC) (40%) + Leucaena (L) 50% + Corn stover (CS) (8.6%) + urea (1.4%)	0.3
CC (40%) + Corn grain (CG)(20%) + L (30%) + CS (8.6%) + urea (1.4%)	0.45
CC (40%) + Rice Bran (RB) (20%) + L(30%) + CS b(8.6%) + urea (1.4%)	0.48
CC (60%) + L (30%) + CS (7.9%) + urea (2.1%)	0.26
Onggok (60%) + L 30% + CS (7.9%) + urea (2.1%)	0.15
CG (60%) + L(30%) + CS(9%) + urea (1%)	0.61

It was found that as with other experiments the inclusion of cassava chips or onggok greater than 40% resulted in a depression in live weight gain. Adding other sources of energy in addition to cassava sources improved liveweight gain. Supplementing only with corn grain as a source of energy in the leucaena and corn-stover basal diet resulted in the highest liveweight gain. Cassava as energy sources combined either with rice bran or corn grain increased liveweight gain over that of cassava sources alone. Onggok did not give as good a result as cassava chips in agreement with results from Experiment 16.This information provides a basis for setting limits to inclusion of cassava and its products and ways to increase overall energy intake through other types of energy based supplements.

Experiment 20 Live weight gain response curve of Ongole and Bali bulls to increasing levels of gliricidia and ground cassava powder in Central Sulawesi

These were two separate experiments performed at the same time in different villages, one using Bali bulls and the other village with Ongole bulls. Treatments included the current feeding system (corn stover or elephant grass) and supplement treatments of a mixture of gliricidia (50%) and cassava tuber powder (50%) offered at levels of 0.4%, 0.8%, 1.2% and 1.6%W/day. Increasing supplement level linearly ($P<0.05$) decreased basal diet intake, but linearly increased total DM intake and LWG ($P<0.05$) in both breeds.

Basal diet DM intake was reduced at the rate of 0.43 kg/kg of supplement DM consumed for both Ongole and Bali bulls. Water intake and faecal pH were not affected (P>0.05) by increasing supplement intake. Inclusion of cassava tuber and gliricidia supplement up to 1.6% LW/day, increased total feed DM intake (up to 3.28 and 3.18% LW/day, for Ongole and Bali bulls, respectively) and LWG (maximum Ongole bulls 0.69 kg/day and Bali bulls 0.46 kg/day). Daily income over feed cost (IOFC) increased significantly (P<0.05) in association with increased supplement intake in both Village experiments. Using the derived model, without supplementation, the value of IOFC was only IDR 7802/day and IDR 7687/day, for both experiments. The highest IOFC was achieved at a supplement intake of 1.6% LW/day with values of IDR 13949/day and IDR 12543/day for Ongole bulls and Bali bulls respectively. It was concluded that the addition of a cassava tuber and gliricidia mixture up to 1.6% LW/day increased LWG and profit for smallholders fattening bulls.

This paper is published in **Animal Production Science**

Marsetyo, Sulendre, I. W., Takdir, M., Harper, K. J. and Poppi, D. P. (2021). Formulating diets based on whole cassava tuber (Manihot esculenta) and gliricidia (Gliricidia sepium) increased feed intake, liveweight gain and income over feed cost of Ongole and Bali bulls fed low quality forage in Central Sulawesi, Indonesia. Animal Production Science. doi: 10.1071/an20297

Experiment 21 Live weight gain response of Ongole and Bali bulls to rations formulated by the ACIAR LCR based on cost and availability of local ingredients in Central Sulawesi

Fifty Bali bulls (LW 168 ± 4.48 kg) were allocated into five treatments: 1) elephant grass (EG) *ad libitum*, 2) EG offered at 1% W/day, plus 2.5% W/day mixed Rice Bran (RB):Gliricidia (G), (1:1), 3) EG offered at 1% W/day plus 2.5%W/day mixed RB:Palm Kernel Cake (PKC) (1:1), 4) EG offered at 1% W/day plus 2.5% W/day mixed Cassava tuber (C):G (1:1), 5)EG offered at 1% W/day plus 2.5%W/day mixed C: PKC (1:1). Faecal pH was measured at weeks 3, 9 and 15. The live weight gain (kg/day) were 0.30±0.02, 0.57 ± 0.03, 0.60 ± 0.3, 0.66 ± 0.05 and 0.69 ± 0.05 kg/day for the above treatments respectively.

Fifty Ongole bulls were allocated into the same supplement treatments as above at a different village. The live weight gain responses were 0.41 ± 0.02, 0.88 ± 0.05, 1.02 ± 0.06, 1.12 ±0.10 and 1.28 ± 0.11 kg/day respectively for the same treatments.

These treatments were formulated using the ACIAR LCR so as to use local ingredients and based on local costs. The results for maximum live weight gain for both Bali bulls and Ongole bulls are among the highest achieved in the project, made even more outstanding in that they were achieved with co-operating farmers in a village based system.

Experiment 22 Live weight gain response curve of Brahman steers to increasing level of cassava tubers with soybean meal or cavalcade hay at Katherine, NT, Australia

Cassava can be grown in Northern Australia and provides an alternative energy source with which to supplement steers for the live export trade to Indonesia. Forage legumes provide an alternative protein source to protein meals and at a lower cost to northern cattle properties. Whole cassava tuber was dried and mixed with cavalcade hay or soybean meal at varying proportions of cassava tuber. The base cassava mixture included: 97% cassava tuber, 2% urea and 1% trace mineral mix (on a dry matter basis) and was included at either 31, 38, 45, 55 or 62 % of the diet. The remainder of the diet was either soybean meal or cavalcade hay as protein sources.

Soybean meal as a protein source with cassava gave better live weight gain results than cavalcade hay (Fig. 3). High levels of cassava inclusion did not result in the marked

decline in live weight gain as seen in most of the Indonesian experiments. Overall, performance was probably lower than expected with most live weight gains less than 1 kg/day although 37 and 50% inclusion of cassava with soybean meal resulted in LWG >1 kg/day. For cavalcade hay diets, there was a general trend for increased growth and LWG with increasing levels of cassava content. High variability for performance existed for SBM based diets.

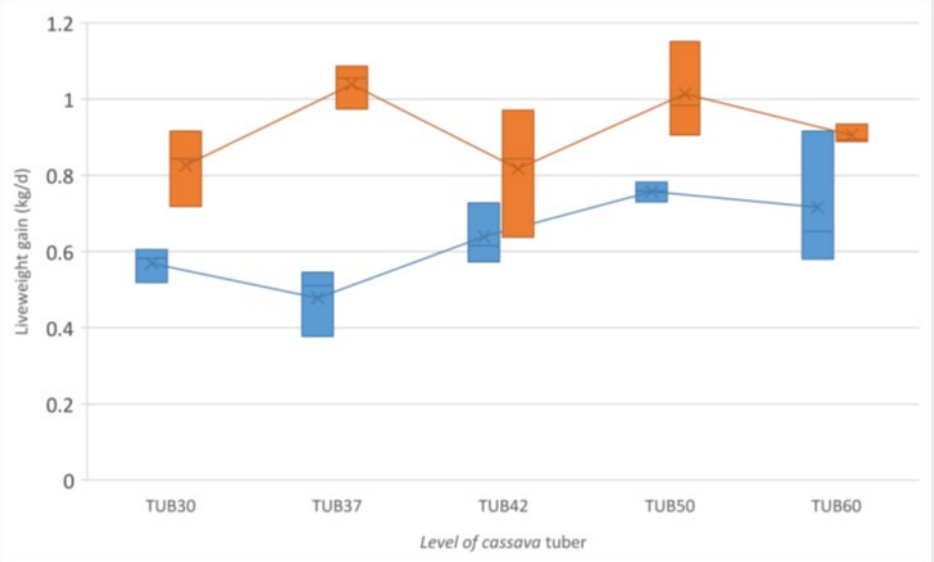

Figure.3 Box plot of liveweight gain for increasing levels of cassava tuber (%) and two protein sources (orange = soybean meal and blue = cavalcade hay). The variation between mean values for each replicate is represented by the box with the highest and lowest values defining the top and bottom of the box. A connecting line to the mean liveweight gain (across the three replicates; represented as 'x') has been added to highlight any general trends with increasing level of cassava tuber for each protein source.

These results suggest that cassava tubers mixed with a protein source could be a valuable supplement or total mixed ration for Brahman weaner steers being prepared for the live export trade. There was no indication of a maximum inclusion level as found in Indonesia but it would be wise to use the same maximum level of inclusion for safety reasons until more experience in feeding cassava in Australia occurs. Cavalcade hay was not as good as a protein meal to supply protein to a mixed supplement.

Published in Proceedings

McCosker, K., Roberio, G., Mello, H., Quigley, S. P. and Poppi, D. P. (2021). *Feed intake and live weight gain of Brahman steers fed diets containing cassava in the Northern Territory*. *33rd Biennial Conference of the Australian Association of Animal Sciences*, Fremantle, WA Australia, 1-3 February 2021. Orange, NSW Australia: Australian Association of Animal Science.

Objective 4. Analysis of costs and benefits of the interventions and their adoption by small scale producers – documenting the economic and social impacts on households and household members.

Economic analysis of small holder systems and small commercial feedlots at villages.

Reviews of economic evaluation and feed costs across regions were published in a series of publications.

Poppi et al. (2021a: b), Poppi et al. (2020). Main findings are summarised below.

The cost/kg feed was obtained from market prices and whilst home grown feed (forage, tree legumes, crops and straw) is often given a zero value it is best to include a labour and infrastructure cost in the cost/kg feed. Prices vary markedly across Indonesia (Table 3) and the Covid-19 pandemic has interrupted the supply chain across Indonesia and increased the variability.

Table 3 Cost (IDR/kg as fed) of common ingredients across 4 sites in Indonesia (at July - August 2020)

Feed type	East Java	Yogyakarta	Central Sulawesi	Sumbawa
Corn grain	3800	5000	4000	3800-4200
Cassava powder (Gaplek)	2500	4500-5500	5500	2800-4000
Cassava fresh tubers	1000	na	na	na
Cassava fresh tubers cost of production by farmer	400	na	na	na
Cassava bagasse (Onggok)	1700	4000	na	2800
Rice bran	2500	3500-4500	2500	2500
Wheat bran (pollard)	3600	3300-3600	na	na
Palm kernel cake	2100	2700	2800	1800
Copra meal	3100	4500	3500	4500
Soybean meal	6600	5000-7000	na	6500
Gliricidia	1000	500	500	600
Leucaena	na	na	500	600
Elephant grass	350	700	500	450
Rice straw	250	200	200	200
Corn stover	na	200	350	200
urea	3200 or 6000 (not subsidized)	8000 (not subsidised)	3500	3500

na: Not available: not grown in region or prices not available

This outlines the major feed ingredients available to farmers. Whilst the daily cost of the current feeding systems was low the daily LWG was also low as was the daily IOFC. Rations formulated for higher ME and CP content should promote a high LWG in line with accepted nutritional principles. Research can often indicate a ration composition which promotes high LWG and may or may not promote a high IOFC depending on the ingredient costs. Table 5 also highlights that ingredients are not readily available across all sites and that the cost may vary considerably by site. Thus developing a standard ration may be very site specific. A simple least cost ration formulator (ACIAR LCR) and the associated App (Beef-upp) have been used to devise rations which promote high live weight gain and IOFC. Table 4 shows least cost rations and cost/kg DM as formulated by

the ACIAR LCR for some of the above regions. This shows that the ration formulated for a region based on specific regional costs can vary but still deliver the ME, CP and NDF levels required. By far the lowest cost ration is if a farmer can grow their own cassava and simply chip, dry and store to feed to their cattle. Similar considerations would apply to any home grown feed ingredient eg leucaena, gliricidia, sesbania, indigofera, rice bran etc

Table 4. Rations formulated by the ACIAR LCR for three regions and potential ration formulation if farmer was to grow own cassava and feed directly to cattle.

Region	Ration %	ME MJ/kg DM	CP %DM	NDF %DM	Cost IDR/kg DM*
Sumbawa only Gaplek available	Leucaena 50%, Elephant grass 5%, Gaplek 8%, rice bran 9.7%, PKC 25%**	11.0	18.0	47.6	2226
Sumbawa with home grown cassava tuber	Leucaena 35%, cassava tuber 40%, PKC 25%	11.6	13.4	35.7	1621
Sumbawa only leucaena	Leucaena 100%	11	23.3	41	1667
Central Sulawesi	Gliricidia 50%, rice bran 32.7%, Corn grain 9.5%, PKC 7.8%	11.0	18.0	38.6	2424
East Java only Gaplek available	Gliricidia 50%, Elephant grass 18.5%, Gaplek 6.5%, PKC 25%	11.0	17.4	48.5	2111
East Java no tree legumes available	Elephant grass 29.8%, Gaplek 40%, PKC 25% Copra meal 4.2%, urea 1%	11.0	12.0	43.3	1792
East Java with home grown cassava tuber	Gliricidia 50%, Elephant grass 10%, cassava tuber 40%	11.4	13.2	35.1	1609
East Java no tree legumes available with home grown cassava tuber	Elephant grass 25.1%, PKC 25%, cassava tuber 40%, copra meal 9.1%. urea 0.8%	11.0	12.0	44.3	1826

*Note cost is /kg DM, ** PKC Palm Kernel Cake or expeller

It follows that a feed with a low Feed for Gain (FFG low kg feed/kg live weight gain) is more likely to have a high IOFC and be more profitable and attractive to a farmer although the daily feed cost might be much higher than a traditional current feeding system. An individual farmer may feed for a lower daily feed cost by feeding cheap ingredients eg large amounts of rice straw but it usually results in a lower daily IOFC. The farmer and extension personnel need to understand the difference between lower daily feeding cost (eg rice straw) and daily profit (IOFC) eg by the use of tree legumes or a formulated ration. Of course a higher daily feed cost if it leads to a higher IOFC is the better option but access to credit and risk are just as important in the decision process. It needs to be noted that formulating a diet for a high ME content does not guarantee a high IOFC if the animals do not achieve a high DM intake for some reason (compare a high onggok ration with simplified feedlot rations where the ME content is similar but for various reasons the intake of the high onggok ration was low).

Experiment 16 Livelihoods survey and adoption

Livelihoods Initial survey summary

Each region was surveyed at the commencement of village experiments. The participant number for each region was 50 in the Yogyakarta region, 30 in the Malang region, 17 in the Palu region and 22 in Sumbawa. The average age of farmer participants was 37 in Palu, 39 in Sumbawa, 51 in Malang and 55 in Yogyakarta. Malang and Yogyakarta had participants over 65 while Palu and Sumbawa did not have elderly participants. The number of members in the household were around 3 for all regions.

Most participants surveyed identified as farmers as their main occupation however the percentage did vary between regions. In Yogyakarta, 96% identified as farmers. In Malang only 63% had farming as their main occupation but 6.6% listed breeding as their main occupation. The Malang participants had a great diversity of occupations including labourers (13.3%), and drivers, sellers, entrepreneurs, and carpenters to a lesser extent. In the Palu region, 88% identified as farming as their main source of income and a further 6% identified as breeders. The remaining 6% were pensioners. In Sumbawa, 77% identified as farmers, while 13% as entrepreneurs. This was the only region who had a participant who was a student. Participants with the most breeding experience were from the Yogyakarta region (26%) followed by Malang (18%), Sumbawa (11.7%) and Palu 7.36%)

Malang region had the great diversity of levels of education in the participants. They had the highest percentage of participants that did not attend school (17%) but also the greatest percentage of university graduates (10%). In Yogyakarta, 36% of participants had either no schooling or only primary schooling. The remainder were high school educated. In Palu, 41% had either not gone to school or were only primary school educated while in Sumbawa, 54% of participants were not high school educated.

The participants in Palu and Sumbawa owned larger areas of land (14429m^2 and 12441m^2 respectively) compared to participants in the Malang and Yogyakarta regions (7096m^2 and 3202m^2 respectively).

In all regions, women played an important role in livestock production. Seventy-four percent of participants in the Yogyakarta region were women and on average these women spent 10 hours/week working in this production system. Five hours per week was spent looking for and collecting food. The other regions, women accounted for 50-55% of participants. The Sumbawa women spent 11 hours/week working, Malang women 14 hours/week, with women distributing their time looking for feed, feeding, cleaning pens and providing water. In Palu women spent nearly double the amount of time (21 hours/week) working with the cattle. Thirty-eight percent of this time was looking for feed and 25% of time was feeding the animals.

Feed use summary

Cassava

The utilisation of cassava varied between regions. The greatest amount of cassava production is in the Malang region with 3100000 tonnes/year. In this region cassava is mainly sold (67%) while 26% is fed to cattle with only 6% consumed for the household. Yogyakarta is also quite a large producer of cassava (873000 tonnes/year). Around 16% is sold and 65% is fed to cattle, and 17% is consumed within the household. Sumbawa produces around 107000 tonnes/year and 70% of this is consumed within the household, 27% is sold and only 1% is fed to cattle. Palu produces less cassava (47000 tonnes/year) with all consumed within the household.

Protein sources

The type of protein used in a diet differed between regions. The only protein used in Sumbawa is leucaena. Of those surveyed, 41% used leucaena because it was readily available but 27% used it because it was of high nutritional value. In Palu, gliricidia was

the main protein used (64%) with 24% using leucaena. The main reason for protein choice was generally due to product availability (53%) and because it was cheap (30%). In Yogyakarta, tree legumes (30% leucaena and 5% gliricidia) are also used as protein sources but other proteins are also used. The reason for choosing a protein is due to availability (35%), product ownership (35%), nutritional value (15%) and cost (10%). Malang farmers used a large variety of protein by-products (palm kernel cake, copra meal) but very little tree legumes. The choice of protein was based largely on availability (40%), being free (26%) but its nutritional value was also an important factor (20%).

Energy sources

The type of energy sources used in cattle feeding also varied between regions. The most popular energy source in Sumbawa was rice bran (72%) with corn as the alternative energy ingredient (27%). These energy sources are used because of their availability (45%). Palu also uses rice bran as a major energy source (76%) with pollard (17%) as an alternative. Availability (41%) was the major reason for them being used, but 29% of respondents based their decision on nutritive value. Rice bran (40%) was also the most common energy ingredient used by Malang farmers but other energy sources include wheat pollard (23%), sweet potato fresh (13% and dried (13%)) and corn stover. A farmer would choose an energy source largely based on its nutritive value (33%) and availability (30%). Yogyakarta farmers often use dried sweet potato (40%) as an energy source, but rice bran (30%) and wheat pollard (30%) are also popular. They use these because they are either free (35%) or cheap (30%), but 20% of respondents based their decision on nutritive value.

Forage sources

The forage component of the diet depended on the region. Sumbawa farmers sourced paddock grass (40%) for forage but King grass (23%) and Elephant grass (22%) were also important. Elephant grass was the major forage used in Palu (41%) but forage sourced from grass paddocks (23%) and King grass (23%) and corn stubble were important forages. Malang farmers utilised a larger variety of forages but elephant grass (30%) and paddock grass (30%) were dominant forages. Yogyakarta farmers largely relied on grass paddocks (40%) and Para grass (30%).

TAKE HOME MESSAGES

- Rice bran is widely used across Indonesia as an energy source.
- Cassava products are often underutilised for cattle feed, but can be hard to get.
- Producers decide on ingredients based on availability and nutritive value.
- Tree legumes are very important as an ingredient

Adoption of better formulations.

Better formulation will enable higher growth rates and higher IOFC which has the dual outcome of enabling farmers to increase their income and participate in the value chain. The investment capital for a fattening period is a barrier for a farmer to adopt a recommended strategy.

A study with the University of Gadjah Mada socioeconomics group and Kasmiyati (retired BPTP Malang) analyzed the farmers' willingness in adopting local feed innovation and background factors in Arjowilangun and Kucur villages. It was found that age and the number of cattle negatively affect the farmers' willingness while membership in a farmer's group and perception towards the cattle farming conditions has a positive effect on the farmers' willingness in adopting local feed innovation. Farmers who run a cattle fattening business have bigger probabilities to refuse the local feed innovation. Optimizing coaching and assisting activities through the farmer's group is an effective way to increase the farmers' willingness to fully adopt the local feed innovations.

Paper about to be submitted.

Objective 5 Strengthen capacity of local scientists including postgraduate students to conduct farmer relevant research and farmers and feed companies to make sound business decisions.

This project developed the capacity of staff to successfully conduct farmer relevant nutritional research.

- Senior scientists were engaged in the project to sustain their development. These scientists have undertaken postgraduate supervision, received promotion within their organisations and attended international conferences during this project. These experiences builds on their skills to increase livestock production of smallholder farmers across Indonesia. Publications of this work is listed in section 9.2.
- Ten Junior scientists were employed on this project appointed to manage the day to day activities at each site. This project funded their enrolment in a postgraduate program, and the research as part of project activities. Other young scientists were also supported that were involved in helping the running of the trials. Junior scientist knowledge and skills developed rapidly under the guidance of the senior scientists. At each annual meeting a training workshop was held with the junior scientists and other interested groups on a variety of topics such as experimental design, collecting feeding trial data, HCN biochemistry, working with spreadsheets and the use of the ACIAR LCR spreadsheet. The BPTP based junior scientists were involved in farmer meetings and all of the employed junior scientists presented seminars within Indonesia. Two junior scientists were awarded an ACIAR travel scholarship and presented a poster each at TropAg2019 in Brisbane. Another junior scientist was awarded SEARCA (Science and education for Agriculture and development) for a summer course in the Philippines. Another travelled to Malaysia to attend the University of Gadjah Mada -UPM conference and another attended the ICARD conference in Medan.
- A further 16 students (undergraduates and postgraduates) were involved in various trials conducted with the projects as part of their program and submitted a thesis. Students gained experience in appropriate feeding, handling, digestibility measurements and liveweight gain data collection of trial animals, as well as laboratory work. A full list of research titles supported by the MoreBeef project is listed in Table 5.

Table 5. List of research titles of the students supported by the More Beef Project.

Student	Title of thesis	Qualification
Rio Rizky Arisandy	Chemical composition, husk content, and density of rice bran from various regions in Indonesia	Honours
Ardha Adi Krisna Putra	Rumen fermentation characteristic on in vitro based on rice straw with supplementation cassava chip and pakan sumber protein at different ratio	Honours
Nur ‘Afifah	In vitro digestibility of rice straw supplemented with Cassava chips and protein meal in different ratio.	Honours

M. Shihabudin Muzaki	Intake and digestibility of ration based on rice straw supplemented with cassava powder and palm kernel cake on ongole crossbred bulls.	Honours
Gita Nofriantika	Evaluation of the in sacco digestibility of ongole bull rations with different proportion of cassava and palm kernel meal	Honours
Apriliana Dwi Putridinanti	Substitution of corn with dried cassava or cassava pulp in rations for feedlot beef cattle with different protein sources.	Masters
M. Shihabudin Muzaki	The effect of different protein level and feed management on daily weight gains, feed consumption, and rumen fermentation characteristics in ongole breeds	Masters
Shifatul Latiefah	Rumen fermentation characteristics, feed intake, and average daily gain of ongole crossbred bulls offered rice straw as basal diet and supplementation with cassava flour and palm kernel cake.	Masters
Noor Asrianto	The ongole farmer's motivation and partial budgeting analysis of cassava flour used as an additional feed in banaran and bleberan villages, playen district, gunungkidul regency.	Masters
Erna Winarti	Optimization of local feedstuffs as feed supplements in beef ration in Gunungkidul	(PhD- to be awarded)
Mohammad Mardiyanto	Profil Senyawa Linamarin pada Umbi Singkong dengan Beberapa Teknik Pemasakan	Honours
Elok Bashirah Yuliana	Analisis Kandungan Senyawa Linamarin pada Umbi Beberapa Varietas Singkong	Honours
Defi Maulida	Pemanfaatan tanaman singkong sebagai pakan ternak	Honours
Nurlita Sari	Teknik Penurunan Kadar Asam Sianida (HCN) Bagian Tanaman Singkong Varietas Cimanggu dan Kaspro Menggunakan Metode Pelayuan dan Pengeringan	Honours
Moh. Afton Nadir	Eliminasi Senyawa HCN Berbagai Bagian Tanaman Singkong Menggunakan Fermentasi EM4	Honours
Mohammad Mardiyanto	Formulasi Silase Tanaman Singkong Rendah Kandungan Asam Sianida (HCN)	Masters
Elok Bashirah Yuliana	Pengembangan metode analisis hcn tanaman singkong menggunakan smart digital camera	Masters
Hamidah	Pemodelan Sistem Dinamis Penyediaan Pakan Ternak Sapi Potong Berbasis Limbah Tanaman Pangan di Pesisir Selatan Kabupaten Lumajang	Masters
Deni Setiadi	Intervention of cassava-based concentrate in the diet of crossbred Limousine raised in lowland areas of Malang regengy: Effects on production and profit	Masters
Surya Retnaningrum	Effects of using varying level of cassava meal in the diet on production and rumen liquid profiles of crossbred Limousine.	Masters
Luh Ade Kariyani N.	Growth response of male Bali cattle fed various combinations of Leucaena with cassava chip or cassava waste.	Masters
Julian Hidayat		Masters

Ujang Kurniawan	The effect of supplementation of ground cassava and gliricidia leaves on the change of body dimension change of Ongole bulls received corn stover	Masters
I Wayan Sulendre	The effect of addition of ground cassava and gliricidia leaves on the change of body dimension and condition score of Bali bulls received elephant grass	Masters
Syahrul	To be submitted	Masters to be awarded
Bonna Andrew Zulu	The rate of disappearance of Hydrocyanic Acid (HCN) from cassava plant parts under drying or silage processing methods	Masters
Oshodi Oluwafemi Adedayo	Making safe silage from cassava	Masters
Shaun Douglas Hudson	Investigating the influence of temperature and pH on the release of hydrogen cyanide from cassava tissues	Honours

- There were 168 smallholder farmers who participated directly in the feeding trials. These farmers received some free feed supplements, health checks and parasite control and villages received the necessary infrastructure (scales, feed bins) for the trial. All sites had education programs for these farmers and those interested which were very well attended. Over the course of the project Palu held 15 extension meetings and workshops, Malang region held 31 meetings and field trips, and Yogyakarta region held 55 meetings and workshops. In addition to this, University of Gadjah Mada held 5 workshops for farmers. The latest one had 436 participants.
- Entrepreneurs and enterprising village partnerships were targeted. This is exemplified with the Kucur village where a mini feedmill was set up and on-selling LCR supplements to other villages. This Kucur Mandiri has now been recognised by the Malang Regency government as one of the drivers of the rural economy in the livestock sector. Another example is the Yogyakarta village group preparing gliricidia meal pellets and selling them as an alternative supplement source and also commercialising a mineral block. In Malang region, there has been significant establishment of linkages with feed companies, farmer co-operatives and small feedlots (refer to 5.3 of the annex for details)

GENERAL DISCUSSION

HCN removal in cassava

The most effective way to reduce HCN in cassava products was to sun dry various products. Ensilage was investigated as it was also commonly assumed to reduce HCN. However there are various way to make silage including pre-treatment such as wilting and partially drying.

The ensiling process, per se (with no pre-treatment or addition of water) does not reduce HCN content. Rather wilting or drying beforehand and adding water do play a role in reducing HCN in the final product. The addition of additives such as salt, sugar, alkalis (such as urea or limestone), lactic acid producers, do not cause any effective drop in HCN content of produced silage.

From the Malang university trial (Experiment 7), the use of silage is effective in ration formulations with high LWG achievable if the silage is limited so that the HCN levels in the ration is below 100 ppm (Indonesian limit). It is therefore vital that HCN content is measured before formulating the ration. For most of the research an ANU HCN kit was

used however these kits are costly and the small amounts of samples required for analysis caused a high variability of results. It would be better if larger sample sizes could be analysed. The UQ team are currently developing their own kits. The prototype works well for small samples and we will modify for a larger sample size. In practice HCN cannot be measured routinely but a safe protocol could be developed based on drying to some extent before ensilage and then sufficient aeration of a few hours prior to feeding out. These precise conditions have not been evaluated.

The feeding of tubers without peels (silage or sun drying) and sun drying cassava (all parts) (to 90% DM) is a very safe method of removing HCN.

Summary of pen trials

There were a wide range of pen feeding and village based animal feeding experiments. They had various aims but essentially the project needed to deliver on some features

- What was the upper level of inclusion of cassava products in rations
- Was there a difference between cassava products in the liveweight gain response
- Could different protein sources be used just as effectively in cassava based rations
- Would diets formulated by the ACIAR LCR result in high live weight gain
- How did these formulated rations compare to available commercial rations
- What were the conditions that influenced IOFC and what was it most sensitive to
- Were there differences in breed types

The set of controlled pen trials generated data from response curves to cassava and byproducts providing a better understanding of the consequences of various management strategies such as level of feeding, ingredient combinations and breed effects. The formulation of various diets in the animal pen trials saw some excellent liveweight gains across breeds. Euro crossbred bulls at the University of Brawijaya had live weight gain (LWG) of up to 1.4kg/day on some formulations in both the 2018 and 2019 trials, Bali cattle at the University of Mataram trials gained around 0.57 kg/day in one of the treatments. These LWG were close to the highest LWG recorded on good quality diets in Indonesia. The maximum live weight gain for Ongole bulls in objective 2 experiments was 0.69 kg/day however in a village trial in Central Sulawesi (objective 3) it was 1.28 kg/day. There is no doubt much genetic variation in Ongoles and opportunities to select for animals with higher LWG potential.

The response relationship between the different breeds of bulls were very similar. The Tadulako University/BPTP Central Sulawesi experiments particularly have shown that Bali bulls and Ongole bulls respond similarly to a high ME content supplement. The ME intake required by all breeds to achieve 0.3 kg/day, a value commonly seen in most village systems, increases from EuroX (0.5MJ/kg $W^{0.75}$.day) to Ongole and Brahman X (0.7 MJ/kg $W^{0.75}$.day) to Bali bulls (0.8 MJ/kg $W^{0.75}$.day). A collation of experimental data from Indonesia and Australia (Poppi et al 2021) indicated no difference in LWG responses to metabolizable energy intake between Brahman steers and Ongole bulls, a higher response with Euro x Ongole bulls (but with a more limited data set) and a lower response with Bali bulls. The results suggested little difference between the breeds with current rations but if rations were improved and fed to higher levels as in a more commercial fattening scenario then Euro Xbred> Ongole and Brahman> Bali bulls. This might be a likely scenario if some of the ration formulation principles developed in this project were to be adopted with a much higher IOFC for farmers and much greater production of saleable beef/region.

Another practical consequence of these relationships is that live weight of the bull has a marked effect on Feed for Gain and the daily requirement of DM intake both of which markedly increase with live weight of the bull reflecting the higher maintenance requirement of the heavier animals. The feed DM required is similar for all breed types at any given live weight given the specification of differences in maximum LWG for the

breeds. It is more profitable for an individual farmer to fatten lighter weight animals (younger) than heavier more mature animals.

The controlled pen experiments have also shown there needs to be limits on the inclusion of some ingredients, especially cassava based products, to avoid digestive upsets such as acidosis, HCN intake or palatability. A consistent output across all of the controlled feeding trials was that LWG was maximised at around 40% inclusion of cassava powder (gaplek), whole cassava tuber, cassava bagasse (onggok) or peel silage in a complete feed (or around 1% W/day). Other limitations to optimal LWG is not exceeding 50% rice bran, 25% for copra meal and palm kernel cake, and 2% urea. Some of these other upper limits were not investigated in this project but were raised from practical observations of participants. Above these levels of inclusion, LWG declined and in the UM experiment a level of 75% cassava inclusion resulted in live weight loss.

LCR formulation

Formulating various rations and testing the LWG response provides confidence in the LCR formulation system. This scientific output allowed us to progress into further village and extension work to maximise LWG for producers.

The formulation of a low-cost ration to meet specifications for ME, CP and NDF content enables local recipes to be devised and changed in response to changing feed prices and bull sale prices. It also enables new systems to be evaluated such as the use of tree legumes, herbaceous legumes or cassava-based rations. Better combinations of existing feed ingredients especially in systems where all feed needs to be purchased externally provide another way to decrease cost and increase LWG.

- The LCR ration outputs vary across regions reflecting the cost and availability of ingredients. Thus, a recipe for Central Sulawesi could be very different to a recipe for East Java.
- The cost of ingredients varies markedly according to region and whether they are bought in the market place or home grown and, for home grown and collected, how labour is accounted for by the farmer.
- Altering the ingredient input may have little effect in some cases eg not using urea to avoid potential toxicity problems results in a small amount of copra meal being substituted in one example (Table 4) with little change in cost. The LCR system allows these sorts of scenarios to be investigated.
- Decreasing the minimal ME content allows more ingredient combinations but the effect on LWG and IOFC is not known eg decreasing the minimal ME content from 11.5 to 11.0 MJME/kg DM is unlikely to have a significant practical effect on LWG. In the University of Gadjah Mada experiment, decreasing the ME content had no effect on live weight gain.
- Total forage systems, eg leucaena, can meet the nutritional requirements for high LWG and the LCR will show this. If this is limited in supply or the farmer wants to carry more animals /ha on leucaena land then an upper inclusion rate can be set and other ingredients added to meet the total mixed ration (TMR) requirements.
- Currently it is recommended that a TMR should be formulated to meet minimal levels of ME (11.0-11.5 MJME/kg DM), CP (12%) and NDF (20%).

There are some limitations and unknowns in the application of the system which require further testing. These include:

- The minimum ME content could be set at 11 MJME/kg DM with little effect on LWG. This has yet to be tested but would enable a wider source of ingredients to be used. Currently cassava and corn grain are the only two readily available ingredients with high enough ME content to raise the total mixed ration (TMR) ME content to 11.5 MJME/kg DM.

- Limits are currently placed on upper inclusion rates of some ingredients to avoid digestive issues such as acidosis, HCN intake or palatability. Currently these are 50% rice bran, 40% for cassava powder (gaplek), whole cassava tuber or cassava bagasse (onggok), 25% for copra meal and palm kernel cake, and 2% urea.
- The values for ME, CP and NDF content vary depending on the source of information. The ACIAR LCR uses Feedipedia values or local values where confident of analysis. Various systems around the world have feed tables and the nutrient content can vary markedly between systems. This has a marked effect on the output based on which value is used for nutrient composition. A standardised approach and collation for Indonesia would be useful. Such proximate tables do exist in Indonesia but they require upgrading to reflect changing processing methods eg in the production of rice bran.
- Formulating various rations and testing the LWG response would give confidence in the application of the LCR. If two rations are formulated for the same ME and CP content but using different ingredients then it is expected that the LWG response will be the same but this has not been tested locally with Indonesian ingredients although it is an assumption for all international feeding standards. The nutritional principles underpinning the LCR system suggest that they should be the same but this requires testing under Indonesian conditions and ingredients. If LWG differs, then it might suggest that the nutrient composition allocated to the ingredients are not correct or that the mix of ingredients affects intake or the efficiency of use of ME for growth. This can be seen in the results of Cowley et al (2020; 2021) and Retnaningrum et al (2021) where the level of gaplek or onggok was increased and protein meals decreased and inclusion levels of cassava products greater than 40% resulted in marked depression in intake and LWG which would not be expected if simply looking at ME content.

Village experiments

The 2018 village cattle trials involved 9 villages and directly engaged 206 farmers. This included: 50 farmers in the Banaren and Bleberan villages around Yogyakarta, 30 farmers in the Arjowilangon village near Malang and 126 farmers from the Malonas, Lembah Mukti, Pngerang, Karya Mukti and Balaroa and Bulu Pontu villages in the Palu region. The 2019 village cattle trials involved 16 villages and directly engaged a further 259 farmers. This included 40 farmers in the Banaran and Bleberan villages,50 farmers from Kucur village and 169 from Central Sulawesi villages. The final 2020 village experiment in the Yogyakarta region extended to the Dengok village as well as the Banaran and Bleberan villages. A total of 60 farmers were directly involved in this trial. These experiments have utilised best bet diets from the university trials as well as utilising diets from the LCR.

Traditional village feeding systems for cattle production are often not profitable and growth rates of bulls under village production systems are low, with associated low income over food costs (IOFC). The use of the LCR for formulating rations to supply a certain amount of nutrients or target a specific growth rate on a least-cost basis increases growth rates and IOFC. The formulation of various diets in the village trials saw some excellent liveweight gains across breeds. The village experiments have shown that growth rates can be increased substantially with supplementation. This is exemplified with village trials supported these findings with close to optimal liveweight gains for each breed of bulls (1.28kg/day Ongoles (Palu), 1.45kg/day Euro Crossbred (Malang), 0.69kg/day for Bali (Palu and Sumbawa).These LWG were close to the highest LWG recorded on good quality diets in Indonesia.

All the different locations of this project could have very profitable systems. These include the cassava based rations in East Java (Setiadhi et al. 2020; Retnaningrum et al. 2021), the gliricidia, soybean hulls and cassava based supplements in Yogyakarta and Central Sulawesi (Marsetyo et al. 2021; Winarti et al 2021a,b), the concentrate based rations in Yogyakarta (Shihabudin et al. 2021), as well as the leucaena and sesbania based

systems in NTB (Dahlanuddin et al. 2019). Marsetyo et al (2021), Retnaningrum et al. (2021), Setiadi et al. (2020), and Winarti et al (2021a,b) have shown positive IOFC associated with current feeding systems (Table 6). Feeding a high quality supplement up to levels of 1-1.6% W/day results in a large increase in IOFC.

Table 6. Some examples of live weight gain (LWG) and daily Income Over Food Cost (IOFC) in current production systems and some selected improved systems of production. Data mainly from village monitoring but also some pen trial data included for comparative purposes.

Region	Breed	Feeding system	LWG (kg/day)	IOFC IDR/bull.day
East Java	EuroX (Retnaningrum et al. 2021)	Gaplek (40%), protein meal, TMR	1.35	42,453
		Gaplek (70%), protein meal, TMR	0.30	(-) 6,394
	Euro X (Setiadi et al. 2020)	Village forage and by-products	0.84	25,400
		Village forage and by-products plus 2%W/d supplement of gaplek and protein meal	1.08	26,525
Yogyakarta	Ongole (Winarti et al. 2021 a,b)	Village forage and by-products	0.31-0.39	10,201-15,881
		Village forage and by-products plus 1%W/d supplement gaplek, soybean hulls, copra meal	0.59-0.75	18,779-23,396
	Ongole (Shihabudin et al. 2021)	TMR of concentrate ingredients	0.99	30,421
Central Sulawesi	Ongole (Marsetyo et al. 2021)	Corn stover	0.30	7,802
		Corn stover plus 1.6%W/d supplement cassava tuber and gliricidia	0.69	13,949
	Bali (Marsetyo et al. 2021)	Elephant grass	0.20	7,687
		Elephant grass plus 1.6%W/d supplement cassava tuber and gliricidia	0.46	12,543

Thus, there is a large opportunity to increase beef cattle productivity (annual LWG) with a resultant increase in IOFC for the farmer. A strategy is to shift to feeding LCR formulated rations which will promote high LWG. This approach has potential to markedly increase IOFC and to increase meat production nationally. The choice of breed is also important. Potential for growth declines from Euro x Ongole to Ongole to Bali cattle but the IOFC for

bulls of different breeds may not differ very much. The bigger breeds may not be able to express their potential for growth if inadequately fed and IOFC is reduced.

Feedback from farmers was extremely positive with improved LWG and BCS (body condition score) of their animals with many farmers willing to change practices based on these improved outputs. A village site in the Malang district, displayed a classic example of end-user engagement. Farmers from this site have formed a co-operative and, using the tested LCR concentrate mixture, have continued to produce it and sell it within the village to feed local cattle and also sell it to other farmers in a commercial venture. Another example of educating potential end-users is the production of a film on the processing of Gliricidia leaves for cattle feed. This film describes the role of BPTP, LIPI, University of Gadjah Mada, farmer groups, farmers and cooperatives as the next user who will develop in the future. The film will be disseminated by Foreign Cooperation Bureau of the Ministry of Agriculture with the hope that many regions will adopt this innovation and develop it in other regions.

It is anticipated that this acquisition and adoption of knowledge towards better nutrition by the participating farmers will see long term benefits in their feeding systems.

Better formulation will enable higher growth rates and higher IOFC to be achieved which has the dual outcome of enabling farmers to increase their income and participate in the value chain but also nationally enable an increase in beef production which will go some way to meeting increasing domestic demand for beef.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The studies in these project experiments have generated liveweight gain relationships to a wide range of feeding strategies using locally available products for Bali bulls, Ongole bulls and Crossbred bulls. Specifically, these response curve relationships enabled a better characterisation of the use of cassava and its by-products, as well as improved use of various protein meal supplements. A consistent output across all of the controlled feeding trials was that LWG was maximised at around 40% inclusion of gaplek or whole tuber (with peels) or peel silage in a complete feed (or around 1% cassava product W/day).

The data produced in this project can be used in the generation of growth and nutrition models, and also provide the nutritional basis for least cost ration formulation. If there is to be a large investment into feed costs then the nutritional principles of feeding and breed effects should be known with established response relationships to ME intake. Farmers often feed for daily cost or availability and the level of feeding may be lower than required to meet production targets and there is a production and financial penalty for this approach.

A least cost ration system (LCR) provides a means by which farmers, advisors and agribusiness can adjust rations to meet minimum requirements for metabolizable energy (ME), crude protein (CP) and neutral detergent fibre (NDF).

Thus, there is a large opportunity to increase beef cattle productivity (annual LWG) with a resultant increase in IOFC for the farmer. This project found an important strategy was to shift to feeding high amounts of LCR formulated rations which will promote high LWG. This approach has the most potential to markedly increase IOFC and to increase meat production nationally.

This project has developed ACIAR LCR from a basic prototype from the Murray State University USA. It is free and has been customised for Indonesian feeding systems and modified to facilitate use.

An App version is available (Beef-upp) free for android phones which has less features but can be used quickly and simply to devise some rations. This app formulates the least cost diet based on energy and protein requirements only. It has inbuilt nutrition precautions such that it does not allow for diets to go over 50% protein meals or grain or cassava product. This allows for safe ration formulation for people not as experienced in nutritional science.

Current feeding systems in most villages generally produced a low LWG with a low IOFC and this relates to the use of low-cost ingredients, eg rice straw and other crop residues, native grass, home grown grass and cheap by-products when available, all of which are low in ME and CP content. Farmers often feed for daily cost or availability and the level of feeding may be lower than required to meet production targets and there is a production and financial penalty for this approach. The formulation of various diets using best bet diets and the LCR formulator showed excellent liveweight gains across breeds in the village trials - most close to the highest LWG recorded on good quality diets in Indonesia. With better diets the IOFC is generally much higher across all breeds when feeding a high-quality ration compared to current systems. The LCR system also offers a means for adjusting rations based on cost and availability. It is anticipated that this acquisition and adoption of knowledge towards better nutrition by the participating farmers will see long term benefits in their feeding systems.

8.2 Capacity impacts – now and in 5 years

8.2.1 Senior scientists

All staff have been given the opportunity to develop their skills and experience to develop simple, low cost rations that promote high LWG in bulls and profitability of small holder farmers. Senior scientists advanced project knowledge by attendance at a range of conferences and seminars and meetings and through publications. The greatest capacity development of staff has come from the regular interaction between Indonesian and Australian counterparts. The involvement of Australian scientists in all stages of the experimental activities of the projects has demonstrated the need for a hands on approach to conducting research. The effect has been reciprocal as the Australian scientists gained a greater understanding of the issues that arise with implementing a research program in Indonesia. This has resulted in Indonesian and Australian scientists learning from each other.

It has also led to further local Indonesian projects. At Tadulako University our collaborators were successful in obtaining " National Priority Research" which is a large national grant aimed at developing breeding and feeding strategies for Donggala cattle from 2020 to 2024. The project is funded by National Research and Innovation Agency in collaboration with Ministry of Education, Culture, Research and Tecknology.

Conferences/seminars

- I**nternational seminar of animal nutrition and feed science** held at the University of Mataram, Lombok (7-9 November, 2017). Dennis Poppi, Dahlanuddin, Tanda Panjaitan
- **Seminar Nasional 2017 (**10-12 Oktober 2017)**.** Kandungan Senyawa Linamarin Pada Beberapa Varietas Umbi Singkong (Manihot esculenta), , PATPI, Lampung,
- **TropAg2017** was held in Brisbane (20-22 November, 2017). The event was attended by Dahlanuddin, Karen Harper, Simon Quigley and Dennis Poppi.
- **Jember cattle festival** at Bondowoso (July 2018). All team attended. Tanda Panjaitan and Dennis Poppi presented.
- **The 10th International Symposium of the Nutrition of Herbivores** (2-6 September, 2018) **France**. Dennis Poppi, Karen Harper, Cuk Tri Noviandi, Ali Agus, Dahlanuddin and Tanda Panjaitan attended.
- **International Leucaena Conference** (November 2018) – Brisbane. Karen Harper
- **Red Meat Seminar** (April 2019) Brisbane. Dennis Poppi
- **1st International Seminar on Indigenous Farm Animals (**14 – 17 October 2019), Senggigi, West Lombok, Indonesia. Dennis Poppi, Dahlanuddin, Tanda Panjaitan
- **ISRP 2019** (3-6 September, 2019) Leipzig Germany Karen Harper, Simon Quigley, Kusmartono, Risa Antari
- **ISTAP 2019** (September 23-25, 2019)) - Yogyakarta – Apriliana Dwi Putridinanti, Shifatul Latiefah, Noor Asrianto and Cuk Tri Noviandi all presented
- **TropAg2019 Brisbane** (November 2019) Dennis Poppi, Deni Setiadi and Wayan Sulendre.

- **University of Brawijaya workshop and lectures** 2019. Dennis Poppi
- **2nd-International seminar on science and Technology (ISST-2)** (16-17 September 2020) conducted in Palu - Marsetyo
- **International conference on development and Innovation in Agriculture (ICDIA)** Indonesia (27 October, 2020). – zoom presentation Karen Harper, Abu Zaenal Zakariya
- **Animal Science and Food Technology Conference** (4-5 November 2020) conducted in Purwokerto, Central Java - Marsetyo
- **The 6th International Seminar of Animal Nutrition and Feed Science (ISAINI**) (7-8 July), 2021. Indonesia – Karen Harper (zoom), Cuk Tri Noviandi
- **Joint ICARD and UNRAM conference**, Mataram 2021. Dahlanuddin, Tanda Panjaitan, Dennis Poppi.
- **The National Conference of Applied Animal Science (NCAAS)**, Jember September 2021. Dennis Poppi.
- **Optimalisasi Teknologi Pakan Dalam Peningkatan Kualitas Pakan Lokal**. University of Gadjah Mada. September 2021. Ali Agus, Cuk Tri Noviandi.
- **Membangun Negeri dengan Singkong; Webinar Singkong Berseri #1** – Mengenal Lebih Dekat dengan Singkong, Direktorat Jenderal Tanaman Pangan Kementan (2021) Ahmed Subagio.

Promotions and work opportunities

- **Abu Zaenal Zakariya** who worked with the BPTP Malang team now lectures at the Agricultural Development Polytechnic – Polbangtan.
- **Dahlanuddin** promoted to Professor
- **Gunawan** promoted to Professor
- **Ahmad Subagio** received the national Academic leader award in the field of agriculture
- **Cuk Tri Noviandi** was awarded an Engineering degree in Animal Science
- **Marsetyo**- Promotion (from level 4D to top level 4E by Marsetyo 2021)
- **Marsetyo** -Achieving engineer degree (IPU Asean Eng) by Marsetyo 2020
- **Simon Quigley** – promoted to Professor at Central Queensland University

8.2.2 Junior scientists

The appointment of junior scientists at each site and the involvement of honours students in the project contributed to the development of research capacity of the next generation of scientists to conduct farmer relevant research. This project provided students with a postgraduate pathway but also valuable experience in animal trials, sample collection , data management and laboratory skills. In a questionnaire at an annual meeting, junior scientists also mentioned they gained skills in team work, problem solving, people skills and improved communication skills.

A summary of our junior scientists includes:

- Apriliana Dwi Putridinanti awarded Masters and now doing an internship at BPTP Yogyakarta.
- Deni Setiadhi awarded Masters and now looking for employment.

- Julian Hidayat writing final paper for award of Masters.
- Luh Ade Kariyani awarded of Masters.
- Mohammad Mardiyanto awarded Masters.
- Elok Bashirah Yuliana awarded Masters.
- Hamidah awarded Masters.
- Noor Asrianto awarded Masters.
- Shifatul Latiefah awarded Masters and now working as a feed quality supervisor candidate, Fisheries and Livestock Office of Garut Regency.
- Surya Retnaningrum awarded Masters and now working as an intern at a cattle feedlot.
- Wayan Sulendre awarded Masters, non permanent lecturer at Department of Animal Science, Tadulako University and started a PhD.
- Erna Winarti currently doing PhD.
- Ujang Kurniawan awarded Masters and now in a family business Central Sulawesi.
- Syahrul Alimudin enrolled in Masters after completing work for project.
- Shihabudin Muzaki (Zaki) currently doing Masters.`

JS Workshops

This project provided specific skill development to junior scientists. There were four formal training programs for the junior scientists involved in this project.

- In January 2018, junior scientists involved in the animal feeding trials went to a 5 day workshop at University of Gadjah Mada led by Simon Quigley. Material covered included: feed preparation, feeding and refusal measurements, weighing and handling animals, animal treatment allocation and data analysis.
- In February/March 2018 all the junior scientists travelled to Lombok and Sumbawa to attend another training workshop led by Tanda Panjaitan. Apart from a training exercise in village experiments, animal handling, it was also a team building exercise for the group.
- In July 2018, as part of the annual meeting, the junior scientists had a training day. This training day involved:
    - Seminar delivered by Karen Harper UQ on rumen digestion, in particular starch digestion.
    - Seminar delivered by Ahmed Subagio on the biochemistry of HCN and its measurement.
    - Workshop with Tanda Panjaitan on regression analysis in particular its use in estimating LWG from the animal experiments.
    - Team building exercise climbing Mt Ijen on the Friday night after training.
- In July 2019, as part of the annual meeting, the junior scientists had a training day. This training day involved a workshop on the least cost ration formulator with Karen Harper and regression analysis in excel with Kieren McCosker.

JS awards and scholarships

All of the JS have presented seminars at conferences within Indonesia. In addition to this some JS have gained awards or travel scholarships to present their work at major conferences including International conferences. They include:

Wayan Sulendre and **Deni Setiadhi** were awarded ACIAR travel scholarships to travel to Brisbane for TropAg19.

Shifatul Latiefah was awarded a SEARCA (Science and education for Agriculture and development) for a summer course in the Philippines

Mohammad Mardiyanto presented at the ICARD conference in Medan 2018

Noor Asrianto attended the University of Gadjah Mada -UPM in Selangor Malaysia.

8.2.3 Indonesian Smallholder farmers and next-users capacity

We have seen great improvements in the skills, knowledge and aspirations of farmers in our focus villages, particularly with regard for farmers making sound business decisions relating to feeding of cattle. Our village research activities directly involved over 168 smallholder farmers who participated in feeding trials for Profitable feeding systems project. This includes 38 farmers in Central Sulawesi, 80 in the Malang region and 150 in the Yogyakarta region. In the NTB region, farmers would come to demonstrations while the feeding trials were on to give a better understanding of feeding and liveweight gain improvements. All sites developed their infrastructure in some way. This included upgrades of animal research facilities, including the animal pens and feed and water troughs – particularly after earthquake devastation. Other sites purchased equipment such as scales and computers. This project provided feed, weighing facilities, vaccinations/worming to all of the smallholder bulls involved in the project. The knowledge of the weight of the animals has empowered the farmers to get an accurate payment for their animals from the trader. A greater knowledge of the feed formulation system to achieve a higher LWG has transformed some production systems from cow calf to a fattening system with greater animal numbers

In addition to this direct involvement of farmers - another important project aspect has been the farmer field days and workshops at all the project sites. These field days encourage all surrounding smallholder farmers, and their families to attend. These village field days provide farmer information of the project and the various feeding treatments, as well as training on feedlot nutrition and management, and health management. This is exemplified with a Malang field trip.

https://drive.google.com/file/d/1Efh8j8FIGR5i1M4auUjox3X8DvCJ5pu6/view?usp=sharing

Over a three year period there were 15 extension meetings and workshops in the Palu region, 31 in the Malang region and 55 in the Yogyakarta region and five farmer large workshops (totalling 980 farmers) at the University of Gadjah Mada. The detailed numbers of these next user engagements can be found in appendix 4.

Increasing the capacity of villages through targeting entrepreneurs and village business venture partnerships is also key to this project. In the Malang region, in the Kucur Village a new mini feedmill business has been set up. In the Yogyakarta region, Gunawan has commercialised a mineral block and also patented gliricidia meal pellets as a feed ingredient for ration formulation. More effort into next user engagement was targeted for the 2020 year of the project. Covid stopped that outreach.

8.3 Community impacts – now and in 5 years.

8.3.1 Economic impacts

The current project aims to have enhanced an understanding of the economic benefits that are possible through use of an LCR approach of ration formulation using locally available products. At present the only direct economic impacts are from the improved cash-flow of farmers involved in the village implementation studies. In general adoption of the LCR formulations by smallholder farmers will reduce costs/weight gain, resulting in turnoff of heavier cattle and turnoff of more cattle by decreasing the length of the fattening cycle. Adoption of the LCR formulation enables local recipes to be devised and changed in response to changing feed prices and bull sale prices. It also enables new systems to

be evaluated such as the use of tree legumes, herbaceous legumes or cassava-based rations. Better combinations of existing feed ingredients especially in systems where all feed needs to be purchased externally provide another way to decrease cost and increase LWG and IOFC. In village-based systems it was found that higher IOFC can be achieved if rations are fed which will enable higher LWG approaching the maximum seen for each breed type. This is exemplified in Asrianto et al. (2019) where feeding a composition of 50% cassava, 25% copra, 25% soybean skins provided an increase of farmers income/animal of Rp1323000.

8.3.2 Social impacts

At this stage it is not possible to ascertain any wider social impacts of the project than with those farmers directly involved. The social impacts of our feeding interventions have not been evaluated. The greatest impact on farmers from using a LCR strategy is through increased cash flow. It is therefore anticipated that adoption of a LCR strategy will potentially have a large social impact. The ensuing financial benefits will impact society through increased cash flow available for education, home improvements, and further investments in farming and livestock enterprises. The higher LWG also allows farmers to have more flexibility in marketing cattle and allows them to sell under favourable conditions. The weighing of cattle in villages has empowered farmers in the selling of the animals to traders, but also provided farmers with an appreciation that improved formulation has significant improvements in cattle LWG.

Farmer survey data did evaluate the barriers to adopt these new feeding systems. It was found that optimizing coaching and assisting activities through the farmer's group is an effective way to increase the farmers' willingness to fully adopt the local feed innovations. The project has already impacted positively on farmer groups with the establishment of a farmer cooperative in the Yogyakarta region and the manufacture of a mineral block in this region. These outputs will provide more knowledge and influence the farmers.

8.3.3 Environmental impacts

No environmental impacts have been monitored in this project. It is not expected that there will be any negative environmental impacts. Better management of fattening operations usually results in better use of faeces and compost and urinary N as fertilizer options for other cropping activities or for sale. On a national basis, improved growth rates results in more efficient use of resources such as feed and water and reduced greenhouse gas emissions per kg of meat produced. Data from this project will be used in a proposed Climate Lens project for methane emission modelling.

8.4 Communication and dissemination activities

The project deployed a range of communication and dissemination approaches which targeted different next-users. This project has developed teaching material for the ACIAR LCR formulation workshops and also factsheets across a range of topics. These will continue to be used in the future. There is also a series of video material including:

- Utilizing and making Gliricidia in the ration – Yogakarta BPTP
- YouTube – https://youtu.be/qVERVPC4C20 Kucur Village innovation, Dau District, Malan Regency – Malang BPTP
- YouTube Channel (Sahabat Ternak Channel) Uploading on farm classes and online courses, including formulating ruminant rations using ACIAR LCR calculator that was created in this ACIAR project.

Fact sheets were developed for distribution to scientists and extension officers. These fact sheets are entitled:

- LCR formulation fact sheets – ACIAR LCR and Beef-upp.
- Haymaking techniques
- Cassava silage
- Kucur village cassava feeding trial and mini feedmill innovation

These are found in appendix 3

Training workshops

The project has supported a variety of on-farm demonstrations and dissemination of information at each site. This project has delivered 49 training workshops targeting farmers, next users and university students, but also involving extension officers and Dinas staff. The village farmer training and field days which occurred are:

Central Sulawesi training and workshops

- Experiment plan and target workshop. Sept 2017. Malonas village, Donggala district. Sulawesi.
- Experiment plan and target workshop. Oct 2017. Bolu Pountu village, Sigi District, Sulawesi.
- Training on cattle feeding and reproduction management. Dec 2017. Malonas village, Donggala district, Sulawesi
- Extension and Dinas Staff meeting coordination on experiment with Australian team January 2018, Malonas village, Donggala district, Sulawesi.
- Training on cattle feeding, feedlot, reproduction, forage, health management. April 2018. Farmers, extension and Dinas staff Malonas village, Donggala district, Sulawesi.
- Training on feedlot and cattle nutrition Apr 2018. Tadulako University and Bolu Pountu, Sigi District, Sulawesi. 70 undergraduate students
- Training on feedlot and cattle nutrition Apr 2019 Tadulako University and Potoya village, Sigi district, Sulawesi. 62 undergraduate students
- Training on feedlot management and forage conservation Apr 2019 Sibedi village, Sigi district Sulawesi.
- Training on feedlot management and forage conservation May 2019 Malonas village, Donggala district, Sulawesi.
- Dissemination of research finding to farmers in Malonas village and surroundings July 2019 Malonas village, Dampelas Sub Dictrict, Donggala District, Central Sulawesi.
- Dissemination of research finding to farmers in Potoya village and surroundings, Potoya village, Dolo Sub Distric, Sigi District, Central Sulawesi.
- Beef cattle fattening strategies using local feed supplements Oct 2019 Sibedi village, Marawola Sub District, Sigi District, Central Sulawesi
- Developing forage bank at village and beef cattle nutrition Nov 2019 Tanah Abang village, Toili su Bistrict, Banggai District, Central Sulawesi 130
- Training on the use of forage conservation for beef cattle Jan 2020 Sidondo village, Tanambulava, Sigi District, Central Sulawesi
- Training on bokhasi making, hay making and developing forage bank at village Feb 2020 Lambara village, Tawaeli Sub District, Palu District, Central Sulawesi

Malang BPTP training and field days

- Local Feedlot in Balearjosari 50 farmers

- Local Cooperative in Jabung, Malang 40 farmers
- Training Feed Technology with Mashudi 40 farmers
- Farmer visit to the Beef Cattle Research Center, Grati, Pasuruan, East Java, Indonesia October 2019
- Operational training of a feed mixer. November 2019 Kucur Village, Malang
- Prof. Dennis Poppi visits Kucur Village and seeing their new mini feedmill business and introduction to LCR system December 2019 Kucur Village, Malang.

Yogyakarta BPTP training and workshops

- Workshop training of weighing of bulls and measuring of body size August 2019 Bleberan village, Playen sub-district, Gunungkidul
- Workshop training of weighing of bulls and measuring of body scale August 2019 Banaran village, Playen sub-district, Gunungkidul
- Training of making the Gliricidia leaf meal for feed. August 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Training of making mineral block feed for bulls August 2019 Bleberan village, Playen sub-district, Gunungkidul
- Workshop on feed management of bulls in farmers Sept 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Workshop - Collecting of cassava feed ingredients for research purposes Sept 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Workshop - Explanation of the collection of Gliricidia leaves Sept 2019 Banaran village, Playen sub-district, Gunungkidul
- Comparative study of making pellet feed Sept 2019 LIPI office, Gunungsempu, Bantul
- Workshop -carrying out the characteristics of Gliricidia plants Sept 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Workshop on Gliricidia leaf collection Sept 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Coordination with farmers about plans to use pellet feed in cattle Oct 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Workshop with farmers to discuss the use of pellet feed in cattle Oct 2019 Banaran village, Playen sub-district, Gunungkidul
- Workshop-Preparation of feed ingredients for pellet feed production for farmers Oct 2019 Banaran village, Playen sub-district, Gunungkidul
- Coordination with farmers to prepare pellet feed Nov 2019 Banaran and Bleberan villages, Playen sub-district, Gunungkidul
- Monitoring to the next user of trial results of ACIAR Project in Yogyakarta. August 2020 Farmer Cooperative (Manunggal Amargo Andhini) Banaran village, Playen sub-district, Gunungkidul,
- Technical guidance (virtual) about processing of mineral blocks and Gliricidia sepium leaf flour September 2020 BPTP Yogyakarta, Karangsari, Wedomartani, Ngemplak, Sleman, DIY
- Evaluation Meeting of feed development by farmer cooperative September 2020 Farmer Cooperative (Manunggal Amargo Andhini) Banaran village, Playen sub-district, Gunungkidul, DIY

- Technical guidance about Processing of mineral blocks by Head of farmer Cooperative September 2020 Karangmojo village, Karngmojo sub-district, Gunungkidul, DIY
- Seminar of Research Proposal of Erna Winarti (Doctoral Program) from ACIAR activity October 2020 Animal Science Faculty of Gadjah Mada University, Yogyakarta
- Evaluation of live weight gain of bulls of the 3rd experiment. October 2020 Banaran village, Playen sub-district, Gunungkidul,
- Evaluation of live weight gain of bulls of the 3rd experiment October 2020 Bleberan village, Playen sub-district, Gunungkidul.
- Research Team Meeting (BPTP & LIPI) about publication and Patent registration October 2020 LIPI office, Gading, Playen, Gunungkidul,
- Evaluation Meeting of feed development by farmer cooperative November 2020 Farmer Cooperative (Manunggal Amargo Andhini) Banaran village, Playen sub-district, Gunungkidul, DIY
- Seminar of Research Results of ACIAR activity in BPTP Yogyakarta December 2020 BPTP Yogyakarta, Karangsari, Wedomartani, Ngemplak, Sleman.

University of Gadjah Mada workshops

- Online workshop: “Pelatihan Formulasi Ransum Ruminansia dengan Metode Least Cost Ration (Feed formulation for ruminants using LCR)”, 24 February 2021. 25 participants.
- Online workshop: “Bagimu Petani kami Mengabdi”, title of presentation: “Sistem Peternakan Terpadu (Integrated Farm System)” 2 April 2021. About 250 participants.
- Online workshop: “Bagimu Petani kami Mengabdi”, title of presentation: “Pakan Ternak Berkualitas (High Quality Ration)” 25 May 2021. About 250 participants.
- On farm training on “Feed formulation using local feedstuffs” for farmers. 16 Juni 2021. About 20 participants.
- Online workshop: “Optimalisasi Teknologi Pakan dalam Peningkatan Kualitas Pakan Lokal “Formulasi Ransum Berbasis Pakan Lokal Dengan Aplikasi LCR Calculator (Feed formulation based on local feedstuffs using LCR calculator)”. 18 September 2021. 434 participants.

Annual meetings

Since the project commenced we have had a start up meeting (May University of Gadjah Mada 2017), annual meeting in Jember (July 2018) and the mid-term review in Malang (July 2019). The meetings have both invited outside stakeholders such as the team members from Indobeef, ACIAR management, ICARD, Grati research station, University dignitaries and university staff. These meetings highlight and promote our research and staff to other stakeholders. The July 2018 and 2019 meetings included junior scientist training days.

Jember cattle festival at Bondowoso.

As part of the July 2018 annual meeting, the project team attended and presented work at the Cattle festival. Dennis Poppi and Tanda Panjaitan both presented a seminar highlighting our research and encouraging cattle production in the area. It was estimated that around 200 local farmers, government officials and students attended these seminar and question sessions. The junior scientist posters were also showcased at this event.

Presentations

Poppi seminars

- Lombok International Seminar 2017
- Jember University workshop and lectures 2018
- Poppi Red Meat Seminar April 2019 Brisbane
- University of Brawijaya workshop and lectures 2019
- The National Conference of Applied Animal Science (NCAAS), Jember 2021
- Joint ICARD and UNRAM conference, Mataram 2021

Harper seminars

- September 2018 ISNH2018 – France. The relationship between efficiency of microbial crude protein production and rumen microbial community structure in steers fed tropical pastures. Poster
- November 2018 ILC2018 – Brisbane. Energy supplementation in Leucaena.
- September 2019 International Symposium on Ruminant Physiology, Leipzig, Germany. The rate of disappearance of Hydrocyanic Acid (HCN) from cassava plant parts under drying or silage processing methods. Poster
- Adelaide University – Indonesia virtual tour of project. 1 October 2020
- 27 October, 2020. International conference on development and Innovation in Agriculture (ICDIA) Indonesia – zoom presentation
- 7-8 July, 2021.The 6th International Seminar of Animal Nutrition and Feed Science (ISAINI)
- Indonesia – zoom presentation

Subagio seminars

- Kandungan Senyawa Linamarin Pada Beberapa Varietas Umbi Singkong (Manihot esculenta), Seminar Nasional 2017, PATPI, Lampung, 10-12 Oktober 2017
- Membangun Negeri dengan Singkong; Webinar Singkong Berseri #1 – Mengenal Lebih Dekat dengan Singkong, Direktorat Jenderal Tanaman Pangan Kementan (2021)

Marsetyo seminars

- 2nd-International seminar on science and Technology (ISST-2) on 16-17 September 2020 conducted in Palu
- Animal Science and Food Technology Conference on 4-5 November 2020 conducted in Purwokerto, Central Java

Dahlanuddin seminars

- Leucaena (L. leucocephala) – an environmentally friendly solution to the low cattle productivity in the dry land. Proceedings, 5th International Conference on Science and Technology, June 2021.
- Produksi dan mutu daging sapi yang digemukkan dengan pakan berbasis lamtoro (Leucaena Leucocephala) National Seminar, Indonesian Association of Nutritionist and Feed Scientist, 6 August 2020.
- Adoption of Leucaena based feeding systems in Sumbawa, Eastern Indonesia and its impact on cattle productivity and farm profitability. International Leucaena Conference, Brisbane, 29 October – 3 November, 2018.

International conferences (not including Indonesia or Australia)

Dennis Poppi, Karen Harper, Cuk Tri Noviandri, Ali Agus, Dahlanuddin and Tanda Panjaitan attended the **10th International Symposium of the Nutrition of Herbivores** (2-6 September, 2018). Clermont-Ferrand France.

Karen Harper, Kusmartono, Simon Quigley attended the **International Symposium on Ruminant Physiology**, Leipzig, Germany, 3-6 September 2019.

Project newsletters and updates

Six newsletters and a further three experiment updates have been sent out to the extended team and interested parties. The newsletters include information regarding important updates, travel, team member information, fun photos, travel and upcoming conferences. Experimental updates via email are sent to team members only and keep the team in touch with what we are all doing experimentally.

News articles

"Livestock profits on the 'upp' thanks to feed app"

https://www.aciar.gov.au/media-search/news/livestock-profits-upp-thanks-feed-app

The following are links to news articles in Indonesia that relate to our project.

https://m.timesindonesia.co.id/read/177815/20180724/231547/beri-pemahaman-soal-pakan-ternak-unej-gandeg-dua-ahli-nutrisi-australia/ MURL

http://beritajatim.com/ekonomi/335067/profesor_australia_sarankan_masa_kawin_sapi_diatur.html

http://m.beritajatim.com/ekonomi/335037/ini_kata_profesor_ternak_australia_soal_pakan_di_indonesia.html

In May 2020, a film documenting all ACIAR activities at BPTP Yogyakarta was released. The scene documented film was taken from 5 to 7 March 2020. The title of the film is "Processing Gliricidia leaves for beef cattle feed". This film mainly documented the processing of Gliricidia leaves into leaf meal (powder) and pellet. It also documented the application of leaf meal and pellet as a cattle feed for farmers. This film produced by Burau Cooperation Ministry of Agriculture and involved several government institutions i.e BPTP Yogyakarta, LIPI, Faculty of Animal Science University of Gadjah Mada and farmer's co-operative namely Manunggal Margo Mandiri at Banaran.

Reports

LPS/2013/021 ACIAR Annual report 2018

LPS/2013/021 ACIAR Annual report 2019

LPS/2013/021 ACIAR Annual report 2020

Whatsapp (all team). This has been an incredibly successful way for the group to communicate instantly. A group chat was established at the first meeting and is used extensively on a daily basis for any query, update and photo opportunity.

9 Conclusions and recommendations

9.1 Conclusions

Profitable beef production is a pathway out of poverty for smallholder cattle farmers. Current traditional systems of production are often not profitable and growth rates of bulls under these village production systems are low with low income over food costs (IOFC). Cattle growth rates can be increased and a system for formulating rations to supply a certain amount of nutrients or target a specific growth rate on a least-cost basis would increase IOFC. Growth rate can only increase if metabolisable energy (ME) intake of the ration can be increased. To increase LWG and IOFC, rations need to be formulated to meet the minimum ME (11MJME/kg DM), CP (12%) and NDF (20%). The formulation of a low-cost ration to meet specifications for ME, CP and NDF content is best served by the application of a least-cost ration (LCR) formulation system such as the ACIAR LCR or beef-upp app. Such an approach has been shown to increase IOFC in this project.

These formulators provide a way of formulating rations to increase the ME content at the least cost and can modify rations based on the local availability and prices of ingredients. therefore allowing rations to be changed to meet changing circumstances of availability and cost. The ACIAR LCR system is simple and can be used by extension staff, farm co-operatives and small-scale feed manufacturers and agri-business to formulate high quality rations for farmers based on meeting minimal nutritional values at lowest cost.

Better formulation will enable higher growth rates and higher IOFC to be achieved which has the dual outcome of enabling farmers to increase their income and participate in the value chain but also nationally enable an increase in beef production which will go some way to meeting increasing domestic demand for beef.

9.2 Recommendations

To improve the potential and efficacy of the ration formulators, the following areas of research are required. These areas of research would consolidate findings of ACIAR project LPS/2013/021 as well as previous ACIAR projects and address gaps of critical research. Once these gaps are addressed and tools are further validated, these LCR programs can be rolled out with confidence.

Least cost ration calculator extension

To extend the usability of the ACIAR LCR excel program and Beef-upp app the following is recommended:

1. Extending these feed libraries would make these programs more applicable to other projects and in other countries.
2. Extending the cattle type and requirements to make the app more applicable to other projects and use in other countries.
3. Design a training module for “feed formulating workshops”. A set of educational training material can be prepared. This will include written text as well as power points and a series of exercises. The material will include important nutritional aspects that relate to animal feeding (animal requirements, mineral nutrition, acidosis, antinutritive problems, feed intake) to gain a better understanding of safely feeding animals. The goal is to enable users to optimise the potential formulator use, safely and effectively create rations as well as to engage the private sector in ration formulation.
4. Promotion of formulators

Analysing for ME and CP in feeds

The LCR programs have been extremely useful and have worked well within our project – formulating rations for experiments and for smallholders. They work on the first principle which is to have an ME range high enough to promote a high LWG. This is usually a ME value around 12 MJ ME/kg DM although we have recommended a lower level of 11 MJME/kgDM so as to have more feed ingredients available. However, this does not always work. One reason is that ingredients are usually not analysed for ME content but rely on book values which also vary markedly. This variation in ME content leads to variation in the ME content of the formulated ration and has a large effect on any LCR system. We also found with the project's rice bran analysis that there is very large sample to sample variation in nutrient content (eg CP ranged from 3.5 to 14.9% and ME ranged from 1.5-13.7 MJ ME/kgDM)). To be able to apply the LCR better, it is imperative that we have better ways to estimate ME and CP and not just work from an average book value. A quick compositional analysis reflecting specific feeds would improve the accuracy of any ration formulator. Local feed analysis has proved problematic in all projects due to high costs and analytical resources. For any feeding project, accurate, consistent analyses is vital. Until we know that we can effectively analyse local feeds, at a reasonable cost, can we start to create effective databases.

1. Improving analytical capabilities through capacity building. Ideally a nominated institution will require more appropriate analytical equipment and trained personnel to better analyse for ME (through digestion) and CP. Training could be at UQ.
2. Another potential technique would be using NIR, in particular portable NIR, which has the potential to be very useful in improving the accuracy of inputs and improve collaborator capability. It is proposed that we purchase portable NIR for various collaborators and one for UQ. We are able to form calibrations with various nutritional variables (ME/digestibility, protein, ether extract) in Australia and then input these calibrations for each collaborator portable NIR. This will allow quick and certainly more accurate nutritional inputs for the LCR.

ME requirement conundrum – relating intake and ME response

Animals fed rations with the same ME content may perform differently. This may be because intake of these rations is different. For example animals will consume more of a sorghum grain based ration than a barley grain based ration to give the same LWG. In a similar fashion, an ingredient mix with a similar ME may lead to a low intake, eg when gaplek is > 50 % inclusion. In this situation the Feed for Gain ratio is very high and the IOFC very low. Formulating without some consideration of the intake response and levels of inclusion can lead to disastrous results. Understanding and better defining the response (in intake and liveweight gain) would give better outcomes for the LCR. More work with regard to animal response to ME and CP is required.

Utilising data from past and present ACIAR projects would consolidate information from a number of ACIAR projects, both in Indonesia but also in other countries. The data sheets collectively represent a rich factorial of cattle breed types, basal forages, and supplements with some of them configured in dose response experimental designs. However, the results do not allow easy translation to other feeding scenarios. These existing response curves to various diet combinations need to be translated into more generic response curves of animal growth rate against intake of major nutrient types, in **particular energy (ME) and protein**. If diet composition and intake was converted to energy intake and regressed against animal growth, the performance of animals given other rations could be predicted based on their energy composition and intake. Such a relationship would lead to several outcomes: i) identify any outliers to the general relationship, indicating either that the energy composition of a feed source had been under- or over-predicted or that components of the ration had some unusual properties (e.g., balance of protein/energy) which affected energy utilisation; ii) establish the different response curves for different genotypes, i.e., Bali, Ongoles and crossbreds (e.g., Limousin/Ongole). The latter would

provide information on the differences in feed for gain ratios for the different genotypes providing key information on the cost-efficiencies of feeding each breed. This could influence the choice of animal to feed on an economic basis.

1. Establish and consolidate generic relationships of LWG and nutrient intakes. ACIAR project data from LPS/2013/021 as well as all other cattle livestock ACIAR projects (particularly those with dose response data) could be utilised for this purpose

This area of research would link effectively with the ACIAR LCR formulator. An LCR is designed to select the most cost-effective ration to achieve a certain energy, protein or other nutrient concentration but does not predict intake of the ration or the animal performance derived from it. That would come from the above-mentioned energy-liveweight gain relationship. Once these gaps are addressed and tools are further validated, these LCR programs can be rolled out with confidence. This would include engaging ACIAR programs as well as private companies.

Opportunities in different production systems

The application of the ACIAR LCR system allows novel systems to be devised and evaluated. Many other opportunities are possible. The outputs of the ACIAR LCR need to be tested especially in the combinations of by-products and forages and to identify upper limits of inclusion of specific ingredients unique to Indonesia. The experimental testing of combinations devised by a LCR system is recommended.

In particular, Leucaena alone has become a very profitable system in NTB (Dahlanuddin et al 2014, Panjaitan et al 2014) with average LWG of 0.6-0.65 kg/day achieved by Bali bulls. The use of a limited amount of leucanea can be extended when fed in combination with a high energy source eg cassava or corn (Harper et al. 2019). Corn grain is perhaps best used for poultry and human rations rather than ruminants. A simpler system is for farmers to grow their own cassava with minimal processing such as whole tuber with chipping and sun drying to remove HCN. Panjaitan and Dahlanuddin (pers. comm.) have proposed that cassava could be grown within the rows of leucaena and this would increase the production/ha of the current leucaena only system or with grass grown in the inter-row area. A ration formulated on 87% leucaena and 13% cassava tuber to match production would give a very high-quality product. The IOFC would be similar to 100% leucaena using Ongole bulls as a comparison or lower for Bali bulls (IDR 42,005-42,565 vs 21,161 respectively, The live weight production for Ongole bulls would be 2920-3869 kg LWG /ha.year for leucaena alone (for LWG of 0.8 kg/d or 1.06 kg/d) vs 3708-4913 kg live weight/ha.year for a Leucaena-Cassava system. The equivalent values for Bali bulls would be 2207-2938 kg LWG/ha.year for leucaena alone. The production/ha would be the highest values recorded in the world eg Petty et al (1998) recorded a value of 1570-2110 kg LWG/ha.year for Brahman steers grazing Leucaena and supplemented with corn grain in the Ord River region of NW Western Australia. There is no reason that this model could not be applied to other regions of Indonesia where land is not such a limitation and could use Gliricidia (Marsetyo et al. 2012; Marsetyo et al. 2021), herbaceous legumes such as Clitoria ternatea or Stylosanthes (Mayberry et al. 2021) or any other high yielding annual that could grow at the end of the wet season and be conserved.

In regions where tree legumes or cropping with herbaceous legumes are not possible or not practical due to soil type or land availability (eg Java) then intensive use of crop by-products or feed ingredient processing by-products (eg wheat pollard, soybean hulls) can be devised but formulated better than at present. In Central Sulawesi the use of gliricidia with rice bran (which on farm can be much cheaper than in the market place) offers an opportunity. In Yogyakarta, soybean hulls and gliricidia can be used to improve LWG and IOFC. In East Java, the use of whole cassava tuber chips, cassava tips and cassava peels with palm kernel cake and/or copra meal offers various combinations at low cost especially if some by-products are purchased at times of low cost by entrepreneurial small scale feed manufacturers or co-operatives.

The same principles apply to the breeding herd but the target production indices are different ie weight maintenance, target body condition score (Syahniar et al. 2012). Low cost and lower quality feed ingredients can be directed towards the cow leaving higher quality ingredients for the fattening bulls. Increased turn-off of heavier and younger bulls will require an increased supply of healthy weaned calves for fattening operations.

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Erna Winarti Optimization of local feedstuffs as feed supplements in beef ration in Gunungkidul (PhD- to be awarded)

Jember University

Mohammad Mardiyanto Profil Senyawa Linamarin pada Umbi Singkong dengan Beberapa Teknik Pemasakan (31 Juli 2017) Honours

Elok Bashirah Yuliana Analisis Kandungan Senyawa Linamarin pada Umbi Beberapa Varietas Singkong (Manihot escuenta) (31 Juli 2017) Honours

Defi Maulida Pemanfaatan tanaman singkong sebagai pakan ternak (31 Juli 2021) Honours

Nurlita Sari Teknik Penurunan Kadar Asam Sianida (HCN) Bagian Tanaman Singkong Varietas Cimanggu dan Kaspro Menggunakan Metode Pelayuan dan Pengeringan (23 Januari 2018) Honours

Moh. Afton Nadir Eliminasi Senyawa HCN Berbagai Bagian Tanaman Singkong Menggunakan Fermentasi EM4 (31 Januari 2019). Honours

Mohammad Mardiyanto Formulasi Silase Tanaman Singkong Rendah Kandungan Asam Sianida (HCN); (31 Juli 2019) Masters

Elok Bashirah Yuliana Pengembangan metode analisis hcn tanaman singkong menggunakan smart digital camera (08 Februari 2021) Masters

Hamidah Pemodelan Sistem Dinamis Penyediaan Pakan Ternak Sapi Potong Berbasis Limbah Tanaman Pangan di Pesisir Selatan Kabupaten Lumajang (30 November 2020) Masters

Brawijaya University

Deni Setiadi. Intervention of cassava-based concentrate in the diet of crossbred Limousine raised in lowland areas of Malang regengy: Effects on production and profit Malang –Masters

Surya Retnaningrum. Effects of using varying level of cassava meal in the diet on production and rumen liquid profiles of crossbred Limousine. Masters.

University of Mataram

Luh Ade Kariyani N. Growth response of male Bali cattle fed various combinations of eucaena with cassava chip or cassava waste. Masters.

Julian Hidayat to submit

Tadulako University

I Wayan Sulendre The effect of addition of ground cassava and gliricidia leaves on the change of body dimension and condition score of Bali bulls received elephant grass

Ujang Kurniawan The effect of supplementation of ground cassava and gliricidia leaves on the change of body dimension change Ongole bulls received corn stover

Syahrul (to submit)

The University of Queensland

Bonna Andrew Zulu. The rate of disappearance of Hydrocyanic Acid (HCN) from cassava plant parts under drying or silage processing methods October 2018 Masters.

Oshodi Oluwafemi Adedayo. Making safe silage from cassava. October 2019. Masters.

Shaun Douglas Hudson Investigating the influence of temperature and pH on the release of hydrogen cyanide from cassava tissues. October 2019. Honours.

Patent

Number of Application: P00202103863
Date of submission: 25-May-2021
Title: Pakan konsentrat pellet berbasis daun *Gliricidia sepium* untuk sapi penggemukan dan proses pembuatannya
Inventor: **Gunawan**, Erna Winarti, Soeharsono, Setyorini Widyayanti, Awistaros Angger Sakti, Taufik Kurniawan, Ahmad Sofyan, Hendra Herdian.

11 Appendixes

11.1 Appendix 1:

TECHNICAL NOTE

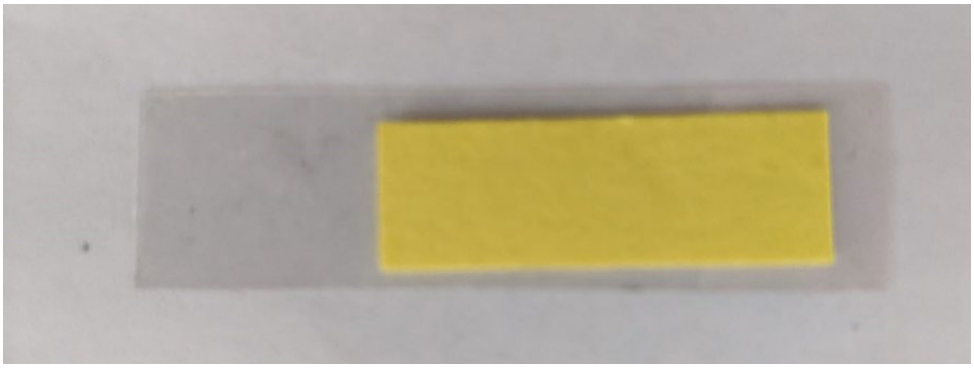
HCN kits from scratch

Preparation of crude linamarase.

- Mature leaves and petioles were broken off from the main branches of the cassava plant.
- Latex on the end of each stalk (petiole) was collected in a small weighed bottle.
- The weight of the latex was determined and an amount of distilled water was added on the basis of about 10 ml water for each 0.1 g of latex.
- The latex plus water was stirred to dissolve the linamarase, allowed to stand for 5 min and filtered through Whatman No 1 filter paper.
- The crude enzyme preparation was stored at -20^{o}C until required.

Preparation of picrate papers.

- A sheet of Whatman 3MM CHR filter paper was dipped in a solution of 0.5% picric acid (w/v) in 2.5% sodium carbonate and then air dried.
- The picric paper was cut into 3cm x 1cm strips and attached to a 5cm x 1cm clear plastic strip using a small amount of PVA glue. These were stored in the dark at -20^{o}C until required.



Preparation of phosphate buffer

2 methods: should be pH 6

(1) Add 750 ml of water to 80 mL of concentrated (about 88%) phosphoric acid. A solution of 10 M sodium hydroxide is prepared by dissolving 100 g of sodium hydroxide pellets in water and making up to 250 mL. The sodium hydroxide solution is added to the phosphoric acid solution slowly with stirring until the pH measured with a pH meter increases up to 6.0.

OR

(2) Prepare two one molar solutions of sodium dihydrogen phosphate and disodium hydrogen phosphate by dissolving the calculated amounts (check the labels on the bottles) of each solid to make 1 M solutions. Carefully add the acidic sodium dihydrogen phosphate solution to the disodium hydrogen phosphate solution until the pH decreases to 6.0

Measurement of HCN in plant material

You will need:

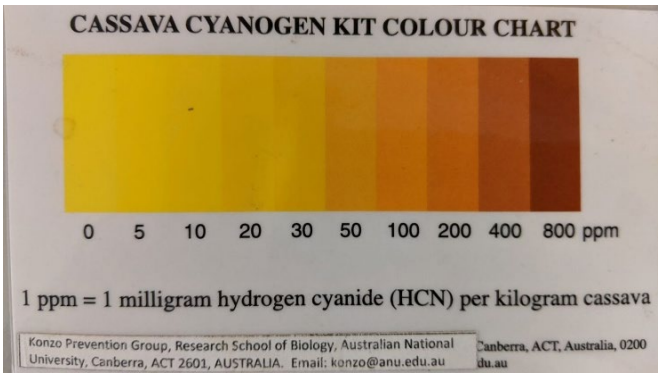
30ml screw time plastic container

Phosphate buffer

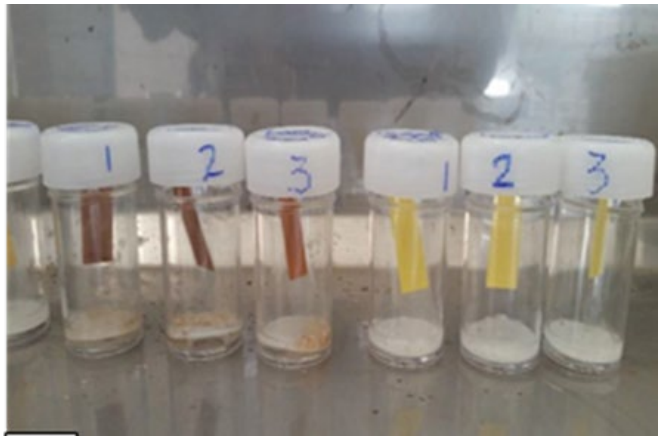
Crude linamarase

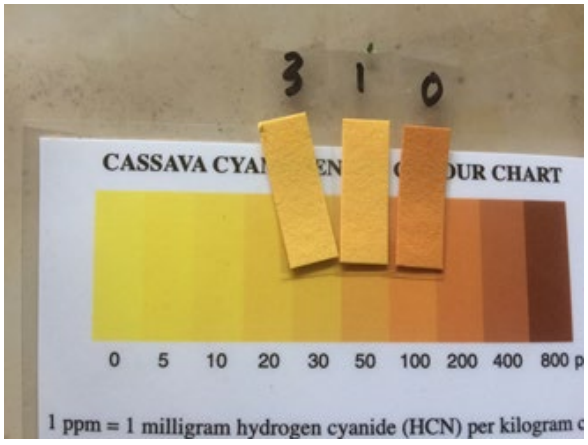
Picric acid strips

Colour chart and/or spectrophotometer



- 100mg of sample is weighed into a 30ml screw top plastic container (best if macerated/ground but needs to be done quickly as HCN is gaseous and is removed very quickly).
- Without delay 1ml of phosphate buffer pH8 is added along with 60µl of the linamarase extract and a picric paper – place the portion of the plastic strip below the picrate paper at the bottom of the container which was then immediately sealed.
- A blank is also run using the method above but without any plant material.
- After 16-24 hrs at room temperature, the strip is removed and its colour compared to a colour chart.
- For a more accurate assessment the picrate paper is removed from the plastic strip and placed into a test tube and 5ml water added.
- After 30 minutes the paper is removed and the colour measured at 510 um against the blank.
- The total cyanide content (ppm) = 396 x absorbance.





11.2

Variability of the nutritive value of rice bran in Indonesia

Around 120 rice bran samples were collected and subsampled for analysis. Rice bran samples were analysed in Indonesia and at the University of Queensland using standard wet chemistry methodology of forages. It can be found in figures 7-11, the nutritional variability of rice bran is very large. This variability is between and within the different areas and it is understandable that it does not have a good reputation. With the crude protein can range from 3.5 to 14%, the ME from 3 to 14 MJ/kgDM.

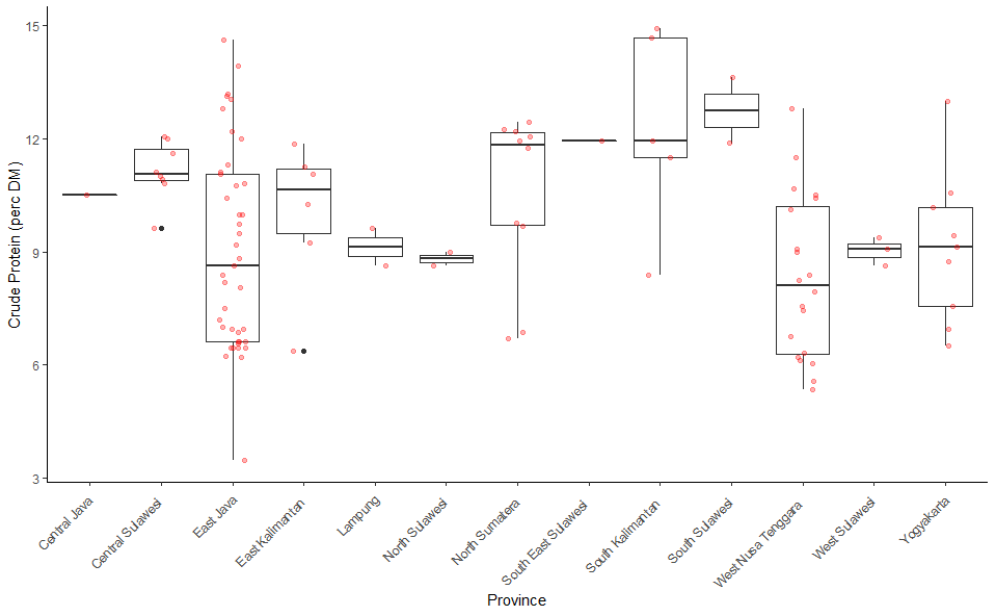


Figure 1 Crude protein contents of rice bran samples collected in regions of Indonesia.

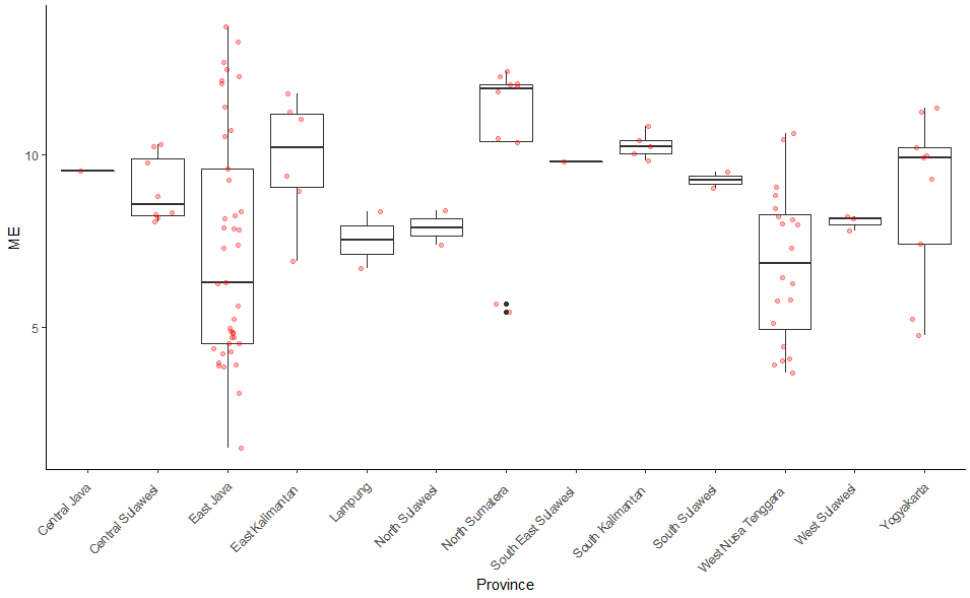


Figure 2 ME contents of rice bran samples collected in regions of Indonesia.

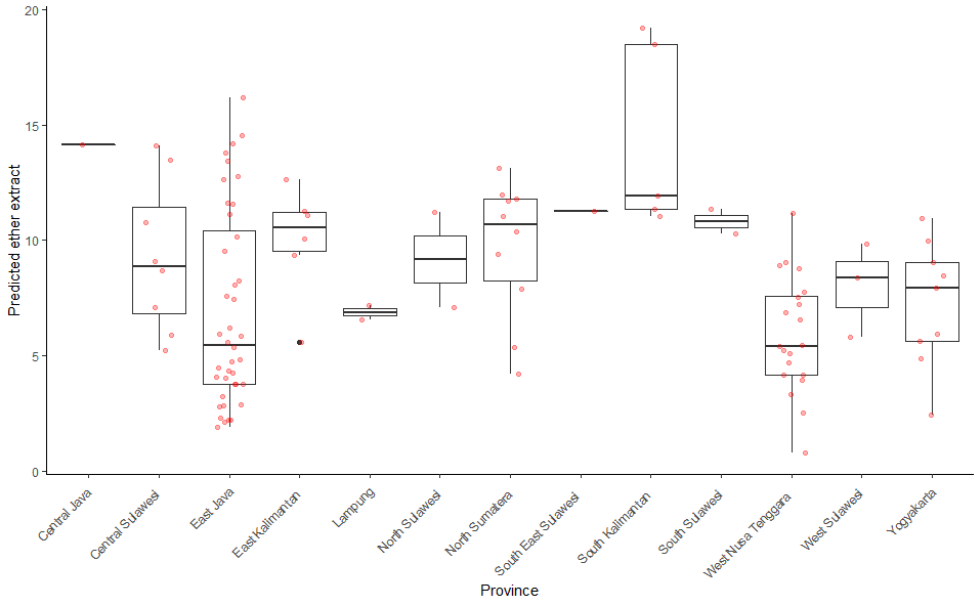


Figure 3. Ether extract content of rice bran samples across various regions of Indonesia

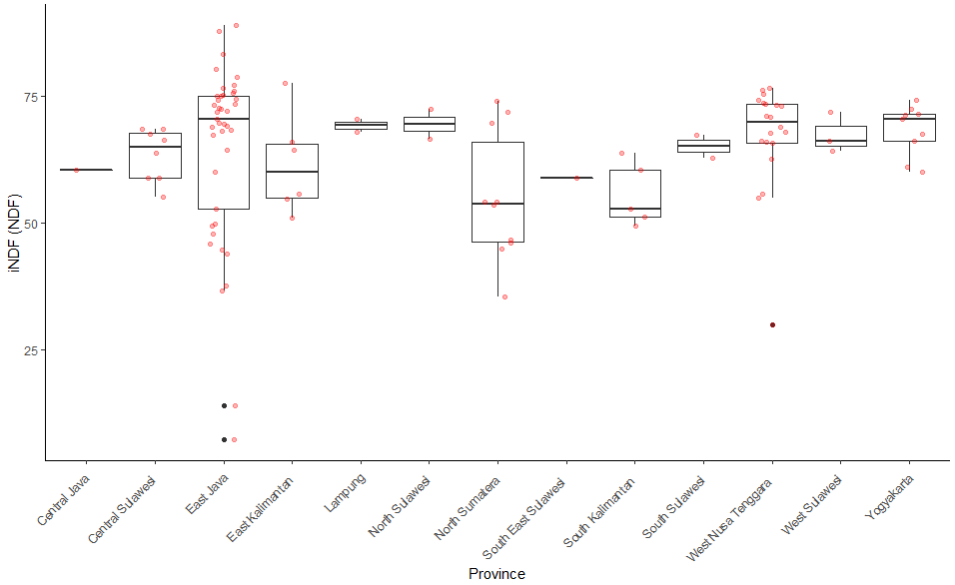
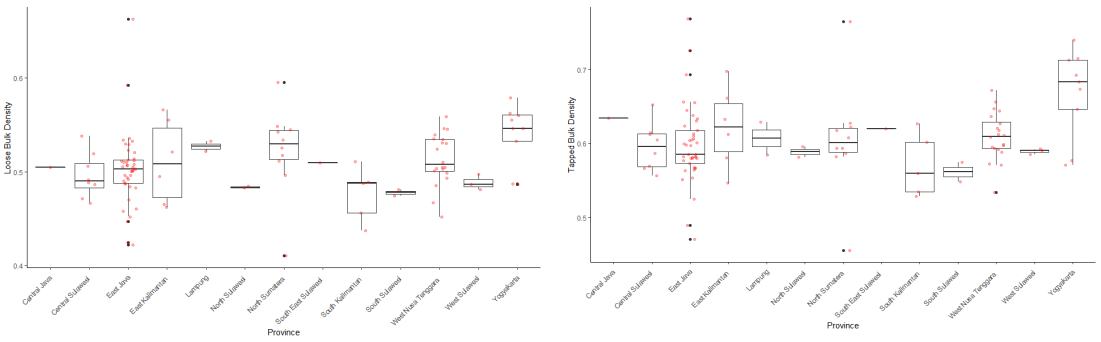


Figure 4. Indigestible neutral detergent fibre (iNDF) content of rice bran samples collected across different regions of Indonesia



a. **b.**

Figure 5. Loose (a) and tapped (b) bulk densities of rice bran samples in different regions of Indonesia.

This variability of nutritional content makes it especially hard to formulate a ration designed for a particular live weight gain. It was hoped that bulk density (either tapped or loose) which indicates quality would correlate to ME or crude protein however this was not apparent in this study (Figure 12).

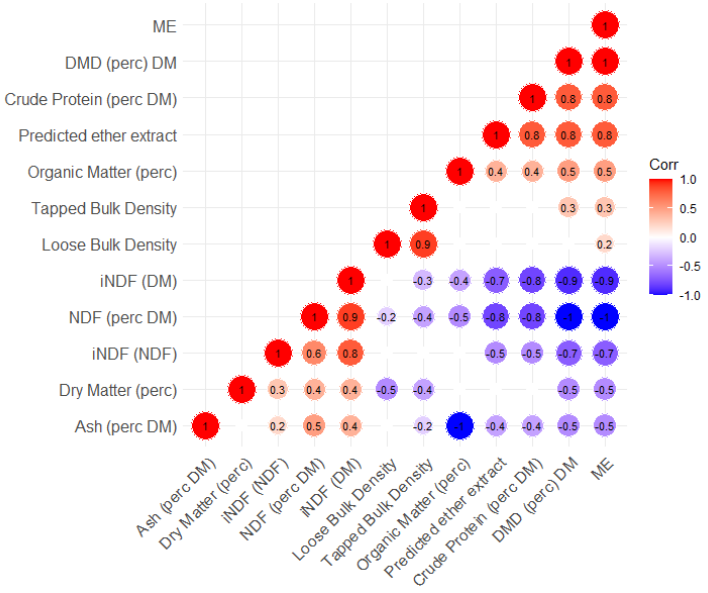


Figure 6. Correlation between nutritional attributes

It is therefore apparent that to utilise rice bran in a ration it either requires wet chemistry analysis – which is not practical, or an alternative system to assess nutritional quality. One method is NIR. At the University of Queensland, sample were put through NIR to determine if nutritional attributes could be estimated with NIR. Importantly both crude protein (figure 13) and DMD (figure 14) (which is used to determine ME) could both be estimated accurately, cheaply and rapidly. For rapid assessment in Indonesia, a portable NIR may be beneficial. These would require testing and creating a different set of calibrations.

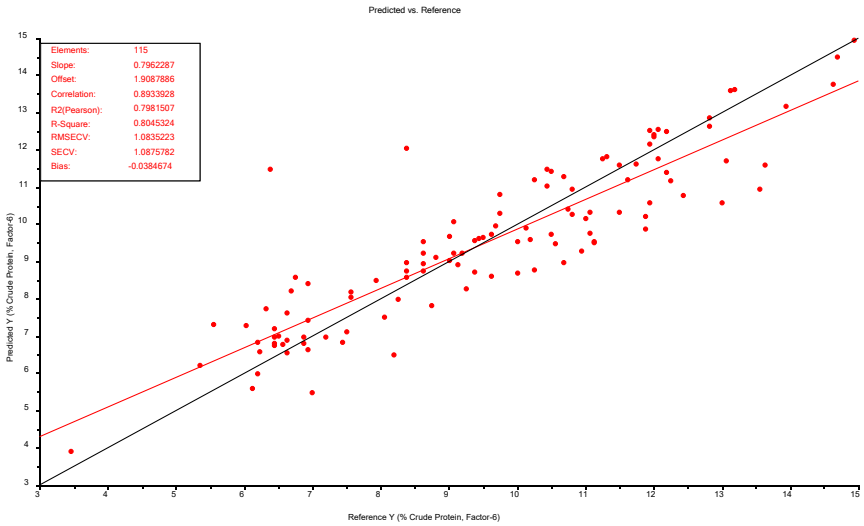


Figure 7. Prediction of crude protein with NIR

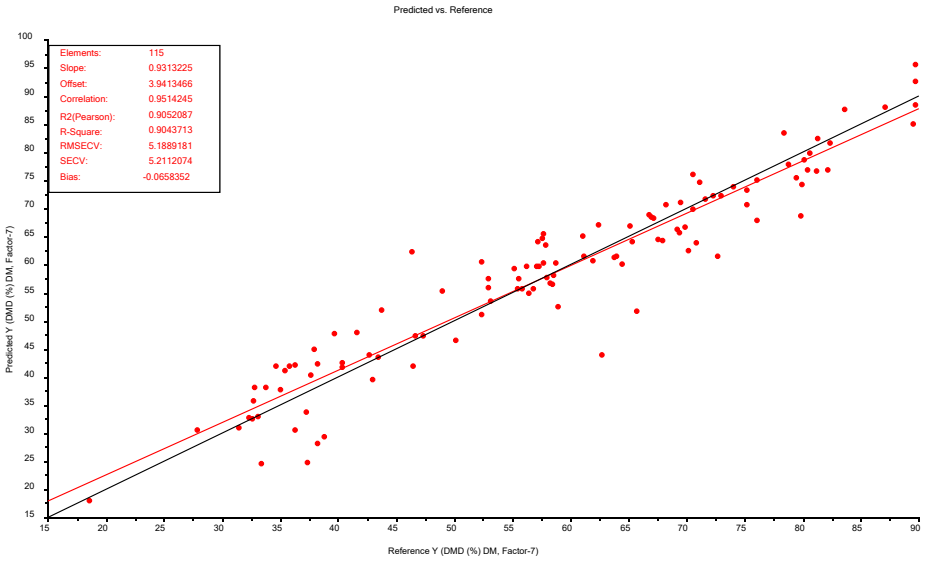


Figure 8. Prediction of DMD with NIR

11.3 Factsheets

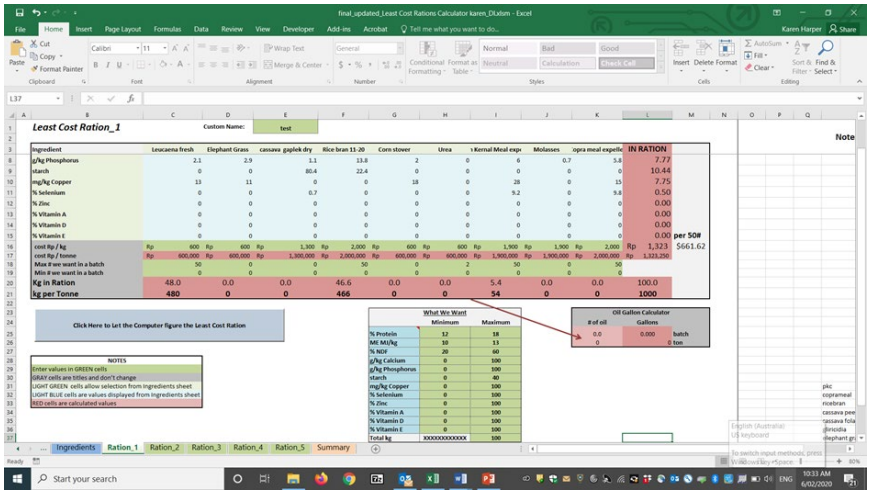
Better formulati ng of local feeds

A major focus for the More-beef project is to identify potential cost-effective feed sources in the various regions which could increase nutrient (energy and protein in particular) intake and thereby growth rates of cattle of different genotypes. In addition to identifying various feed sources and their main nutritional components, this project aimed to develop simple, reliable least-cost ration (LCR) formulators for farmers, farmer advisers, feedlotters, feed processors and extension staff to easily assess and compare available feed additive options in their region on both efficacy and cost.

This project has developed two such formulators. A least cost ration formulator based on an excel solver program (available on request from karen.harper@uq.edu.au) and an android app called “Beef-upp” which is available for free on google play.

Excel – LCR

- The more-beef project has developed an LCR aimed for researchers with a nutritional background. The aim of this formulator is to develop a formulation based on a range of nutrients.
- The LCR is an excel spreadsheet using the solver addin. This LCR has a feed database which can be added to or modified. The excel spreadsheet is linked to the feed database so that a drop bar with the feeds appears for a feed selection and then automatically fills in the nutrient cells. Manually add up-to-date prices of each feed
- Any number of nutrient requirements can be inputted for LCR calculation
- Consideration must be given to results for palateability, overall nutrient and mineral balance.
- All results in given in dry matter and as fed terms.



Step 1. Select feeds

Step 2. Enter feed prices

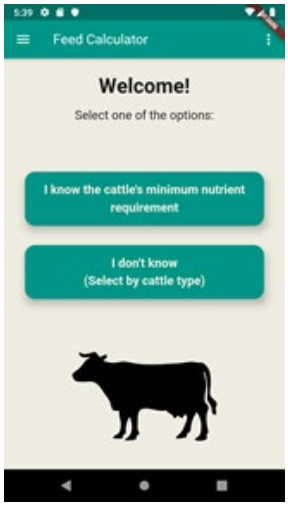
Step 3. Enter nutrient requirements

Step 4. Set feed constraints if desired.

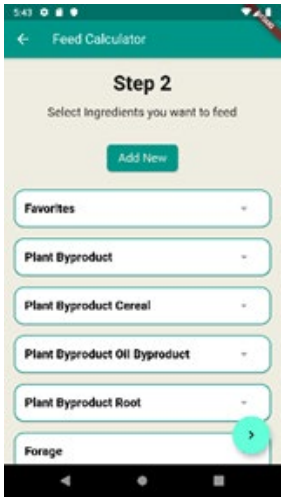
Step 5. Press the calculate button

Beef-upp – an android app for least cost rations – free on google play.

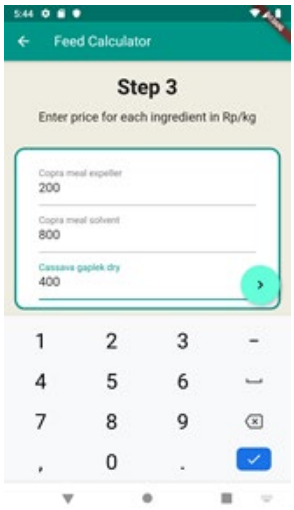
- Beef-upp app was developed by the More-Beef team in collaboration with a postgraduate IT group from the University of Queensland.
- Beef-upp is an android app for least cost ration formulation, freely available on google-play
- The success of this app is based on simplicity. Formulations are based on energy and protein however once a diet is formulated, the final major nutrient composition is provided.
- This app is developed for a range of users, in particular producers, leader groups and small feedlots.
- Beef-upp has a number of nutritional safe-guards to reduce palateability issues and to reduce the chance of a nutritional or mineral imbalance.
- Least cost formulations are presented in both an as fed and a dry matter basis.



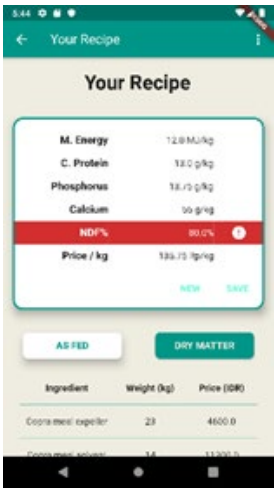
Step 1. Choose your animal/and or nutrient requirements



Step 2. Select available feeds



Step 3. Enter feed prices



Step 4. Press the arrow and cheapest recipe that meets energy and protein requirements, is calculated.

HAY MAKING TECHNIQUES

PREPARED BY:
Prof. Marsetyo, M.Sc.Ag., Ph.D
Moh. Takdir, S.Pt., M.Sc
I Wayan Sulendre, S.Pt., MP.

BACKGROUND

Hay is grass, legumes, or other herbaceous plants that have been cut and dried to be stored for use as animal feed, particularly for large grazing animal raised as livestock, such as cattle, horse, goats, buffalo and sheep. The water content of hay is approximately 15-20%.


Elephant grass


Stylosanthes guianensis


Peanut straw


Clitoria ternatea


Corn stover


Centrosema pubescens


Rice straw


Setaria grass


Native grass

HAY MAKING

- With sunlight about 2 days.
- Using the heater in the room, the time is shorter but the cost is expensive.

PURPOSE OF HAY MAKING

- Utilization of excess forage production in abundant seasons
- Utilization of forage during the shortage season
- For livestock trade
- For intensive farming
- To improve the quality of forage
- To convert agricultural by products into animal feed

Collaboration between Tadulako University and Agricultural Technology Assessment Centre, Central Sulawesi, The University of Queensland and Australian Centre for International Agricultural Research

FACULTY OF ANIMAL HUSBANDRY AND FISHERY

Jl. Soekarno-Hatta Km. 9, Palu Central Sulawesi
Indonesia 94118 | +62 81325642336 | io@untad.ac.id |
http://io.untad.ac.id/

Australian Centre for International Agricultural Research

HAY MAKING TECHNIQUES

HAY STORAGE

- Stored hay must be dry, its water content is less than 15%.
- Hay storage facility must be dry, free from seepage of water, and protected from rain.




GOOD QUALITY HAY

- The color is still greenish
- The shape of the leaf is still clear
- The texture is supple and not easily broken
- The smell is not musty and looks clean




Tadulako University

BPTP Sulteng

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Australian Government
Australian Centre for International Agricultural Research

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Jl. Soekarno-Hatta Km. 9, Palu Central Sulawesi
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http://io.untad.ac.id/

CASSAVA PEEL SILAGE

THE TEAM:
Surya Retnaningrum, Kusmartono, Mashudi, Karen Harper, Dennis Poppi

EMAIL: surya_retnaningrum@yahoo.com

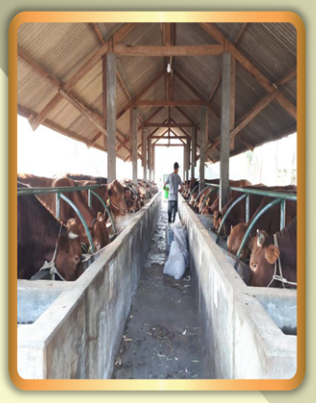
Cassava peel silage (CPS) is a by-product of the processing of cassava tubers to be produced into tapioca flour.

BACKGROUND

One method for processing cassava peel is to make a product that involves fermentation techniques namely by making silage with the aim to reduce the amount of cyanide and maintain stability of cassava peel due to high water content which cause spoilage in a faster time.

Some countries in Southeast Asia especially Indonesia and Thailand, have used cassava peel as animal feed because of its large availability and one way of processing it by making silage.

Cassava peel silage (CPS) is made from a mixture of cassava peel with 5% molasses addition then ensiling for at least 21 days.



The nutrient composition of CPS was dry matter (DM) 71.2%; ash 11.7%; crude protein (CP) 5.8%; ether extract (EE) 1.2%; crude fiber (CF) 10.7%; Ash free Neutral Detergent Fiber (NDF) 25.3%; Ash free Acid Detergent Fiber (ADF) 14.3%; Starch 22.9%; Non Fiber Carbohydrate (NFC) 56% and the cyanide content was 56 ppm.

The Research Funded by: Australian Government, Australian Centre for International Agricultural Research
Organised by:
More Beef Project
LPS/2013/021
Profitable feeding strategies in small-holder cattle farmers in Indonesia
A Research Collaboration between Brawijaya University and The University of Queensland funded by Australian Center for International Agricultural Research (ACIAR) Project

Australian Centre for International Agricultural Research

The University Of Queensland AUSTRALIA

IMPROVING LIVE WEIGHT GAIN (LWG) OF FATTENING CATTLE WITH DIETARY CASSAVA PEEL SILAGE (CPS)

CPS can be used in feed for fattening cattle with the following composition: 20% maize stover, 30% CPS, 25% copra meal and 25% palm kernel cake with the addition of urea and mineral mixtures. Urea was added to the CPS at 2% inclusion and the mineral mixtures was added at 2% of the total mixed ration.

The fattening cattle with 12 weeks fattening period and fed CPS has intake 2.6% live weight (LW) with LWG 1.35 kg/head/day (the cumulative LWG see in Figure 1) and FCR 6.56 while the amount of cyanide is only at 0.5 mg HCN/kgLW/day and this amount was safe dose for the cattle.

Using CPS for fattening cattle also resulted in a low value of feed cost of gain, namely the amount of feed costs used to produce one kilogram of meat only IDR 18,612.

Several steps in the process of making Cassava Peel Silage (CPS):

1. Drying the fresh cassava peel until DM content reaches 70%.
2. Adding molasses 5% from total dry weight of cassava peel.
3. Mixing cassava peel and molasses based on the formulation
4. Filling the mixture of cassava peel and molasses into plastic bag.
5. Compacting the mixture to achieve anaerobic conditions then bound the plastic bag and fermentation lasts for a minimum of 21 days

Cassava peel silage (CPS) is a feed energy sources and has great potential for fattening cattle.

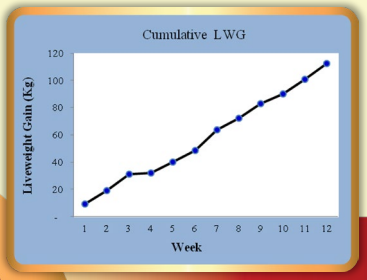


Figure 1. The cumulative LWG graphics of fattening cattle which is fed CPS

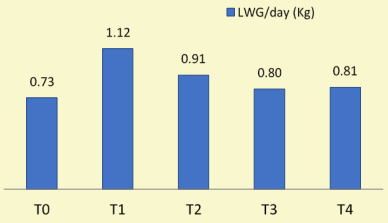
More Beef Project

All supplementation except T0 were offered at 2% from live weight (calculated after every weighing).

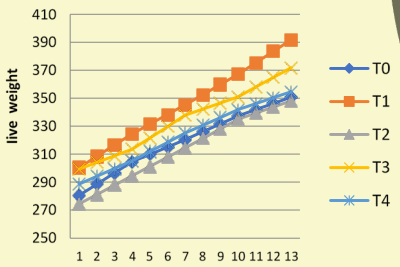
Australian Centre for International Agricultural Research

RESULTS

Live weight gain per day



Live weight per week



RESEARCH OUTPUT

The Mini Feedmill Kucur Mandiri was established!

Mini feedmill "Kucur Mandiri":

- Produced 11.5 tons/month of concentrate
- Per March 2020 they have produce about 200 tons feed
- The market is Kucur farmers and farmers from another village
- They have about 30 farmers registered as shared member and up to 50 farmers became their customers

TRAINING AND FIELD TRIP

To improve farmers' skills and knowledge, trainings and field trips were held for farmers.

RESEARCH OUTPUT

FEED TRIAL ACTIVITIES

TRAINING AND FIELD TRIP

COOPERATED WITH

More Beef Project

LPS/2013/021 | Profitable feeding strategies in smallholder cattle farmers in Indonesia | Kucur, Malang, Indonesia

11.4 Farmer meetings and workshops

Palu

2017	23-Sep	Malonas village, Donggala district	22 farmers	meeting coordination on experiment plan and target
2017	07 Oct	Bolu Pountu village, Sigi District	15 farmers	meeting coordination on experiment plan and target
2017	4 Dec	Malonas village, Donggala district	26 farmer	training on cattle feeding and reproduction management
2018	18-Jan	Malonas village, Donggala district	54 farmer, extension and Dinas Staff	meeting coordination on experiment with Australian team
2018	2-7 Apr	Malonas village, Donggala district	38 famers, extension and Dinas staff	training on cattle feeding, feedlot, reproduction, forage, health management
2018	28-Apr	Tadulako University and Bolu Pountu, Sigi District	70 undergraduate students	training on feedlot and cattle nutrition
2019	11-Apr	Tadulako University and Potoya village, Sigi district	62 undergraduate students	training on feedlot and cattle nutrition
2019	20-Apr	Sibedi village, Sigi district	30 farmers	training on feedlot management and forage conservation
2019	3 May	Malonas village, Donggala district	28 farmers	training on feedlot management and forage conservation
2019	19 July	Malonas village, Dampelas Sub Dictrict, Donggala District, Central Sulawesi	42	Dissemination of research finding to farmers in Malonas village and surroundings
2019	13 Sept	Potoya village, Dolo Sub Distric, Sigi District	27	Dissemination of research finding to farmers in Potoya village and surroundings
2019	4 Oct	Sibedi village, Marawola Sub District, Sigi District, Central Sulawesi	25	Beef cattle fattening strategies using local feed supplements
2019	5 Nov	Tanah Abang village, Toili su Bistrict, Banggai Distric, Central Sulawesi	130	Developing forage bank at village and beef cattle nutrition
2020	17 Jan	Sidondo village, Tanambulava, Sigi District, Central Sulawesi	27	Training on the use of forage conservation for beef cattle
2020	8 Feb	Lambara village, Tawaeli Sub District, Palu District, Central Sulawesi	38	Training on bokhasi making, hay making and developing forage bank at village

Malang

In 2018 the group had 6 group meetings when working in the Arjowilangun Village (details in the 2018 annual report).

For 2018-2019 The **Malang village team** have monthly meetings in the area that they do project work in. these are held on the 21st of each month and involve around 30 farmers at each meeting in Kucur Village, Malang, East Village.

1. Socialization and PRA= 55 farmers
2. Preparation meetings (3) before experiment= approximately 45 farmers
3. Routine meetings (6 so far)= average attendance was 50 farmers
4. Special meeting

- With Prof. Dennis= 25 farmers
- With Head of BPTP East Java= 25 farmers
- With Head of Livestock and Animal Health Agency of Malang District=30 farmers

5. Training and Visitation
   - To Local Feedlot in Balearjosari= 50 farmers
   - To Local Cooperative in Jabung, Malang= 40 farmers
   - Training Feed Technology with Mashudi= 40 farmers
6. Meet and greet during Annual Meeting in Kucur Village. The attendance are farmers from all around Malang (8 hamlets). Approximately 250 farmers gathered in the meeting.

2019-2020

date	where	Reason/theme	Number of participants
3 July 2019	Kucur Village, Malang	Team's visiting during 2nd Annual Meeting in Malang to Kucur Village	250
22 October 2019	Beef Cattle Research Center, Grati, Pasuruan, East Java, Indonesia	Farmers visit Beef cattle research center to improve their knowledge about beef cattle	75
28 November 2019	Kucur Village, Malang	Operational training of a feed mixer mixer	25
13 December 2019	Kucur Village, Malang	Prof. Dennis visits Kucur Village and seeing their new mini feedmill business Introduction to LCR operations (The LCR system)	40
November 2020		Prof Kusmartono Workshop on complementary local feed technology and formulation	15
December 2020	University of Brawijaya	Research collaboration with feed factory-Sinta Prima	Research activity
May 2021	University of Brawijaya	Palm date seed research	Research with 7 farmers

Yogyakarta

2019-2020

Date	Where	Reason/Theme	Number of participants
6 July 2019	Banaran village, Playen sub-district, Gunungkidul	Coordination with farmers group regarding number of cows and farmers for the next experiment.	5
13 July 2019	Bleberan village, Playen sub-district, Gunungkidul	Coordination with farmers group regarding number of cows and farmers for the next experiment.	5
27-28 July 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Discussion with farmers group regarding local feed availability for the next experiment.	5

3 August 2019	Bleberan village, Playen sub-district, Gunungkidul	Form a team work for weighing of bulls and measuring of body size	5
10 August 2019	Banaran village, Playen sub-district, Gunungkidul	Training of weighing of bulls and measuring of body scale	5
24 - 25 August 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Training of making the Gliricidia leaves meal for feed	5
31 August 2019	Bleberan village, Playen sub-district, Gunungkidul	Training of making mineral block feed for bulls	5
6 - 7 Sept 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Explanation of the feed management of bulls in farmers	5
14 - 15 Sept 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Collecting of cassava feed ingredients for research purposes	5
17 Sept 2019	Banaran village, Playen sub-district, Gunungkidul	Explanation of the collection of Gliricidia leaves	60
19 Sept 2019	LIPI office, Gunungsempu, Bantul	Comparative study of making pellet feed	10
21 - 22 Sept 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Coordination with farmers in carrying out the characteristics of Gliricidia plants	5
28 – 29 Sept 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Gliricidia leaf collection by farmer groups	60
14 – 15 Oct 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Coordination with farmers about plans to use pellet feed in cattle	5
17 - 18 Oct 2019	Banaran village, Playen sub-district, Gunungkidul	Meeting with farmers to discuss the use of pellet feed in cattle	8
26 Oct 2019	Banaran village, Playen sub-district, Gunungkidul	Preparation of feed ingredients for pellet feed production for farmers	5
5 - 6 Nov 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Dropping of research facilities and feed ingredients in farmers	10
14 - 15 Nov 2019	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Coordination with farmers to prepare pellet feed	5
6 - 8 Dec 2019	Banaran village, Playen sub-district, Gunungkidul	Field observation of pellet feed storage in farmers	5
23 Dec 2019	Banaran village, Playen sub-district, Gunungkidul	Field observation of pellet feed storage in farmers	5
7 January 2020	Banaran village, Playen sub-district, Gunungkidul	Field observation of feed ingredients for pellet feed production	5
8 January 2020	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Famers meeting with scientist of BPTBA LIPI (Indonesia institute of science)	8
24 January 2020	Banaran village, Playen sub-district, Gunungkidul	Preparation for the implementation of the 3rd experiment	10

27-28 January 2020	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Monitoring and evaluation in field from Foreign Cooperation Bureau of the Ministry of Agriculture	8
3 February 2020	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Preparation for documentary film shooting of ACIAR activity with farmers participants	4
5 -7 February 2020	Banaran and Bleberan villages, Playen sub-district, Gunungkidul	Documentary film shooting of ACIAR activity with farmers participants	10
27 February 2020	Banaran village, Playen sub-district, Gunungkidul	Socialization of the 3rd experiment to farmers group	65
29 February 2020	Banaran, Bleberan and Dengok villages, Playen sub-district, Gunungkidul	Data collection of bulls Weight	60
3 March 2020	Banaran, Bleberan and Dengok villages, Playen sub-district, Gunungkidul	Set bulls in the treatment	60
6-8 March 2020	Banaran village, Playen sub-district, Gunungkidul	Preparation of the 3rd experiment: injection of vitamins and anthelmintic in bulls and feed supply	60
10 March 2020	Banaran village, Playen sub-district, Gunungkidul	Distribution of mineral block for bulls in farmers	60
12 March 2020	Banaran village, Playen sub-district, Gunungkidul	Monitoring and evaluation of feed adaptation of bulls in farmers	60
4-5 April 2020	Banaran, Bleberan and Dengok villages, Playen sub-district, Gunungkidul	Data collection of bulls Weight and body measurement	60
22-23 April 2020	Banaran, Bleberan and Dengok villages, Playen sub-district, Gunungkidul	Data collection of bulls Weight	60
16 – 17 May 2020	Banaran, Bleberan and Dengok villages, Playen sub-district, Gunungkidul	Data collection of bulls Weight	60
4-6 June 2020	Banaran, Playen, Gunungkidul	Discussion with farmers about blood sampling collection for analysis of blood glucose content	5
7-8 June 2020	Banaran, Bleberan and Dengok villages, Playen sub-district, Gunungkidul	Data collection of bulls Weight and body measurement	60
12-13 June 2020	Bleberan, Playen Gunungkidul	Preparation of blood sampling collection for analysis of blood glucose content	5
17 June 2020	Bleberan, Playen Gunungkidul	Blood sampling collection for analysis of blood glucose content.	8

26 June 2020	Bleberan, Playen Gunungkidul	Preparation of feed in farmers for Gas test on bulls	5
	Ciawi, Bogor, West Java	Launching of film documenter ACIAR Project BPTP Yogyakarta via zoom meeting	70
1 July 2020	Banaran, Playen, Gunungkidul	Blood sampling collection for analysis of blood glucose content.	8
2-3 July 2020	Banaran, Playen, Gunungkidul	Evaluation of bulls condition after blood sampling collection	5
7 July 2020	LIPI office, Gading, Playen, Gunungkidul, DIY	Research Team Meeting (BPTP & LIPI) about Pellet Feed	7
7 August 2020	Farmer Cooperative (Manunggal Amargo Andhini) Banaran village, Playen sub-district, Gunungkidul, DIY	Monitoring to the next user of trial results of ACIAR Project in Yogyakarta	6
9 September 2020	BPTP Yogyakarta, Karangsari, Wedomartani, Ngemplak, Sleman, DIY	Technical guidance (virtual) about processing of mineral blocks and *Gliricidia sepium* leaf flour	97
23 September 2020	Farmer Cooperative (Manunggal Amargo Andhini) Banaran village, Playen sub-district, Gunungkidul, DIY	Evaluation Meeting of feed development by farmer cooperative	8
29 September 2020	Karangmojo village, Karngmojo sub-district, Gunungkidul, DIY	Technical guidance about Processing of mineral blocks by Head of farmer Cooperative	30
2 October 2020	Animal Science Faculty of Gadjah Mada University, Karangmalang, Yogyakarta	Seminar of Research Proposal (S3) of Erna Winarti (Doctoral Program) from ACIAR activity	11
9 October 2020	Banaran village, Playen sub-district, Gunungkidul, DIY	Farmers Meeting (evaluation of live weigh gain of bulls) of the 3rd experiment	27
16 October 2020	Bleberan village, Playen sub-district, Gunungkidul, DIY	Farmers Meeting (evaluation of live weigh gain of bulls) of the 3rd experiment	25
27 October 2020	LIPI office, Gading, Playen, Gunungkidul, DIY	Research Team Meeting (BPTP & LIPI) about publication and Patent registration	7
13 November 2020	Farmer Cooperative (Manunggal Amargo Andhini) Banaran village, Playen sub-district, Gunungkidul, DIY	Evaluation Meeting of feed development by farmer cooperative	8
21 December 2020	BPTP Yogyakarta, Karangsari, Wedomartani, Ngemplak, Sleman, DIY	Seminar of Research Results of ACIAR activity in BPTP Yogyakarta (2020)	38

Workshops for Farmers (Cuk Tri Noviandi – University of Gadjah Mada

1. Online workshop: “Pelatihan Formulasi Ransum Ruminansia dengan Metode Least Cost Ration (Feed formulation for ruminants using LCR)”, 24 February 2021. 25 participants.
2. Online workshop: “Bagimu Petani kami Mengabdi”, title of presentation: “Sistem Peternakan Terpadu (Integrated Farm System)” 2 April 2021. About 250 participants.
3. Online workshop: “Bagimu Petani kami Mengabdi”, title of presentation: “Pakan Ternak Berkualitas (High Quality Ration)” 25 May 2021. About 250 participants.
4. On farm training on “Feed formulation using local feedstuffs” for farmers. 16 Juni 2021. About 20 participants.
5. Online workshop: “Optimalisasi Teknologi Pakan dalam Peningkatan Kualitas Pakan Lokal (Optimizing Feed Technology in Improving Local Feedstuffs Quality)”. Title of presentation: “Formulasi Ransum Berbasis Pakan Lokal Dengan Aplikasi LCR Calculator (Feed formulation based on local feedstuffs using LCR calculator)”. 18 September 2021. 434 participants.