MANUAL FOR DEVELOPING FEED RESOURCES AND IMPROVING NUTRITION OF BEGAYIT CATTLE

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Foreword

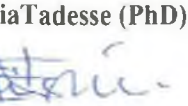
Agriculture continues to be among the key development agenda of the government of Ethiopia. In the present GTPII period, one of the four strategic issues set to achieve the higher level objectives of the agricultural development sector is increasing livestock production and productivity. To this effect, the Ethiopia's agriculture sector policy and investment framework (PIF) document clearly shows that the milestone idicators for growth in livestock production and productivity are set at 8% and 4%, respectively.

Ethiopia claims to have 57 million heads of cattle herds while its annual beef carcass weight equivalent production has not exceeded 385.9 thousand metric ton. In contrast, Australia keeps almost half of the Ethiopia's population (28.8 million heads of cattle herds) and is able to produce 2.3 million metric ton of carcass annually. These facts vividly show that there is a long way to go to modernize livestock production in Ethiopia and enhance its productivity to become competitive in domestic and export markets. Such a process requires to rely on sustainable supply and use of improved livestock technologies. Therefore, there is a need to intensify the existing livestock technology generation process by integrating the conventional and the new bioscience research approaches.

Recently, a roadmap document was prepared by the Policy Study and Research Center of Ethiopia to guide the country's move towards modernization of meat animal development and research. Following the roadmap, an implementation plan was prepared for improving Begayit cattle breed of Tigrai Region in particular. Series of consultative meetings were conducted with the facilitation of the Ethiopian Agricultural Research Council Secretariat and in the process the regional state of Tigrai has shown its keen interest to support the initiative for its implementation. To this effect, a memorandum of understanding was signed between Tigrai Agricultural Research Institute (TARI), Ethiopian Institute of Agricultural Research (EIAR) and Ethiopian Agricultural Research Council Secretariat (EARCS) to jointly work for the implementation of the initiative.

It is felt necessary to follow an integrated multidisciplinary approach for enhancing improvement of Begayit cattle breed by establishing nucleus herd at Maiweyni Ranch in Humera area. To guide the implementation of Begayit cattle breed improvement program, there is a need to prepare technical manual in each discipline (animal breeding and genetics, animal reproductive biotechnology, animal feeds and nutrition and animal health) that helps the undertakings to follow standard scientific principles and procedures. Hence, this manual is prepared for developing feed resource and improving its utilization at Maiweyni ranch based on the nutrient requirements of the nucleus herd of Begayit cattle breed.

MekuriaTadesse (PhD)



Chief Coordinator of EARCS

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1 Introduction

As part of the overall economic and social transformation to be achieved by 2025, the government of Ethiopia has identified modernization of meat animal production system as one of the key interventionsand hence supported the making of a roadmap to provide policy guidance towards this goal. The key element in the policy guidance is the recognition of available resources for meat production (indigenous breeds, feed/water, agro-industries and their byproducts etc.) and government commitment to put enabling environments (human capacity, physical capacity, technology and institutional innovations) in place to ensure competence in the global meat market. Begayit breed is among the potential indigenous cattle breeds with a far reaching implication in realizing export led economic growth. It is a large framed and fast growing indigenous breed presumably demanding better nutritional management to express its full genetic potential. Among various indigenous breeds, Begayit has relatively received little attention in the Ethiopian research for development arena and much remains to be done to make best use of this breed.

Among factors of production, the road map for modernization of meat animal production system recognizes the central role of ensuring availability of quality feed (feed security) and proper plane of nutrition.Against this plan, low quality grazing pastures and crop residuesare used as basal diet of Begayit cattle and these feed resources are inherently of low nutritional quality (chemical composition, intake and digestibility). Specially during long dry season, animals exclusively kept on these feed resources are unable to support their maintenance requirement and forced to lose body weight. Thus,marked seasonality in nutritional quality of the basal diet and absence of adequate supplementation largely dictates the overall productivity (production and reproduction efficiency) of grazing herbivores such as Bagait. Achieving year round production at desired production efficiency of Begayitbreed is thus an issue of feed security (availing adequate feeds of the desired quality for all animals throughout the year) and ensuring proper feeding.Not surprisingly, the elite herd of Begayit demands quality feed and optimal nutrition to express its full genetic potential. The key nutritional intervention in this regard is thus enhancing feed resource development and ensuring proper nutritional management of various classes of animals as per their physiological requirements.

The overall purpose of this manual is to providescientific guidance for developing feed resources and improvingnutritional management of Begayit cattle to express its full genetic potential.The specific objectives include provision of guidance for carrying out appropriate implementationof:

- feed resource development plan for Begayit cattle at Humera ranch
- improved forage, natural pasture and supplementary feeds development and their utilization for Begayit cattle
- ration formulationand nutritional management for various categories of Begayit cattle that include growing calves, heifers, bulls, pregnant/ lactating cows and feedlot animals
- monitoring feed development, utilization and performance of major categories of Begayit cattle.

In terms of scope, this manual is targeted for provision of guidance for technical personnel (with first degree and above) engaged in feed resources development and ruminant nutrition particularly in beef cattle.

KEY MESSAGE OF CHAPTER ONE

- This chapter underpins the policy background of the Ethiopian meat sub-sector at a macro level and unique features of Bagait breed.
- Marked seasonality in nutritional quality of the basal diet and absence of adequate supplementation is expectedto dictate overall productivity (production and reproduction efficiency) of grazing herbivore such as Bagait.
- Achievement of year round production and desired production efficiency of Begait breed is a function of feed security (availing enough feed of the desired quality for all animals throughout the year) and ensuring proper feeding.
- It is be noted that the elite herd of Begait demands quality feed and optimal nutrition to express its genetic potential. The key nutritional intervention in this regard is thus feed resource development and ensuring proper nutritional management of various classes of animals as per their physiological requirements.
- This manual is therefore prepared to provide scientific guidance for feed resources development and nutritional management of Begait cattle to express its full genetic potential.
- In terms of scope, the manual is targeted for provision of guidance for technical personnel (with first degree and above) engaged in feed resources development and ruminant nutrition particularly beef cattle.

2 Feed Development Plan and Feed Management

2.1 Feed development plan

Ensuring feed security of elite herd of Begayit cattle at Humera ranch basically demands feed resource development plan depending on herd structure/size and the land available for feed development. The available land and current utilization of Humera ranch at Maiweyni is indicated in Table 1 below.

Table 1.Land use pattern of Humera ranch

No	Mode of use	Size (ha)
1	Irrigable land for cultivated forage production*	33
2	Land for rain fed annual forage production (currently in use)	91
3	Land for rain fed annual forage production (currently not in use)	40
3	Range/pasture (land size for grazing)	180
4	Land for hay production	128
5	Waste Land (land not suitable for livestock production/grazing)	1444
6	Land used for office, barn and residence	21
	Total	**1937**

* *Potential land for irrigation and irrigation facilities and structure to be fixed*

Ensuring yearoundoptimal nutrition of different categories of Begayit herd in turn requires availability of basal feed and supplement in relation to the number of animals. Assuming the herd structure/sizeand annual feed requirement as indicated in Table 2, an average of 5264 ton DM basal feed and 3023 ton DM supplemental feed have to be secured to support optimal nutrition. When the herd size reaches the maximum number (year four) additional land close to 750 ha has to be leased for rain fed forage production and about 4700 ton DM supplemental feed should be procured to support annual feed requirement of the herd.

Table 2.Herd Structure and annual feed requirements of Begayit cattle at Humera ranch

Year	Animal	Number of Animal	Feed requirement per animal per year (ton DM)		Total feed requirement /year (ton)	
			Basal feed	Supplement	Basal feed	Supplement
One	Heifer	425	1.53	0.66	650	281
	Calves	166	2.96	1.97	491	327
	Total	**591**			**1283**	**608**
Two	Heifer	898	1.53	0.66	1374	593
	Bull	148	2.96	1.97	438	292
	Cows	786	2.55	1.10	2004	865
	Calves	307	0.37	0.37	114	114
	Total	**2139**			**3930**	**1576**
Three	Heifer	915	1.53	0.66	1400	604

Year	Animal	Number of Animal	Feed requirement per animal per year (ton DM)		Total feed requirement /year (ton)	
			Basal feed	Supplement	Basal feed	Supplement
	Bull	275	2.96	1.97	814	542
	Cows	1093	2.55	1.10	2787	1202
	Calves	427	0.37	0.37	158	158
	Total	**2710**			**5159**	**2506**
Four	Heifer	637	1.53	0.66	975	420
	Bull	383	2.96	1.97	1134	760
	Cows	1478	2.55	1.10	3769	1626
	Calves	578	0.37	0.37	214	214
	Total	**3076**			**6092**	**3020**

The indicated annual feed requirements (Table 2) can be met through theintended production of basal feed (irrigated forage, rain fed annual forage, grazing pasture/hay) using available land in the ranch or additional land from outside the ranch and purchase of supplementary feed. Based on the land use pattern indicated inTable 1, it is possible to produce basal feed/roughage biomass of about 2.9 thousand metric ton DM from irrigated forage production, rainfed annual forage production, grazing pasture and hay production as detailed out in Table 3.

Table 3.Estimates of basal feed/ roughage/ production at Humera ranch

No	Category	Area (ha)	Productivity/ha/year (ton DM)	Estimated annual production (ton DM)
1	Irrigated forage	33	30	990
2	Rainfed annual forage	117	10	1170
3	Grazing pasture and hay production	308	2.5	770
	Total	**458**		**2930**

The feed development plan should take into account the possibility of producing additional basal feed outside the ranch (Table 4)inorder to meet the growing nutrient demands as a result of the herd projection and the limited expansion potential of the ranch. Assuming that the average estimate for annual forage crop yield is to be 10 ton DM/ha/year under rain fed condition, the additional landsrequired for forage production are 100, 223 and 316 ha in years 2, 3 and 4 ,respectively, to bridge the gap of basal feed requirement. Likewise,the supply requirements of annual supplemental feeds are estimated at 608, 1576, 2506 and 3020 ton in years 1, 2, 3, and 4, respectively.

Table 4.Annual basal feed development planfrom the available land of Maiweyni ranch and supplemental feed required per year

No	Category	Year1	Year 2	Year 3	Year 4
1	Land for irrigated forage (ha)	33	33	33	33
2	Land for rainfed annual forage* (ha)	117	117	117	117
3	Land for grazing pasture and hay (ha)	308	308	308	308
4	Additional land to be leased for rain fed annual forage (ha)	0	100	223	316
5	Total area for basal feed production (ha)	444	544	667	760
6	Additional basal feed required (ton DM)	0	1000	2229	3162
7	Supplemental feed needed per year (DM ton)	608	1576	2506	3020

** Excludinga total of 14 ha of land which is allocated for forage seed production*

2.2 Feed management

Proper feed management is critical for maintaining the desired feed safety and quality. Precautions are therefore required during feed procurement, production, storage and utilization. During procurement, feed ingredients for compound feed/concentrate preparation should be checked for their purity (absence of admixture/adulterant), moisture, chemical composition and nutritive quality. Ingredients with high moisture level are liable to fungus formation and spoilage in the process of storage leading to health hazards in animalsor humans. Feeds targeted for hay production should also be properly cured and stored. Towards maintaining the desired feed safety/quality proper storage of feed is an integral component of feed management. It is worthwhileto givedue attention to the following points in terms of maintaining proper feed storage:-

- stored feed must be kept dry and protected from animals, moisture and fire
- cover hay stacks with thatching or other materials
- store feed in a well ventilated area to avoid mould development and excessive heating
- feeds especially ingredients or concentrates should be stored on pellets to avoid direct contact with floor which could cause spoilage
- since mixed feeds are usually liable to spoilage, mixing should be done in quantities that can be sufficient for a week or one month at most
- baled fodder is easier for handling, storage and utilization. It is therefore advisable to bale roughages using simple balers

Proper record of feed production, procurement and utilization should be kept by category of feed and animalto serve as data base for monitoring feed production, feed utilization, economics of feeding. All inputs of production (land preparation, seed, weeding, harvesting, baling and others) for on-farm production and procurement of supplemental feeds (price of each ingredient or compound feed and cost of transport) should be kept recorded. Daily records of roughage (hay) and supplemental feeds by category of animals should also be kept.

KEY MESSAGE OF CHAPTER TWO

- This chapter is meant to describe feed resource development plan of Humera ranch based on the nutrient requirement of the projected herd and the land available for feed development.
- A total of 472 ha land is estimated to be available for feed resource development at Humera ranch (33 ha for irrigated forage, 131 ha for annual forage and 308 grazing pasture or hay).
- Beginning with 425 heifers and 166 calves in year 1, the maximum herd size in year 4 is expected to reach at 1478cows, 637 heifers , 578 calves and 383 bulls.
- Based on nutrient requirement of the projected herd, additional land of 86, 209 and 302ha of land is respectively required in year 2, 3 and 4 to bridge the gap of basal feed requirement.
- The respective supplemental feed needed per year (DM ton) in year 1, 2, 3, and 4 is projected to be 608, 1576, 2506 and 3020ton DM.
- Proper management at various stages of feed procurement, production, storage and utilization should also be ensured for maintaining the desired feed safety and quality.

3 Feed Development and Mode of Utilization

3.1 Cultivated forages for herbage production

Most of the cultivated forages require specific biophysical characteristics (altitude, soil and rainfalletc) and care is required in making the right choice for a particular environment. For Humera area, deliberate decision was made to use the following cultivated forages which are known to do very well under similar environment to Humera or have been tested and verified under Humera environment itself.The main forage crop types that serve the purpose include Elephant grass, Rhodes grass and Alfalfa with the seed supply to come fromWerer Research Center. Peagon pea and Cow pea are the other alternative forage crops known for their adaptation to the environment and Humera Research Center can serve as supplier of their seeds.

Elephant grass

Elephant grass or Napier grass (*Penisetumpurpureum*) isa deep rooted perennial grass adaptable up to 2400 masl. Based on soil fertility and agro-ecology its height usually ranges from 2-6 meter with its leaves having 20-40 CM diameter and 1 meter lengh.Napier grass establishment requires fine seed bed preparation of 3 times ploughing. Planting material of the grass can be either root splits or stem cuttings.When stem cuttings are used, it is mandatory that 3 stems are used i.e 2 stems planted in a hole of 25 CM depth, tilted 45 degree and covered with soil to ensure good establishment. It is usually recommended to use spacing of 1 M between rows and 50-100 CM between planting material.

It is recommended to follow appropriate cultural practices (weed, fertilizer/nutrient and disease/pest management) to have good establishment, stand and productivity. In terms of weed management, it is usually recommended to protect cultivated forages from broad leaf weeds. Hand weeding or selective herbicides can be used to control broad leaf weeds.

Soil or fertility management is also an essential agronomic practice in cultivated forage production. Forage crops of fast growing like Napier grass can lead to fertility depletion and use of inorganic fertilizer or manure is recommendable to maintain soil fertility. Taking into account the high cost of chemical fertilizer, it is usually recommended to use 100 kg of Di-ammonium Phosphate (DAP) and 50 kg urea per hectare during establishment. On a fertile soil like the virgin land of Humera ranch at Maiweyni, use of chemical fertilizer during the first establishment is not necessary. After establishment, fertilizer application once or twice a year is important. For Napier grass, it is recommended to use 8 ton /ha of manure or 100 kg/ha urea to support the desired level of productivity.

The preferred mode of utilization of Napier grass iscut and carry system. It is not recommended to cut and use elephant grass during the first year of establishment. In the second year of establishment and on wards it can be harvested after reaching minimum of 0.5-1.0 meter height leaving 5-10 cm stubble on the ground. Then after, Napier grass can be harvested every 6 weeks keeping the time with the right height. It is not recommended to cut this grass if the irrigation practice fails.

Image 1.Elephant grass (*PenisetumPurpureum*) at establishment stage

Rhodes grass (*Chlorisguayana*)

Rhodes grass is among the popular grassesthat can be produced very welluder irrigation condition. It is a stoloniferous grass that can grow to a height of1.5 cm. It has wider adaptation from 600- 2400 masl, 20-40 degree centigrade of ambient temperature and 650-1200 mm average rainfall.Kalaid and Massaba are the most popular cultivars of Rhodes grass widely adaptable to various agro ecologies under irrigation. For successful establishment Rhodes grass requires fine seed bed preparation. Depending on seed purity appropriate seed rate varies from 5-10 kg per hectare using spacing of 25 cm between rows. It is recommended to cover the seed with soil very thinly for successful establishment. Fertilizer application of 100 Kg/ha Nitrogen or manure application at harvesting time is recommended. Rhodes can be produced in companion with desmodium or alfalfa.Under irrigation, Rhodes grass can be planted any time of the year while under rain fed condition the best time for planting is soon after the rain starts. Weed control using hand weeding or tools is advised during early phases of establishment and in an environment dominated by weeds.

In an environment where availability of arable land is limited, Rhodes grass can be established using irrigation and used either as cut and carry system or in a form of hay. In an environment where land is available, Rhodes grass can be established in a large plot and used in a form of hay. An average productivity of Rhodes grass is 5-8 ton DM/ha and under good management it goes up to 25 ton DM per hectare. It is among perennial grasses that farmers can easily produce seed. Its seed yield is usually in the range of 65-650 kg/ha. if irrigation is used, Rhodes grass seed can be harvested 2-3 times a year on average.

Image 2. Rhodes grass (*ChlorisguayanaMassaba*)as seen while heading

Alfalfa (*Medigaco sativa*)

Alfalfa is among herbaceous legumes with wide environmental adaptation ranging from1000-2500 masl. It is widely cultivated using irrigation. It requires light and well drained fertile soil with fine seed bed preparation for successful establishment and good stand. Broad casting or row planting can be used to establish alfalfa. In row planting depth of 10-15 mm is recommended. Alfalfa can be planted any time using irrigation while under rainfed condition planting during early phase of the rainy season is advisable. Recommended seed rate for alfalfa is usually 10 kg/ha but in environment where leaf diseases are expected 17-34 kg/ha can be used. Under environment similar to Maiweyni, seed rate of 12 kg per ha has been noted to be successful.

Alfalfa can be harvested when at least 30% of the plant flowers or the latest when the plant starts pod setting. Average productivity of alfalfa under irrigation is in the range of 7-17 ton DM/ha.Alfalfa is usually used as supplementary feed for lactating cows or calves in a form of cut and carry or harvested and used as hay. Under supplementary irrigation alfalfa can be harvested every 1-2 monthsand used for year round supplementary feeding.

Image 3. Alfalfa (*Medigaco Sativa*)

Pigeon Pea (*Cajanuscajan*)

Pigeon pea is a multipurpose annual legume whose seed can be use for food and its leaf for livestock feed. It is suitable for semi-arid environment with average rainfall of 500-800mm and acidic soil. Recommended seeding rate of pigeon pea is 4-6 kg/ha with spacing of 1 m between rows. On a land of low fertility it is usually recommended to use 20-40 kg phosphate fertilizer for successful establishment and good stand. Appropriate harvesting stage is usually when it starts pod setting and to be cut at the height of 25-50 cm length. Recommended mode of utilization is chopping it at green stage and be offered to animals. Under situation where the seed is intended for human food, branches with no pod or seed can selectively be offered to animals while branches with seed areused for human food.

Image 4.Pigeon Pea (*CajanusCajan*)

Cowpea (*Vigniaanguiculata*)esgen)

Cowpea is multi-purpose (food and forage) annual legume that can best be intercropped with maize and sorghum. The haulm from cowpea is also an important fodder resource which contains about 21% crude protein. Additionally, it is very important in improving soil fertility through the process of N-fixation. Thus, it has wider scope of adoption particularly in under small farmers situation.

Recommended time of planting of cowpea is at mid-July using 40cm between rows and 20 cm between plants. It is usually recommended to use 100 kg DAP/ha and 50 kg/ha urea at the time of planting as deemed necessary. In a vergin land similar to that of Maiweyni fertilization may not be needed during the first year of establishment.

Appropriate time of harvesting for herbage is at 50% flowering stage of maturity which is about 48 days after planting. At this stage the average CP content and IVOMD of the forage is 17 and 61%, respectively. The CP content of cowpea appears to decline to 11 when harvested at 100% flowering stage.

Image 5. Cowpea (*Vigniaanguiculata*)

Mezrut grass (*Echinochloasp.*)

Mezrut (*Echinochloasp*) is one of the palatable local grass species released by Humera Agricultural Research Center (HuARC) and has higher nutrient contentsas compared to the other lowland local grasses of Western Tigrai, Ethiopia. Mezrut can be used in the form of fresh green feed, hay or silage to be able to contribute towards the increments of meat and milk productivity. The dry matter yield (DMY) of Mezrut grass is 18.5-20 ton/ha which is much higher than the DMY of Rhodes grass (8.74 ton/ha in 2012 and 9.1 ton/ha in 2013 as reported by Yenesew*et al.*, 2015) in mid-altitude areas of Amhara region, Ethiopia. Mezrut has a promising CP contents of 14.53%, 13.88% and 10.50% at onset of flowering, 50% flowering and 100% flowering, respectively. This local grass has better CP content than Buffel grass (9.6%) and also has closer dried organic matter digestibility (DOMD) with that of Rhodes grass (57.16% versus 65%).

Proper planting time ofMezrut,for herbage production, is at at the onset of main rainy season which is around first week of July in Humera area.Its proper harvesting time is at 50% flowering stage which is 50 days after planting.

Image 6 Mezrut(*Echinochloaspp*

Mechellograss (*Sorghum aethiopicum*)

Mechello (*Sorghum aethiopicum*) is one of the palatable local grass species released by HuARC and is believed to have higher nutrient contents.Like that of Mezrut, Mechello can also be used as fresh green feed, hay or silage form. The DMY of Mechello is ton/ha with CP contents of 13.56%, 8.76% and 6.51% at onset of flowering, 50% flowering and 100% flowering stages, respectively.

Proper planting time for Mechello is at first week of July for herbage production and first week of Juneif it is for seed production.Proper harvesting time of the grass,to attain quality forage, is at 50% floweringdemanding some 65 days to reach this stage after planting.

Image 7.**Mechello (*Sorghum aethiopicum*)**

3.2 Cultivated forages for seed production

Availability of forage seeds in terms of quantity, quality and varietal choices is one of the major impediments towards wider use. Forage seed importation requires hard currency and it is a costly venture. Thus, availing sustainable and affordable forage seed requires domestic production through alternative supplier schemes such as farmers union,youth association and private investors.

Identification of appropriate environment

While selecting site for forage seed production, we ought to ensurehow fit is the basic biophysical requirements including the following additional prerequistes:

- Making the environment free from invasive weeds and pests
- Availability of adequate land to avoid cross pollinization
- Appropriateness of the land for use of farm machinery and availability of irrigation scheme
- The site should not be frost pocket for adequate seed setting of tropical forage crops

Land preparation, planting and crop management

Forage seed production has so much in common with herbage production described in section 3.1and the following additional practices described below ought to be followed.

Fine seed bed preparation and effective weed control are important cultural practices for successful establishment, attaining good stand and seed yield. Fine seed bed preparation is the recommendable basic practice for forage seed production.To get the desired quality of seed, it is mandatory to check seed purity and it is usually recommended to obtain the seed from a recognized enterprise with adequate background information/description about the forage crop variety in question. It is usually recommended to use row planting than broad casting while targeting forage seed production.As a general practice a spacing of 60-120 cmand seed rate of 2-7 kg /ha is usuallyrecommended for seed production of most forages with specific seed rates described in section 3.1 for each forage.

Soil fertility management is among the important cultural practices to ensure successful seed production. Nitrogen, phosphorus,sulpherand molybdenum are among the essential elements for seed production. Application of 100-150 kg /ha of diammonium phosphate (DAP) is recommended for forage seed production. Effective weed control is the best cultural practice to get the desired quantity and quality of forage seed. Selective herbicides can also be applied for effective weed control.

Among pathogens/diseases effective control of rust is important to have good stand of forage and seed production. Integrated pest control practices i.e use of disease free seed, rogging out infected plants etcshould be practiced for effective control of pest. Seed harvesting at the right time and the use of proper harvesting method are among essential practices in getting the desired quantity and quality of seed yield.

Seed harvesting, threshing, cleaning and storage

Monitoring appropriate time for seed harvesting is an important task in forage seed production. Towards this goal, the best practice is to monitor changes that take place in relation to the color of the seed pod and seed shattering. In some herbaceous legumes like lab lab, pigeon pea and others, their seeds can be collected by picking matured seed pods selectively. While for fine seeded legumes like cowpea, vetch,styloand others, it needs tofirst detect state of the seed maturity by taking sample for physical assessment to decide on the right harvesting time of the whole field.

Recommended time of harvesting of selected forage crops forseed production purpose is indicatein this manual on Table 5.

Table 5.Recommended time of harvest of selected forages for seed production

No	Forage	Harvesting time	Remark
1	Elephant Grass		
2	Rhodes Grass		
3	Alfalfa		
4	Pigeon Pea (*CajanusCajan*)		
5	Cow pea (Vigniaanguiculata), (Temesgen)	At maturity	76 days after planting
6	Mezrut (*EchinochloaSpp*)	At maturity	87 days after planting
7	Mechello (*Sorghum aethiopicum*)	At maturity	89 days after planting

Following harvesting and threshing forage seeds, there needs to be labeling of the produce with identification of variety name, date of production, producer name and stocked in appropriate store (pest free). For a short storage period (like 2-3 years), the temperature of the store should be kept below 15 degree centigrade with humidity of less than 45%.

3.3 Natural pasture/range

Natural pasture/range is a major basal feed for beef cattle in the pastoral/agro-pastoral production system. Pursuant to climate change and mode of utilization, the productivity, quality, sustainable use and biodiversity of range resources are under serious threat. Most rangelands are currently encroached by undesirable bush and invasive weed species. Thus, participatory range land rehabilitation and rational uses are needed to support pasture or range based beef production. Under Ethiopian situation, research efforts on range land rehabilitation and improvement options are limited to few sites such asBorena, Afar and Fentale. Integrated use of biological and physical techniques were also examined and demonstrated in some areas. Among options tried thus far, re-seeding with indigenous grass species has been noted to be worthy interventions. Global experiences also indicated that re-seeding range lands with improved grasses such as Stylo which is adaptable to low fertility gradient is also among the best bet options for rehabilitation of range lands. Under Humerasituation, the takeoff point for rehabilitation of the pasture/range is species identification (desirable or undesirable) in a participatory manner with the community. At appropriate time, undesirable bushes can be removed using mechanical means and augmented with the use of soil seed banks of desirable grass species to rehabilitate the natural pasture/range.

Additionally systematic stock exclusion from the natural pasture/range during rainy season and hay making at the right time can help ensuring best use of the natural pasture. Rotational grazing practiceusing appropriate stocking rate as supported by paddocking is also a good means towards improved range based feed utilizationand beef production. Among the aforementionedintervention options for improving natural pasture/range, interventions that are felt suitable and appropriate for Humera/Maiweynicircumstances shall be identified, planned and implemented in a participatory manner.

Image 8. Pastureland condition at Humera Branch

KEY MESSAGE OF CHAPTER THREE

- The feed development plan recognizes use of improved forages i.e irrigation supported or rain fed and natural pasture. Choice of cultivated forages is based on national or regional experiences with a good mix of potential grasses and legumes.
- In getting good establishment, stand and productivity of cultivated forages, varietal choices and appropriate cultural practices (weed, fertilizer/ nutrient and disease/ pest management) are essentials.
- Aspects of herbage and seed production should be taken into account to address sustainable use of cultivated forages.
- The section on natural pasture underpins critical evaluation of current status and choice of best bet practices tailor made to local condition.
- Among various options, re-seeding with indigenous grass species could be a worthy interventions. Stock exclusion of natural pasture/ range during rainy season supported by hay making at the right time are the possible interventions for ensuring best use of natural pasture.
- Additionally paddocking and rotational grazing are also potential interventions towards range based feed development and beef production.

4 Basics of Ruminant Nutrition under Grazing

Much of what we understand about livestock nutrition has been developed from studies and experience with confinment feeding operations, where concentrated nutrients in the form of grain, oilseed products and harvested forages are delivered to animals in a drylot. These types of practices leave out many of the biological and climatological variables that accompany grazing situations: plant species, forage stage of maturity, soil fertility etc. Cattle, sheep, and goats have the ability to convert plant carbohydrates and proteins into available nutrients for human use, and therefore render productive vast portions of otherwise unusable land. Grasslands offer humans a nutritious supply of meat and milk. Many farmers and ranchers have changed production practices to take advantage of this natural process, bypassing the energy intensive grain-fed operations that have dominated American livestock production for the past several decades. Products from grass-finished livestock are higher in omega-3 fatty acids and conjugated linoleic acid than conventionally raised counterparts. Additionally, these products may reduce cholesterol and the incidence of certain types of cancer.

In ruminant nutrition under-grazing conditions several aspects need to be understood among which ruminant physiology, nutrient requirements of grazing livestock, forage resources and grazing nutrition, matching nutritional requirements of livestock to the forage resource, strategic supplementationand concept of limiting nutrients such asplant toxicity and grazing-related disorders and grazing managementdeserve special attention. Ranch owners are required take each of these variables into account as they do a plan to meet the nutritional needs of their grazing animals.

It is to be noted that unlike the tropical environment, confined stall feeding systems of delivered forages and concentrated feeds have been the norm in the temperate region since the 1950s. However, in the tropical region, beef or dual purpose cattle production depends mainly on grazing and this peculiarity ought to be understood. Additionally on top of environmental/production system differences, genetic variations in nutrient partitioning and in nutrient requirements of *Bostarus* and *Bosindicus*animals are expected. Recent findings of genomic regions responsible for feed conversion efficiency of indigenous Nelore cattle in Brazil revealspeculiarity ofindigenous animals in the tropics. While using global knowledge and late comers' advantage in terms of basic science of ruminant nutrition it is worth understanding the fundamentals of nutrition targeted for grazing herbivore particularly in tropical environment. The key feature or attribute in the tropics is the interconnectivity of the grassland ecosystems and ruminant nutrition. Grasslands and ruminant animals are intrinsically related suggesting practices that impact one will necessarily influence the other. The soil,in the system,serves to derive water, nutrients, structural support, and temperature buffering required for pasture production. Soil microorganisms also recycle nutrients and make nutrients, that otherwise unavailable,to be available for plant uptake. Microorganisms in the rumen also enable the grazing herbivore to recover nutrients from poor quality materials which otherwise would have been wasted. In a net shell, production and productivity of grazing herbivore in the tropics is largely governed by the following key principles of ruminant nutrition.

Key Principles of Nutrition Targeted for Grazing Herbivore

- Ruminants are adapted to use forage because of microbes in their rumen.
- To maintain ruminant health and productivity, feed the rumen microbes, which in turn will feed the ruminant.
- Ruminant nutritional needs change depending on age, stage of production and weather.
- Adequate quantities of green forage can supply most –if not all– the energy and protein a ruminant needs.
- Forage nutritional composition changes depending on plant maturity, species, season, moisture, and grazing system.
- Supplementation may be necessary when the grass is in short supply, too mature, dormant, or if it is intended for high-producing animal.
- Excessive supplementation may reduce the ability of the rumen microbes to use forage

Based on experiences of tropical region, this chapter is intended to provide livestock managers or nutritionists with best bet practice and approache to make informed decisions that ensure biological, economic and ecological viability of Begayit cattle production under Humera situation.

4.1 Ruminant physiology and digestive process

Proper care of the land and its grazing animals requires a sound understanding of ruminant nutrition. First we must understand how a ruminant animal (cattle, sheep, goats) digests plant matter. Ruminant comes from the word "rumen," which is the first and largestsectionof the four-compartmentalized stomach of a cow, sheep, and goat. This structure is a "vat" where microbial fermentation takes place. Millions of bacteria, protozoa, and fungi live in the rumen and break down energy-rich plant parts, making them digestible for the host animal. After the forage has been digested in the rumen and is broken down into small pieces, it can pass through the reticulum and omasum, which function as strainers that keep large pieces of material from passing into the abomasum, or "true stomach," where digestion continues. From the abomasum onward, the ruminant digestive system closely resembles other animal digestive systems with a small and large intestine, colon, and anus.

It is worth understanding ruminant physiology offers several benefits. As stated earlier, grazing animals have the ability to harvest and convert plant energy, especially cellulose, from grasslands and rangelands not suited to cultivation. Cellulose is a portion of the plant structure that comprises the walls of the plant's cells, and is very fibrous and indigestible. Rumen microbes produce cellulase, the enzyme that breaks down the chemical bonds in cellulose, making it digestible to the microbe and, subsequently, to the ruminant animal. Another advantage of rumen fermentation is microbial synthesis of important vitamins and amino acids. All the vitamins the animal needs are synthesized by microorganisms, except vitamins A, D, and E. However, animals fed high quality hay or green pasture get their requirement of vitamins A and E. Vitamin D is supplied through exposure to sunlight, which is another advantage of pasture production. Amino acids are the building blocks of protein—a crucial nutrient for growth and

reproduction in animals. Rumen microbes synthesize these building blocks from ammonia, a by-product of fermentation in the rumen.

Given this fact, even poor quality forage can supply some protein for the grazing animal. Once it is understood how the rumen works to convert forage to digestible energy and protein, it becomes clear how important grazing animals are to the environment and, in turn, human culture. "Nutrients absorbed from the digestive tract include volatile fatty acids, amino acids, fatty acids, glucose, minerals, and vitamins. These are used in the synthesis of the many different compounds found in meat, milk and wool, and to replace nutrients used for maintaining life processes including reproduction (Minson, 1990). Digestion begins when an animal takes a bite from the pasture. As the animal chews, the feed is formed into a bolus—a packet of food capable of being swallowed. Saliva is excreted, which further aids in swallowing and serves as a pH buffer in the stomach. Once in the rumen, the feed begins to undergo fermentation. Millions of microorganisms ingest the feed, turning out end products which serve as a major source of nutrients for the animal. Some of the principle products formed are ammonia, methane, carbon dioxide, and volatile fatty acids (VFAs). VFAs are absorbed and used as energy by the animal. Ammonia can be absorbed into the animal's system through the rumen wall, or can be consumed by bacteria to become microbial protein. This microbial protein is then passed through the digestive system to be absorbed in the small intestine.

4.2 Nutrition of grazing livestock: the basics

For producers, what are the important nutritional considerations for grazing livestock? This is a good question to deal with because livestock nutritionists have developed a science of nutrient analysis and subsequent ration balancing. But the analyses are built on nutrient content of processed or harvested feedstuffs delivered to ruminants in pens, rather than grazing ruminants selecting a diet frompasture. Forage nutrient analysis can be a good tool to determine forage quality. However, forage quality for grazing animals is more accurately determined by observation and adaptive management of the grazing resource, basal diet quality,supplementand supplement interaction. In a net shell,the basics of ruminant nutrition under grazing system focuses on forage intake, energy, protein, minerals, vitaminsand water.

4.2.1 Intake

Intake is the ingestion of feedstuffs by the animal, and is regulated by the following interrelated and complex factors such as palatability, foraging behavior, chemical characteristics of the feedstuff, forage quantity, density, dietary energy, fiber content, physiological stage of the animal and temperature.

Palatability is the flavor and texture of the feedstuff. Ruminants seek sweetness in their feed, probably because sweet is an indicator of soluble carbohydrates, the most critical dietary element for the animal after water. Ruminants avoid feedstuffs that are bitter, as these often are associated with toxic secondary chemicals. Foraging behavior describes how an animal goes about the grazing process. Grazing livestock, unlike confined stall-fed livestock, have the opportunity to graze selectively and therefore tend to select a diet higher in leaf proportion than what the overall pasture has to offer (Minson, 1990). Bite size and bite rate also have an

influence on intake. The more dense a pasture sward, the more forage the animal can take in with each bite. Research has shown that a dense, vegetative pasture yielding at least 2.24 ton dry matter per hectare is adequate for maximizing bite size and therefore intake. However, when pasture yield drops below this level, intake decreases (Minson, 1990). This signifies that the relationship between grazing management, animal behavior. and nutrient uptake is not a simple relation. It is complex and constantly changing with the change in season, forage quality, and forage quantity.

Chemical factors include nutrients, but also secondary chemicals that are often associated with plant defense. Secondary chemicals are often referred to as toxic substances, but toxicity is really just a matter of degree of dosage. All plants contain toxic secondary chemicals to some degree, but animals have evolved an innate sense of what is good to eat. Animals limit the amount of plants they consume that contain secondary chemicals through a feedback mechanism that results in satiety or the feeling that they have had enough. When ruminants consume enough of a certain toxic substance, a feedback mechanism induces a switch to an alternative source of nutrients. This is why cattle graze more or have higher intake on a diverse pasture. The variety stimulates their appetite and provides alternative sources when they reach the limit of their first choice of plants. Secondary chemicals in forages may include alkaloids in reed canary grass and lupines;tannins in trefoil, lespedeza;terpenes in sagebrush or bitter weed;endophyte toxin in tall fescue.

Forage availability, quantity and densitydirectly influence forage intake and also intake isdirectly related to the composition of the pasture sward. Ruminants can take only a limited number of bites per minute while grazing, and cattle in particular will only graze for about 8 hours per day. It is important then to ensure that each bite taken by the grazing animal is the largest bite an animal can get. A cow grazes by wrapping her tongue around and ripping up forage; sheep and goats use their lips and teeth to select highly nutritious plant parts. Large bites of forage are therefore ensured by maintaining dense pastures. Dense pastures are those with actively growing and tillering forage plants. Tillering occurs in grasses that are grazed or mowed while vegetative, resulting in the activation of basal growing points (clusters of cells that initiate growth near the bottom of the plant) and the growth of new stems and leaves. Tillering results in a plant covering more basal area, which helps make a pasture denser while protecting the soil. The length of the grazing period (the time an animal is in a paddock) also has a direct effect on pasture intake. An animal's intake decreases as the longer it remains in a given paddock. This happens due to (1) the effect of plant disappearance (as plants are grazed) and subsequent searching by cattle for the next bite, and (2) the decrease in forage crude protein content begins roughly two days after the animals have been turned into the paddock.

Dietary energy and fiber content. As has been mentioned, livestock eat to the level of satiety. Another good definition of satiety is gastrointestinal satisfaction. Ruminants possess instinct nutritional wisdom to select a diet high in digestible organic matter, because the most critical nutrients selected by ruminants are soluble carbohydrates. What an animal actually eats from a pasture sward is often of higher nutritional quality than the average of the pasture overall. Forages with a dry matter digestibility (DMD) of 60 to 69 percent are considered as high quality forages from the perspective of its energy content. Dietary fiber is also a forage quality indicator which is necessary for proper rumen function, and is a source of energy as well. However, high

level of fiber in the diet decreases intake. Less digestible forages tend to stay longer in the animal's digestive system thereby slowing the rate of passage and the animal remains "full" for a longer period. However, the younger a plant means the more soluble carbohydrates and the less fiber (cell wall components) it contains. Therefore, younger plants are generally more digestible than mature plants.

Physiological stage refers to the stage of life the animal is in, and what level and type of production are being supported. The key physiological stages in the life of ruminant animals are: growth (calves, heifers, bullsincluding feeder animals), late pregnancy, lactation (production or maintenance of offspring) and body maintenance (such as the cow's dry period). For example, the peak intake of lactating cow occurs after peak lactation. Between peak lactation and peak intake, the body must draw on body reserves to maintain energy balance. Thus lactating animals generally lose body condition during this period. For this reason it is important to ensure high-quality pasture to maintain productivity versus optimum health and the animal's ability to recycle so as to re-enter into the next lactation at the appropriate time. Temperature affects the amount of feed an animal needs to maintain its body functions. Metabolic rate of an animal increases as the temperature drops below the animal's comfort zone. As temperature drops, more energy is needed to maintain internal heat and hence intake increases accordingly. Animals typically will not graze much during hot and humid weather.

Options for increasing intake on high quality: High intake from pasture is one of the key components to ensuring adequate nutrition for high producing ruminants. Ensure high forage intake by keeping forage in the vegetative stage through grazing management, diversifying pasture composition to include several grass species with around 30 percent of the pasture in legumes, and maintaining a dense pasture for animals to take larger bites. Intake is maximized when pastures are dense, digestible, palatable,diverse, correctly stocked, plentiful (8-10 inch tall for cattle), familiar to the animal and fresh (not trampled or heavily manured).

4.2.2 Energy

Energy is the single most important dietary component for an animal after water. Energy is derived from carbohydrates, fats, proteins, and from the animal's body reserves. Energy intake maintains body functions and facilitates growth and development, including reproduction and lactation. Energy is supplied to ruminants by highly digestible plant cell contents and a portion of the less digestible plant cell wall fraction. Starches like corn and barley are also high energy sources, and are used extensively in the conventional livestock feeding industry as well as for pasture-based systems where energy supplementation is sometimes useful to enhance production.

Not all the energy taken by a grazing animal becomes meat, milk, or wool. The hierarchy of energy digestion begins with gross energy, which is the energy of intake. Some of the energy of intake is digestible, and some is not. What is not digestible is excreted as fecal energy, and what is left for use by the body is digestible energy. Metabolizable energy is the energy left after accounting for digestive and metabolism lossesas urine and methane. The energy partition left after losses in heat increamentis used for the maintenance of body temperature, respiration, growth, reproduction, and milk production. This fraction is called net energy and is usually split into net energy for maintenance (NEm), net energy for gain (NEg), and net energy for lactation

(NEl). Animals can adjust to available energy by putting on fat or by using fat stores. As a method of visually appraising animals to arrive at a qualitative description of nutritional status body condition scoring can be used. Animals must not be too thin or too fat or complications can arise. If too thin, animals may not conceive, may be prone to disease, and usually have reduced milk production. If too fat, animals may experience difficulty in giving birth (dystocia).Body condition scores (BCS) are ranked on a numerical scale and the lower the number on the scale, the thinner the animal is. For beef cattle, optimum BCS for breeding is 4.5 to 5.0 on the scale of 1-9.

4.2.3 Protein

Protein:- "Crude Protein" (CP) is calculated from the nitrogen content of the forage. The CP value is important since protein contributes energy and provides essential amino acids for rumen microbes as well as the animal itself. The more protein that comes from forage notifies the less supplement is needed. However, most nutritionists consider energy value and intake of forages to be more important than CP (Robinson et al, 1998). As has been discussed, the energy value of a forage is best determined by forage maturity, density, and availability. Protein in forages is most correlated with forage maturity, as more mature forages have a lower percentage of crude protein. Cattle require two types of protein in their diet. One type is degraded in the rumen and is used to meet the needs of the microbial population, and the other one by-passes the rumen and is used primarily to meet the productive needs of the animal.

When protein is degraded in the rumen it is called rumen degradable protein. Rumen degradable protein is essentially food for rumen bacteria. When the microbes die they are passed through to the stomach and small intestines where they are digested by the animal. The resulting microbial protein is then absorbed into the animal's bloodstream. Some of the protein in the diet does not undergo degradation in the rumen, but passes straight to the abomasums or stomach for digestion. When protein escapes rumen breakdown and passes to the stomach it is referred to as rumen un-degradable protein or by-pass protein.

By-pass protein is important because a large percentage of the rumen degraded protein is absorbed as ammonia and, if in high concentrations, can be lost through the urine as urea. In high-producing animals this represents an in-efficient utilization of protein, so increasing the amount of protein that is by-passed to the intestines constitutes a more efficient utilization of protein for growing or lactating animals on high-quality pastures. In forages, roughly 20 to 30 percent of the protein taken in by the animal is by-passed to the intestines. Lactating or growing cattle generally require 32 to 38 percent of their total protein intake to be in the un-degradable form (Muller, 1996). For those animals that require supplementation, corn, cottonseed and linseed meals, brewers dried grains, corn gluten meal, distillers dried grains, and fish meal are typically high in by-pass protein.

The microbial degradation of protein is an energy-dependent process. Carbohydrates are the energy-yielding nutrients in animal nutrition and are supplied by the production of volatile fatty acids in the rumen. Generally more microbial protein is synthesized from green forage diets than from hay or mature forage diets. When a ruminant animal grazes fresh forage on high-quality pasture, about 70 percent of the protein is degraded in the rumen by microorganisms, and about

30 percent escapes to the small intestine for absorption. Ruminant animals need approximately 65 to 68 percent of the protein to be rumen degradable for adequate rumen function and the development of microbial protein. But if more protein is degraded in the rumen, less is available to the animal for absorption in the small intestine. This is important because rumen un-degradable or by-pass protein consists of certain essential amino acids that are missing or deficient in rumen degradable protein. Much of the rumen degraded protein is absorbed as ammonia and excreted out of the body via the urine, and is therefore a waste of protein. This is why by-pass protein is important, especially for high-producing (growing or lactating)animals even in protein-rich-pasture diets.

4.2.4 Minerals and Vitamins

The major minerals of concern for livestock on growing forages are calcium and magnesium. Others to consider are salt, phosphorus, potassium, and sulfur. These minerals are very important for cellular respiration, nervous system development, protein synthesis and metabolism, and reproduction. Mineral supplements are available in many formulations. Because soils differ in mineral contentsfrom place to place, it is difficult to recommend a mineral mix that works in all places, although most animal scientists suggest at the very least a mineral mix with a calcium to phosphorus ratio of 2:1. Consider using a loose mineral mix fed free choice rather than mineral blocks for cattle on lush spring or small grain pasture to avoid grass tetany (hypomagnesaemia) and to ensure the animals are getting enough mineral.

Vitamins are important for the formation of catalysts and enzymes that support growth and body maintenance in animals. Green growing plants contain carotene, which is a precursor to vitamin A. If ruminants are on green forage (including green hay) vitamin A willnot be deficient. Vitamin A deficiency occur when ruminants are placed on concentrate feeds, or when fed dry. Vitamins are important for the formation of catalysts and enzymes that support growth and body maintenance in animals.B vitamins are synthesized by rumen microorganisms so supplementation is not necessary. Vitamin D is synthesized in the skin from exposure to sunlight, so Vitamin E is the only other vitamin of concern that sometimes requires supplementation.

Mineral and vitamin supplementation is very important to maintain herd health, and careful attention must be paid in developing a mineral and vitamin supplementation plan. Keep the following points in mind when feeding these supplements to livestock:

1. Keep mineral mixes dry. Wet mineral is unpalatable and is known to lose some of its efficacy when damp.
2. Monitor consumption to make sure it is always available. Keep the feeders full.
3. Donot forget that some animals display social dominance. Older and more dominant animals will often eat more than their share of mineral mix. Remedy this by having more than one feeder, separated into different parts of the pasture.

In terms of water requirement, cattle usually require from 3 to 30 gallons per day. Factors that affect water intake include age, physiological status, temperature, and body size. A rule of thumb is that cattle will consume about one gallon of water per 100 pounds of body weight during winter and two gallons per 100 pounds of body weight during hot weather. In general, you can

easily double the estimates for lactating cattle. Water should be clean and fresh, as dirty water decreases water intake. It is good to remember that all other nutrient metabolism in the body is predicated on the availability of water, and if an animal stops drinking, nutrient metabolism (which results in growth and lactation) will decrease.

4.2.5 Matching nutritional requirements of livestock to the forage resource

One of the most important questions a livestock manager can ask is "what do I need to know in order to match the nutritional requirements of my animals to the forage resource?" To answer this question with the highest level of certainty, the producer should perform the following crucial management tasks:

- take inventory of available forage resources including documentation of re-growth
- prioritize grazing of highest quality pastures by animals with highest nutrient requirements (growing, lactating)
- observe and determine the forage growth curve for your pastures
- it is also worth understanding about the aspects of species diversity.

As shrubs and forbs typically have higher protein concentrations than most grasses, why are they generally considered substandard as livestock forage? The main reason is that most shrubs and many forbs contain secondary chemicals that are often toxic to grazing animals. Animals grazing sagebrush, for example, will very quickly get their fill as the level of alkaloids accumulates in their systems. However, livestock display nutritional wisdom and often eat small portions of various species in order to (1) obtain essential nutrients, and (2) neutralize the effects of more toxic plant species.

Forage growth phases and forage supply is not continuous throughout the year. Cool-season pasture growth begins in the early spring and quickly produces very large amounts of forage, then tapers off toward mid-summer. Given adequate moisture, cool-season pastures will often produce a second surge of growth in the fall before going dormant. Warm–season pasture begins later in the spring and continues into early autumn when day length shortens and temperatures fall. Warm-season pastures complement cool-season pastures nicely by providing forage when cool-season growth wanes in mid-summer. A diverse mix of cool- and warm-season pastures benefits livestock managers by overlapping the growth curves of both types, meaning more high-quality pasture than otherwise.

It is worth understanding the peak animal demand in relation to forage growth phases andcoinciding the forage growth curve with peak animal demand is towards optimal utilization of forage resources. Monitoring ofanimal numbers and type are key aspects towards appropriate use of forage resource. The highest nutrient demand for beef cattle is one to three months after parturition (birth) and lowest demand is three to four months before parturition. For dairy animals, the entire lactation period is critical. Knowing the forage growth curve for your pastures will allow you to match forage growth with animal demand.

4.2.6 Supplementing protein or energy: when is it necessary?

By nature, grazing and browsing animals grow and reproduce well on pasture alone. However, aspects of realizing full genetic potential and nutritional efficiency of Bagait cattle is higher thanwhat a pasture system can deliver due to marked seasonality in quality and quantity of grazing resources under Humera condition.When supplementing ruminants on pasture, consider the following questions: will the added production cover the expense, especially if the feed is shipped from off the farm? Is there an inexpensive local source of protein? Do you produce the feed on the farm? Do you have necessary harvest, storage, and feeding equipments?

Remember:substitution effect—is a condition that forage intake can decrease with less fibrous and more digestible supplements like corn. Supplementation of protein on lowquality forages will increase forage intake and, therefore, increase energy intake

4.2.7 Concept of first limiting nutrient

Determine which nutrient is limiting and hence supplement that one first. For instance, degradable intake protein requirements need to be met for microbial growth first. Then and only then consider by-pass protein supplementation, and only if it is deficient. Likewise, if energy is deficient, protein supplementation will be wasteful and expensive.

Remember: on high-quality pastures, energy is often the limiting nutrient. Digestible fiber feeds are good for ruminants on high quality forages because they do not reduce intake, and provide energy for protein metabolism. Examples are: corn gluten feed (corn gluten meal plus the bran), wheat midds (screenings from wheat flour processing), and whole cottonseed.

Feeding cottonseed products to cattle:- three types of cottonseed products are typically fed to beef and dairy cattle. These are whole cottonseed with lint, cottonseed meal, and cottonseed hulls. Whole cottonseed is a very good source of protein for cattle. However, whole cottonseed contains a chemical called gossypol that can inhibit the reproductive performance of breeding cattle, particularly bulls. For this reason it is recommended that producers limit whole cottonseed supplementation to calves at 1.5 pounds per day, stocker cattle at no more than 3 pounds per day, and mature cows at 5 pounds per day. Avoid feeding whole cottonseed to bulls.

4.2.8 Plant toxicity and grazingrelated disorders

Grazers must pay careful attention to the negative health effects that certain plants can cause in livestock. Plant toxicosis occurs either through the ingestion of (1) poisonous plants or (2) forage plants that contain toxic substances due to environmental or physiological conditions. Plant poisoning can be significantly reduced by proper grazing management. Poisonous plants contain resins, alkaloids, and/or organic acids that render them unpalatable. If the pasture contains enough good forage, there is little reason for the animals to select bad-tasting plants. Information from local extension office and the community regarding poisonous plants underHumera /Maiweyni conditioncan be used.

4.2.9 Plant toxicity and grazing related disorders

Grazing management is the regulation of the grazing process by humans through the manipulation of animals to meet specific, predetermined production goals. The primary considerations of grazing management aretemporal distribution of livestock (time), spatial distribution of livestock, the kind/class of livestock, and number of livestock. If given a choice, livestock will only eat the highest quality, most palatable plants in a pasture. In order to ensure that plant biodiversity is maintained in the pasture, it is necessary to set up a grazing management system to better control livestock grazing. The elements of grazing to control are timing and intensity of grazing. This simply means controlling the number of animals and how long to stay in a pasture. Rotational grazing systems take full advantage of the benefits of nutrient cycling as well as the ecological balance that comes from the relationship between pastures and grazing animals. High density stocking for short period helps to build soil organic matter and develops highly productive, dense and resilient pastures. Some other measurements to consider in managing livestock grazing include:

- Forage density after-grazing
- Plant residue
- Paddock rest time
- Range condition and trend,
- Animal body condition, health, and physiological stage
- Grazing systems, including stocking rate and stock density
- Pasture and rangeland monitoring

KEY MESSAGE OF CHAPTER FOUR

- This chapter underscores peculiarities of ruminant nutrition in the tropics as opposed to the temperate region where animals are kept under confinement, fed quality roughage and supplement
- While nutritional principles hold true for both environments customizing to local situation is of great benefit.
- For managers and nutritionists to make informed decisions towards ensuring biological, economic and ecological viability of livestock operation it is worth understanding the basics of **ruminant nutrition under grazing.**
- The basics of ruminant nutrition centers around
  - (1) Intake
  - (2).supply and quality of key nutrients i.e energy, protein, minerals or vitamins and water
  - (3).Matching Nutritional Requirements of Livestock to the Forage Resource
  - (4) Strategic supplementation and concept of first limiting nutrient

(5). Plant Toxicity and Grazing Related Disorders

(6). Plant Toxicity and Grazing Related Disorders

- Realizing genetic potential and nutritional efficiency of Bagait cattle is higher than what a pasture system can deliver demanding strategic supplementation based on concept of first limiting nutrient.

5 Ration Formulation for BegayitCattle

Beef cattle are most productive when fed a ration balanced according to their needs. The required nutrients should also be supplied at lowest possible cost. This can be done if producers use locally available feed ingredients and use purchased feed to fill the gap in nutrient supply from the locally available feeds. This chapter of the manual is intended to present the basic procedures and methods of ration formulation from locally available feed ingredients.

5.1 General considerations

There are several approaches in formulating rations.The choice of a method usually depends on the number of feed ingredients and requirements of nutrients to be considered. Whatever approach is used the following general procedures is valid.

1. Prepare a list of the requirements of the nutrients to be considered under a given circumstances and target animal.
2. Determine the feed that is available for the formulation and consult available information on their use
3. Prepare a listing of the nutrient composition of the feeds to be used. Information on nutrient profile of Ethiopian feeds (Seyoum et al 2007) and other sources can be used for this purpose.
4. Obtain feed costs at the site of mixing
5. Proceed to balance the ration using the guides for the nutrient requirement of beef cattle(age, physiological condition, productivity etc.)
6. Make the necessary adjustments by asking the following questions

- Have all deficiencies been corrected?
- Are excesses present?
- Does the formula appear the most economical combination of feeds?
- What is the cost of the ration per quintal or what does it cost to feed the animal in question?
- What will be needed in addition such as free choice salt, minerals etc

5.2 Information needed for ration formulation

The following information is needed before going to the mathematics of ration formulation.

List of nutrient requirements

This can be obtained from standard nutrient requirement tables. Nutrient requirements of ruminant livestock in developing countries or nutrient requirement of beef cattle (NRC Tables can be used). Factors such as age, sex, physiological function (maintenance, growth, pregnancy, lactation) and level of production should be considered.In general, the nutrients considered in the formulation of rations for beef cattle production are protein, energy, calcium and phosphorus.

List of available feeds

If more than one type of feed as a source of a nutrient is available, it will be good to prioritize the available feed stuffs based on relative suitability and whether they are the most economical sources of the desired nutrients. Then one can proceed to list the contribution of each feed of the critical nutrients. Analytical data of the feeds are usually preferred if available. Alternatively, use of average composition data from appropriate feed composition tables or other available information sources can be used. The publication on composition and nutritive value of Ethiopian feeds produced by EIAR (Seyoum et al 2007) can be used. Calculate the unit cost of the major nutrients (energy, protein, calcium and phosphorus) to determine whether the feed is an economical source of the nutrients. The cost of processing, transportation and storage should be considered.

Type of ration to be formulated

The type of ration to be formulated will determine the needed nutrient contents of the ration and the details of the formulation procedure. For instance it makes a difference whether we intend to formulate a complete feed of concentrate mix for finishing animal and to feed it as a supplement to a roughage source. For beef cattle we would normally consider roughage as the base feed and then determine what nutrients are needed to supplement the roughage.

Considerations in the formulation of rations

It is worth noting the following points while preparing ration using any method of ration formulation:-

1. ***Simplicity:*** try to keep rations simple. The rule of thumb is that simple and nutrient needs can be met by simple feed formulae since complex formulae do not necessarily guarantee better performance.

2. ***Feed composition data:*** Feed composition data may be given on dry matter or on as fed basis depending on the publication from which the information is taken. Thus, some recalculation can be required before ration formulation commences. Ration could be formulated on dry matter basis specially if we include ingredients such as silage, molasses etc is needed.

3. ***Formulation on the basis of the daily need:*** Formulation can be done on the basis of amounts of nutrients rather than concentration. Use of percentage units is the simplest means as the final values can easily be converted to any weight gain

4. ***Drymatter intake:*** Physical and physiological limits exist for an animal beyond which the dry matter intake cannot go depending on body size, physiological state and the nature of the diet i.e palatability, texture and bulkiness

5. ***Units of measure for nutrient requirement and feed composition:*** Select the same units of measure for example for protein either crude protein (CP) or digestible crude protein (DCP); for energy total digestible nutrient or metabolizable energy or net energy

5.3 Methods of ration formulation

The whole purpose of formulating a ration is to provide the desired allowances of nutrients in correct proportions economically and there are many methods of ration formulation for various situations. The common ones include the Pearson square method and the trial and error method

5.3.1 The Pearson square method

The Pearson square or simply the square method provides a simple and rapid formulation that allows blending of two feeds or feed mixtures with different nutrient concentrations into a mixture with the desired concentration. It is usually employed in cases of mixing feeds rich in energy with feeds rich in protein. For this method to work, the desired level of nutrient should be a value between the compositions of the ingredients that constitute the mixture. The Pearson square method allows quick substitution of feed ingredients in response to market fluctuationswith out disturbing the content of the nutrient under consideration. Different situations for application of the Pearson square are given below.

Scenario1. When only two feeds are involved

Suppose a producer wants to formulate a concentrate supplement that provides 16% crude protein and wants to mix maize with 9%CP and cottonseed cake (CS cake) with 40%CP. What combination of maize and cottonseed cake will provide a mix of 16% CP?

Solution:

1. Draw a square given below

2. Insert the% CP desired in the final mixture at the middle (16)

3. Place maize with its percent CP (9) on the upper left and CS cake with its CP(40) on the lower left corner

4. Subtract the %CP desired in the final mix (16) from the CP in corn (9) and place the difference (7) without the negative sign on the corner of the square diagonally opposite to the corn on the lower right side of the square

5. Subtract the % CP desired in the final mix (16) from the CP in the CS cake and place the difference (24) at the corner of the square diagonally opposite from the CS cake (at the upper right of corner of the square). The above reminders represent proportions of the two feeds that will provide a mix containing the desired CP

6. The amount then be converted to a percentage basis and then to any other weight basis (e,g quintal or ton) as desired for mixing purposes

Thus, mixing 77.4% maize and 26 % CS cake (40%CP) will provide a mix of 16%CP

Checking

You can check whether the final mix really contains the desired CP level by calculating the contributions of the ingredients constituting the mixture (maize and CS cake) and summing up.

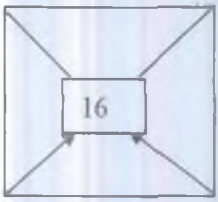
Contribution of maize = (9x77.4)/100= 7

Contribution of CS cake= (40x22.6)/100=9

Total CP in mix= 7+9=16

Ingredient Proportion on% basis on quintal basis

Maize 9 24



CS cake 40 7

Maize9	24	(24/31)X 100=77. 4%	77.4 kg maize
CS cake 40	7	(7/31)x100=22.6%	22.6 kg CSC
TOTAL	31 parts	100	100

Scenario2. When three or more feeds are involved

When three or more feeds are needed to be combined to attain a specific nutrient level say 16% CP from maize with 10%CP, wheat bran with 13%CP and cottonseed meal with 40 %CP the following procedures can be used.

Solution

Construct the Pearson square and do the following

1. Categorize the feeds into two groups since the square can handle only two categories at a time
2. Specify the proportion of each feed in each group
3. Calculate the weighted average% CP in each group

For this example, let us assume that maize and wheat bran are grouped together in the proportion of 2:1 with cottonseed meal being used alone. The weighted average %CP in maize and bran must then be calculated as follows

2 parts maize contributes 2X10%CP= 20

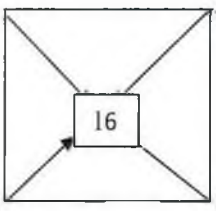
1 part wheat bran contributes 1X13%CP=13

TOTAL 33

A mixture of 2 parts maize and 1 part bran (total of 3 parts) contain 33/3=11%CP. This %CP will be used for the 2 parts corn = 1 part bran designated as MB to occupy one corner of the square and cottonseed cake meal on the other corner

Proceed with calculations as in previous example

Divide the final figure for maize +bran into 2/3 maize and 1/3 bran (the proportion of each feed in each group must always be indicated initially and compiled with the final mixture)

Ingredient		Proportion on% basis	on quintal basis
MB 11		(24 /29) X100=82. 7 %	82.7 kg MB 16
CS cake40		(5/29)x100=17.24%	22.6 kg CSC
TOTAL	29 parts	100	100

Ration composition will, therefore, be as follows

Maize (2/3x82.76) = 55.17%

Wheat bran (1/3x82.76) = 27.59%

Cottonseed meal =17.24%

Checking

To check your calculations, multiply the last ration composition by the CP of each feed source as follows

Maize contributes (55.2/100)x10 =5.52

Wheat bran contributes (27.6/100)x13=3.59

CSM contributes (17.2/100)x40 = 6.89

16.00%

Scenario3. With a fixed percentage of one or more ration components

It may sometimes be desirable to formulate a mixture using more than two different ingredients containing a particular percentage of a nutrient such as protein but with a fixed percentage of one or more ration components.

Let us assume that a beef producer wishes to formulate 14%CP mixture using maize (9%CP), oats (12%CP), nougcake-NC (35%CP) and mineral/vitamin supplement (0%CP). If he decided to include exactly 20% oats and 3% mineral or vitamin supplement in the mixture what combination of maize andnoug cake can be used to make the remaining 77% of the ration?

Solution

A CP level of 14% is desired for the overall mixture. This means 14 kg of protein per 100 kg of mixture. Since 20 kg of each 100 kg mix is oats (20%) it would supply 2.4% (12%of 20 kg). The 3% mineral/vitamin supplement provided no protein. Thus, the 23 kg of oats and mineral vitamin premix per 100 kg of mix would provide 2.4 kg CP. The reminder of the 14 kg of CP needed i.e 11.6 (14-2.4) must come from the 77 (100-23) kg maize and noug seed cake. In order to determine what combination of 77 kg of maize and noug seed cake will provide the needed 11.6 kg of protein, an adaptation of the square method can be used

To do this it is necessary to calculate what % CP will be needed in the maize and nougseed cake combination to provide 11.6 kg of CP per 100kg as follows:

77 kg should contain 11.6 kg

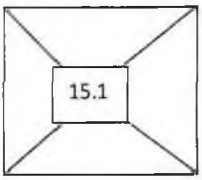
100 should contain ?

(11.6/77)x100=15.1 (the needed CP% of the maize and Noug cake)

This figure is then used in conjunction with the square method as follows

Per 77 parts (calculated by ratio)

Ingredient	Proportion on% basis	on quintal basis
Maize 9	(19.9 26)*77−X1X1=	58.93 pars maize
NSC 35	(6.15/26)*77=X2X2 =	18.07 parts NSC
TOTAL 26 parts	77.00	77.00



Therefore, the constitution of the final ration will be

Oats 20.00

Mineral vitamin supplement 3.00

Maize 58.93

Noug seed cake 18.07

TOTAL 100

Checking

One can check whether the final mix provides the desired level of protein by summing up the contributions of each of the constituent feed ingredients

Contribution of oats 20x(12/100) = 2.4

Contribution of mineral/vitamin supplement 3x (0/100)= 0.0

Contribution of maize 58 93x(9/100) =5.3

Contribution of noug seed cake 18.08 x(35/100) =6.3

Total % CP in final 100% mix 14.0

Scenario4. When definite amounts of two nutrients are required

A modification of the Pearson's Square method known as the "Double Pearson Square" method can be used to formulate a ration mixture that has the exact amount of two nutrients. Consideration of more than two nutrients using this method becomes too complicated. Other methods like the trial and error method can be convenient in this case. The following example demonstrates the use of the Double Person Square method.

Example:

Suppose we want to formulate a mix with 16% CP and 2.8 mega calories/kg (Mcal/kg) Metabolizable Energy by the following feeds:

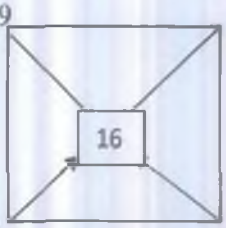
Feed	CP (16)	ME(Mcal/kg)
Maize	9	3.4
Cottonseed cake	42	2.86
Alfalfa hay	18	2.49

Solution

To solve this problem, one has to go through two squares and get a mix for one of the nutrients. Any one of the nutrients can be taken first. Let us take CP. The first step is to formulate two different mixes- one that exactly 16%CP and ME greater than the desired (>2.8 Mcal/Kg) and another mix with 16% CP and ME less than the desired level (<2.8 Mcal/kg ME). At least three feedstuffs are needed to do this.

Step 1 Mix 1 16%CP, >2.8Mcal/kg ME

Ingredient		Proportion on% basis	Calculate ME
Maize 9	26	(26/33)X100=78.7%	78.7%X3.4=2.68
CS cake 42	7	(7/33)x100=21.3%	21.3%x2.86=0.61
TOTAL	33 parts	100	3.29



This mx supplies 16% CP and 3.29 Mcal/kg ME (greater than the desired 2.8 Mcal/kg ME level)

Step 2 Mix 2 16%CP, <2.8 Mcal/kg ME

Ingredient			Proportion on% basis	Calculate ME
Maize	9	2	(2/9)X100=22. 2%	22.2%X3.4=0.75
		16		
Alfalfa	18	7	(7/9)x100=77.8%	77.8%x2.49=1.94
TOTAL			9 parts	100	2.69

This mix supplies 16% CP and 2.69 Mcal/kg ME (less than the desired 2.8 Mcal/kg ME level)

Step 3 Then solve for ME

Mixing the two mixes formulated in steps 1 and 2 above in any proportion will not change the CP composition of the final mix since both contain 16% CP. The nutrient that will vary would be the ME. The last step is therefore, to find the proportions of the two mixes that should be combined to give 2.8Mcal/kg ME

Mix 3 final mix 16%CP and 2.8 Mcal/kg ME

Ingredient			Parts	Proportion on% basis
Mix 1	3.29	0.11	(0.11/0.60)X100=18.3%
		2.8		
Mix 22	2.69	0.49	(0.49/0.6)x100=81.7%
TOTAL			0.6 parts	100

Step 4 Calculate ingredient composition in final mix

Maize

In mix 1, 78.7 (18.3% of mix 1 in mix3)=78.7X18.3/100)=14.40

In mix 2, 22.2 (81.7% of mix 2 in mix 3)=(22.2x81.7/100)=18.14

Total mix=14.4+18.14=**32.54%**

Cottonseed cake

Only in mix 1, 21.3 (18.3% of mix 1 in mix 3)= (21.3x18.3/100)=3.90%

Alfalfa

Only in mix 2 77.8 (81.7% of mix 2 in mix 3)=(77.8x81.7/100) = 63.56%

Therefore the ingredient composition of the final ration will be (%)

Maize 32.54

CSC 3.90

Alfalfa 63.56

Total 100.00

Checking

Ingredient	Composition		Proportion	Nutrient	
	CP%	ME(Mcal)		CP%	ME(Mcal)
Maize	9	3.4	32.54	2.93	1.11
Cottonseed cake	42	2.86	3.90	1.63	0.11
Alfalfa	18	2.49	63.56	11.44	1.58
Total			**100**	**16.00**	**2.80**

5.3.2 Computer assisted ration formulation

Ration formulation using the conventional methods, such as simultaneous equation, trial-and-error and square, is a tedious job to do. As a result, nowadays, feed formulation using the conventional way is becoming rare and being replaced by computer programs as they can perform various calculations within no time. In this regard, there are various softwares which are simple and practical with user friendly interface for combining many feed ingredients in a certain

proportion to provide target animal with a balanced nutritional feed with least possible cost. A person with basic knowledge of computer can easily use this software.

Some of the least cost feed formulation softwares are:

- FeedWin
- Winfeed 2.8 ,
- Mixit,
- Excel Solver,
- FeedMania,
- FeedLive
- Bestmix,
- Feedsoft,
- Brill

The chosen software for this manual to focus on is WinFeed 2.8 software because of the following reasons:-

- It is simple and user friendly for least cost feed formulation

- It can serve to formulate feed formula for any kind of animal including cattle
- WinFeed (www.winfeed.com) is more simple and straight forward least cost feed formulation software developed in the year 2012.
- It allows you to import the feed ingredient information from excel file, instead of key in data for it, which makes it compatible with MS Excel for data import and export
- It has on-screen editing facilities, attractive icons and user friendly menus
- It can handle unlimited number of feed ingredients and nutrients. However, the demo version (completely free) cannot handle more than 20 ingredients and 20 nutrients. It does not support hardcopy printing or data exporting functions. But, for class room teaching and lab practical a limit of 20 ingredients or 20 nutrients is more than sufficient.
- It works in two modes, ***Linear Mode***: suitable for conventional feed formulation and **Stochastic Mode**: specifically for probability based least cost feed formulation. Almost all the existing feed formulation software prepares feed formulas based on Linear Formulation or **Linear Programming**. This method provides only **50%** assurance of meeting nutrient requirements in the feed. On the other hand **Stochastic Formulation** can provide up to **99.99%** assurance of meeting the nutrient requirements in the feed. So, it is the first feed formulation software in the world that is capable of doing **Stochastic Formulation**.

Here below is given the major steps to formulate least cost ration formulation using WinFeed 2.8 software.

Example is given in formulating a ration using FeedWin software

A local farmer has a cow with a weight of 450 kg. The cow could produce 10 kg of milk with 4.0% of milk fat if fed accordingly to maintain the stated production level. Assume that the

farmer has access to the following feed ingredients/raw materials to buy and include in the diets of his cows(Tables 6-8):

Table 6.List of locally available raw materials, their nutritive values(%DM) and respective prices.

Raw materials	Price (Birr/Kg)	DM %	ME(Mcal/kg)	CP%	Mineral	
					Ca%	P%
Wheat bran	0.15	89.9	3.1	16.8	0.14	1
Sesame seed cake	0.35	93.1	2.65	30.7	0.77	1.5
Molasses	0.13	73	1.77	4.5	0.92	0.05
Natural grass hay	0.10	92.3	1.98	6.4	0.24	0.01
Cottonseed cake	0.22	92	2.86	42	0.12	0.54
Salt	0.14	95	0	0	0	0

Table 7.Cow's characteristics/descriptors, requirements and composition of the roughage.

COW DESCRIPTORS			
Average body weight (kg)	DMI (kg/day) @2.5% of body weight	Average daily milk yield(kg)	Milk fat (%)
450	11.25(450*0.025)	10	4
MAINTENANCE REQUIREMENT	**NUTRIENTS**		
TDN (g/day)	DCP (g/day)	Ca (g/day)	P (g/day
3400	275	18	14

MILK PRODUCTION REQUIREMENT	**NUTRIENTS**			
	TDN (g)	DCP (g)	Ca (g)	P (g)
Demand for 1kg milk with 4% milk fat	330	60	2.7	2
Demand for 10 kg milk	3300	600	27	20

Total requirement	TDN (g/day)	DCP (g/day)	Ca (g/day)	P (g/day
Maintenance	3400	275	18	14
Milk production	3300	600	27	20
Total Requirement	**6700 (ME= 2.2Mcal/kg)**	**875 (CP=12.3%)**	**45**	**34**

Table 8.Cow's daily dry and fresh matter intake, feed costs and cost of milk.

Name RM	Feed win%	Daily DMI(kg/d) =11.25kg/day	Daily fresh Matter-FM (kg/d)	$/kg FM)	$/day
Salt	0.5%	0.06(11.25*0.005)	0.06(0.06/0.95)	$0.14	$0.01
Natural grass hay	60.0%	6.75(11.25*0.6)	7.5(6.75/0.9)	$0.12	$0.90
Wheat bran	20.0%	2.25(11.25*0.2)	2.5(2.25/0.866)	$0.15	$0.38
Sesame cake	4.0%	0.45(11.25*0.04)	0.5(0.45/0.93)	$0.32	$0.15
Cane molasses	4.0%	0.45(11.25*0.04)	0.6(.045/0.75)	$0.16	$0.10
Whole cottonseed	11.5%	1.29(11.25*0.115)	1.4(1.29/0.93)	$0.22	$0.31
Total	**100.0%**	**11.25**	**12.51**		**$1.85**
Cost per kg of milk			**1.85/10=$0.185**		

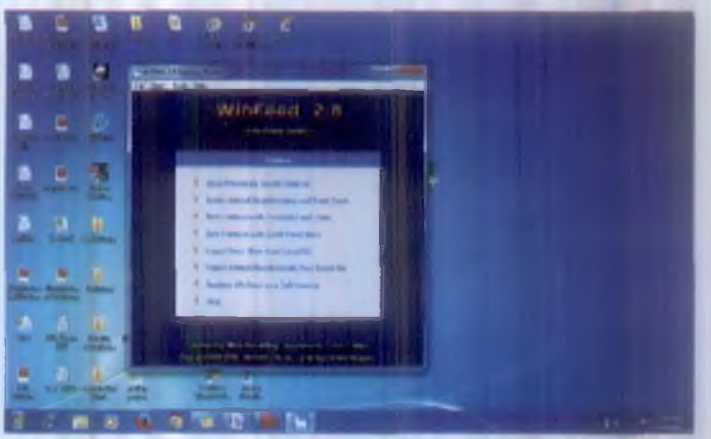
Remarks:

A cow which has the capacity to give 10 kg of milk/day is giving only 2.7 liters of milk per day from natural grass hay only. The cost per kg of milk was $ 0.56; that is price of hay multiplied by Fresh Matter Intake divided by total milk produced (0.12/kg*12.51/2.7). However, after correcting the deficiencies (shortages) using locally available feed ingredient, the daily cost of feed for 10 kg of milk has now become $1.85, i.e., $0.185 per kg of milk. This implies that the daily milk yield has increased from 2.7 kg per day to 10 kg per day. The daily return from the milk has also increase with a significant reduction in the feed cost per kg of milk.

This software should be installed into the computer as an administrator

1. Opening Window

To open the WinFeedclick the installed WinFeed 2.8 from the desktop



This window provides the following options.

1.1. Open an already saved formula

This option will let you open a previously saved formula. Few example formulas have been provided with WinFeed. These formulas can be open through this option.

1.2.Select animal requirement set and an appropriate Feed Store

This is one of the most important functions of this software. WinFeed allows you to save animal's nutrient requirement in one file and the Feed Store (Ingredient Composition Database) in another file. For example, you can have various requirement files like "Nutrient Requirement for Broiler", "Nutrient Requirement for Layer Finisher", Nutrient Requirement for Lamb", Nutrient Requirement for Dairy Cow" etc. in separate files. Similarly you can save various Feed Stores such as "Feed Store for Summer Season", "Feed Store for Poultry", "Feed Store for Region 1", "Feed Store for Cattle Region 2", etc. Once you have these files ready, you can use this option to select one requirement set such as "Nutrient Requirement for Broiler" and an appropriate Feed Store such as "Feed Store for Summer Season", and then start formulation. Few example requirement sets and Feed Store have been provided with WinFeed.

1.3.Start a new formula using an existing Feed Store

By selecting this option you can start a new formula with a selected Feed Store. When you click on this option, you will be asked to select a Feed Store file. After selecting Feed Store, you will be taken to the Main Window where you can select ingredients to be used in formulation. You will also be required to enter nutrient requirements manually in the Main Window.

1.4.New formula with Blank Feed Store

When you select this option a blank Feed Store and a blank formula will be opened. You will have to enter Ingredients and their price and nutrient composition in the Feed Store Window. The Feed Store Window can be accessed from the Main Window. You will also be required to enter nutrient requirement values in the Main Window.

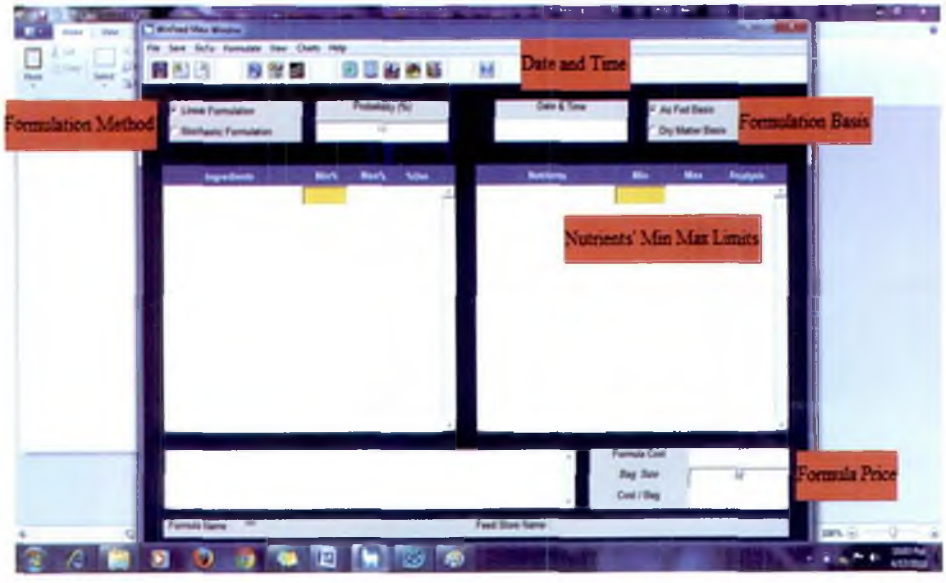
1.5.Import animal nutrient requirements from MS Excel file

This function lets you import Animal Requirements from an Excel file into WinFeed. Many organisations publish Feeding Standards in MS Excel format. After changing data order in these files according to WinFeed required pattern, these files can be directly import into WinFeed.

2. Feed formulation main window

2.1. To stat feed formulation click the start a brand new formula with a new Feed Store (New formula with bank feed store) in the opening window.

This main window which contains all the controls for feed formulation. All selected ingredients, their minimum and maximum limits and calculated formula appear on left side. All nutrients, their minimum and maximum limits and nutrient analysis of the calculated formula appear on the right side.



2.2. Formulation method

The formulation method can be selected as "Linear" or "Stochastic". The probability box will be automatically enabled if formulation method is selected as "Stochastic". The valid value of probability of success ranges from 50 to 99.99 %. Do not put "%" with the value. 80% will be

written as 80. Please note that Stochastic Formulation at 50% probability of success is exactly same as Linear Formulation. It is because the standard normal deviate of 0.5 is zero.

2.3. Formulation basis

The formulation Basis radio buttons provide options for "As-Fed Basis" or "Dry Matter Basis". These options indicate basis for nutrient requirements. When entering nutrient requirements, you must tell WinFeed the basis for these requirements. This is a very critical point. An improper selection of basis will result in an incorrect formula. In monogastric animals, e.g. poultry, usually nutrient requirements are reported on "As-Fed Basis". However, in ruminants requirements are expressed on "Dry Matter Basis". But this is not always the case. You must always look for basis when collecting nutrient requirement from any source.

The resultant formula will be on same basis as that of nutrient requirements. For example, if nutrient requirements are entered on "As-Fed Basis", the formula will be on "As-Fed Basis" too. The mixing sheet will automatically calculate final formulas on both basis. To prepare a mixing sheet click on the button labeled as "Make Batch".

2.4. Formula price

The price per unit of the calculated formula appears under the Formula Price box. No units for weight or currency are mentioned here. The weight and currency units are same which are used in Feed Store database.

2.5. Date and time

This box shows date and time when actual formulation was done.

2.6. Ingredients' min max limits

Feed formulation is done on percentage bases. Therefore, ingredients' minimum and maximum limits should be in percentage but without mentioning any symbol or unit. For example "5.8%" should be entered as "5.8".

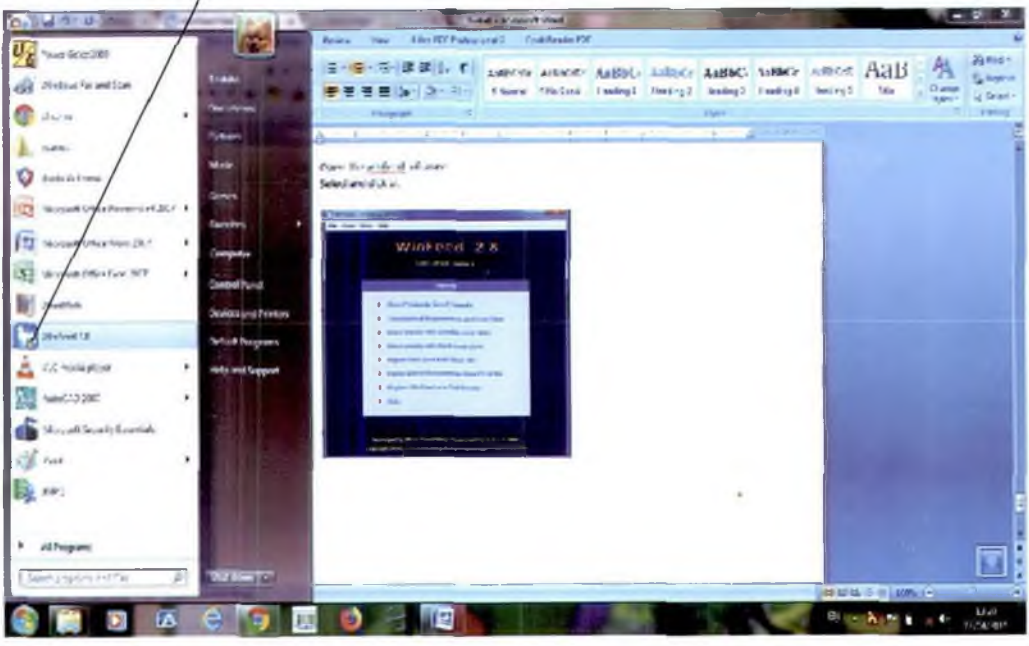
If an ingredient has to be set at a fixed level then both minimum and maximum values should be entered as same. For example if you want to keep Mineral Mixture fixed at "1%" then its both min and max values should be "1".

2.7. Nutrients' min max limits

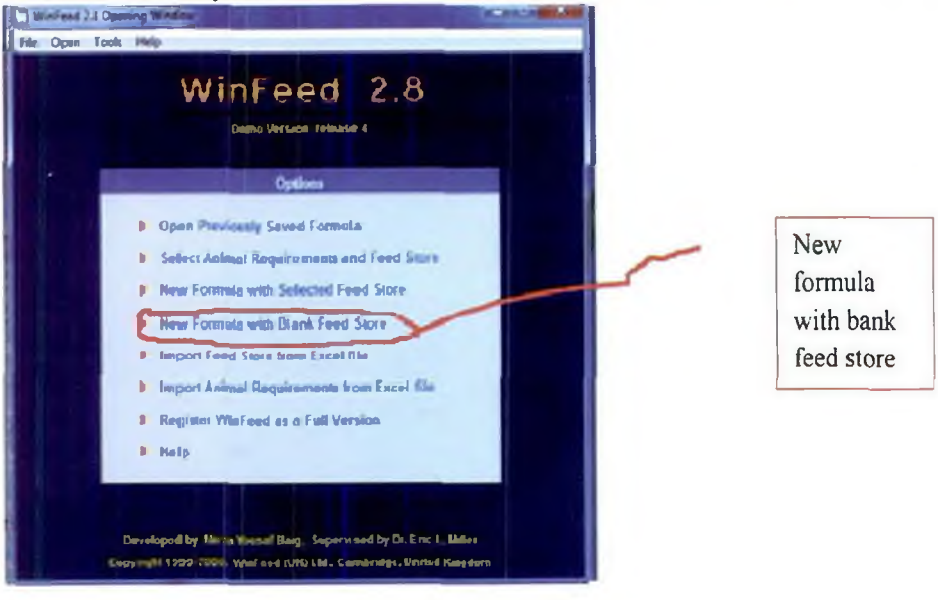
Nutrient limits are not in any specific units. Any units could be used to describe nutrient levels. However, these units should remain the same throughout the programme. To fix nutrient at a specific level use same values for minimum and maximum limits.

Example

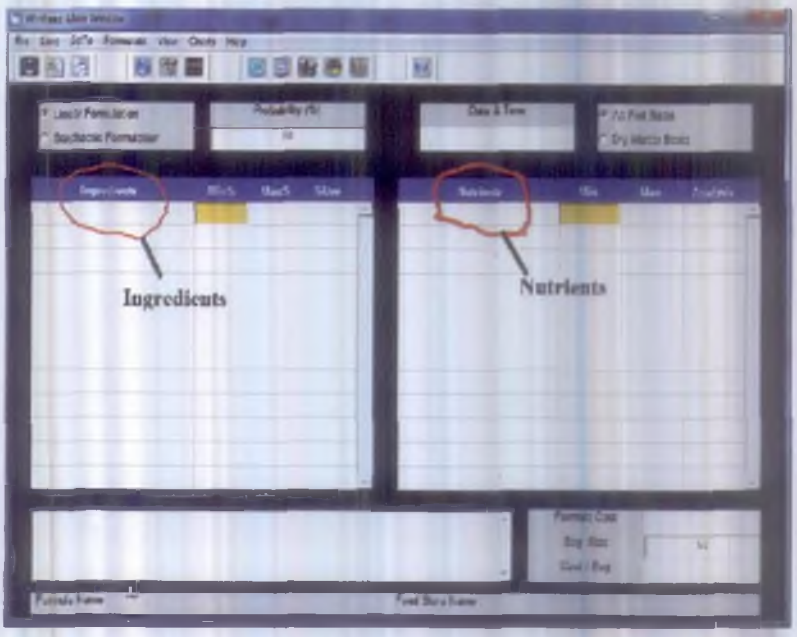
a. Open the WinFeedsoftware



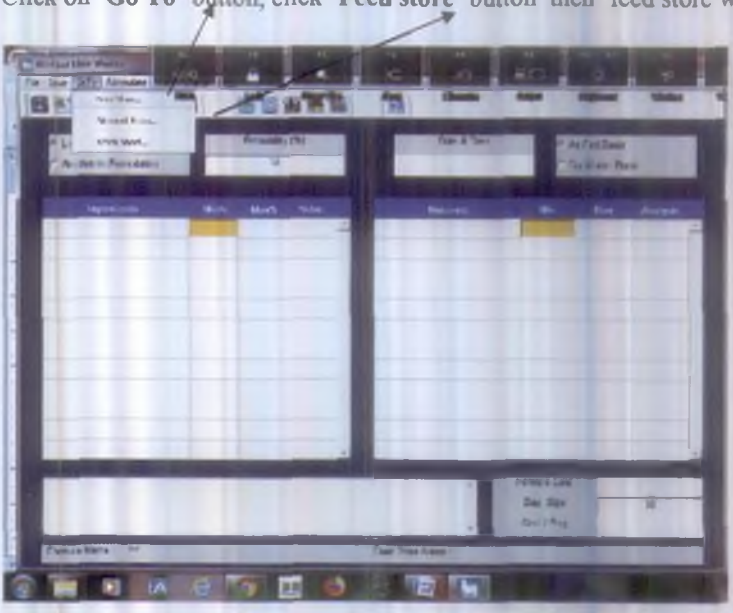
b. Select and click at "New formula with bank feed store" or you can select any other from the listed bars based on your interest



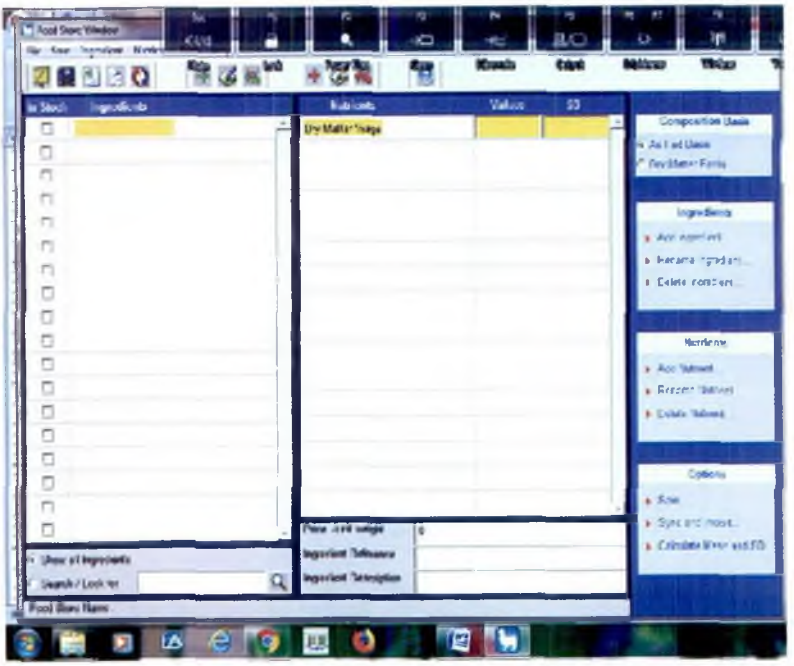
c. WinFeed main window with two boxes (**Ingredients** box and **Nutrients box**) will be displayed to the left and the right side respectively



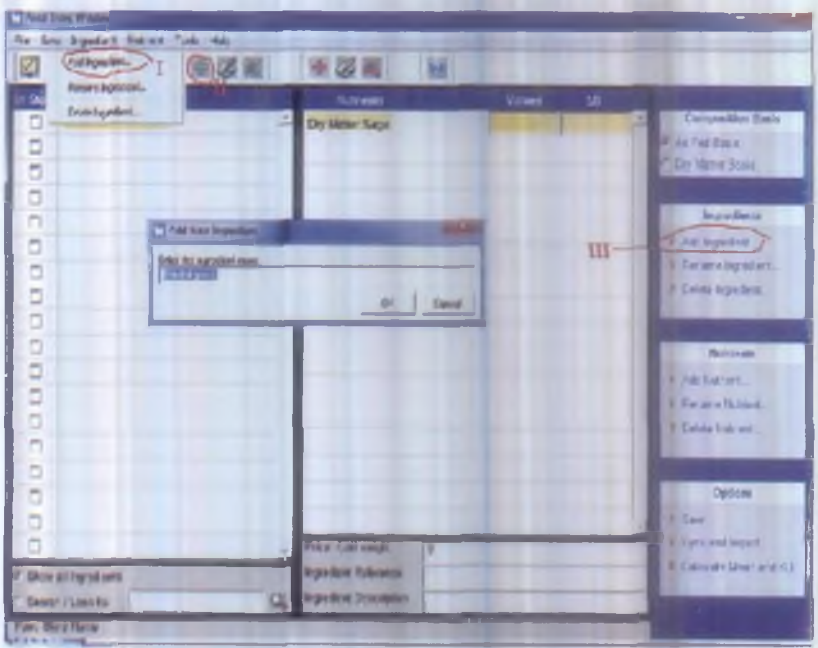
d. Click on **'Go To'** button, click **'Feed store'** button then 'feed store window' will be displayed



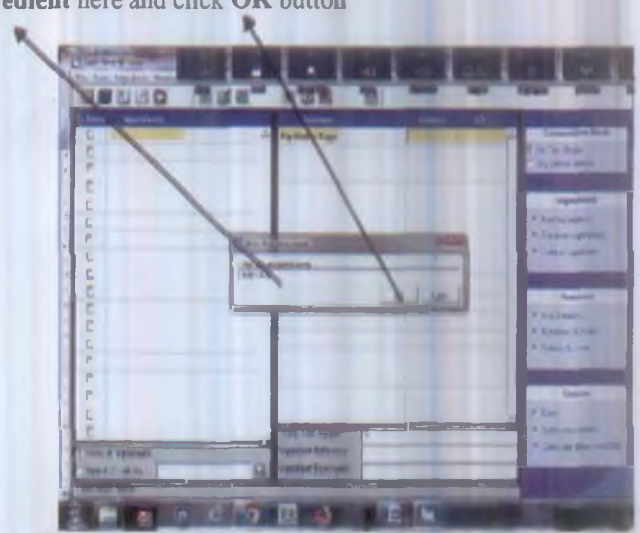
e. Feed store window



f. There are three alternatives to add ingredients in to the feed store window
I, Click ingredient button from the tool bar and then select add ingredient
II, Click on the green cross on the tool bar then the ingredient box will be displayed
III, Click add ingredients from the ingredients box on the right side then the ingredient box will be displayed



Insert your **ingredient** here and click **OK** button



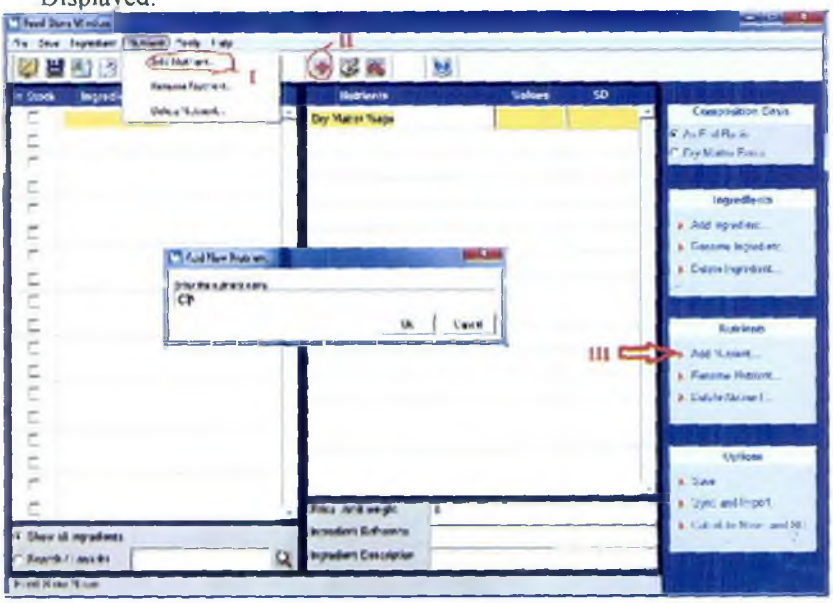
Your ingredients will be displayed under the 'Ingredients' button

g. Similarly insert nutrient content of each ingredient like DM content, ME, CP, Ca& P on the right side of the box with similar way as used to insert your ingredients.

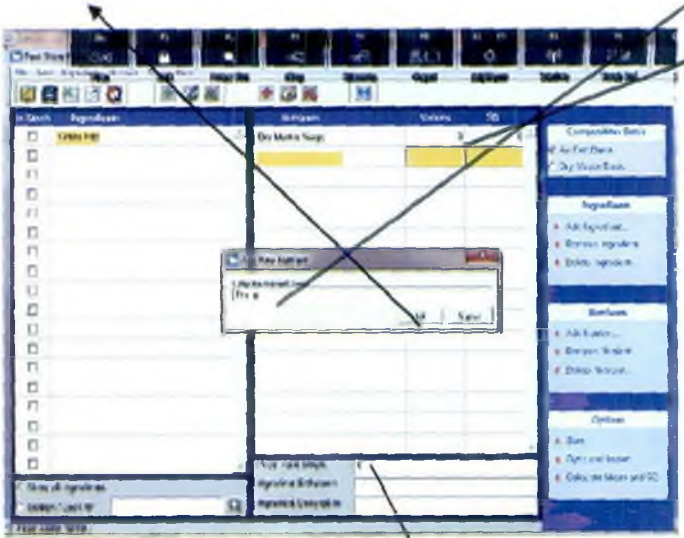
I. Click nutrient button from the tool bar and then select add nutrient

II. Click on the red cross on the tool bar then the nutrient box will be displayed

III. Click add nutrient from the nutrient box on the right side then the nutrient box will be Displayed.

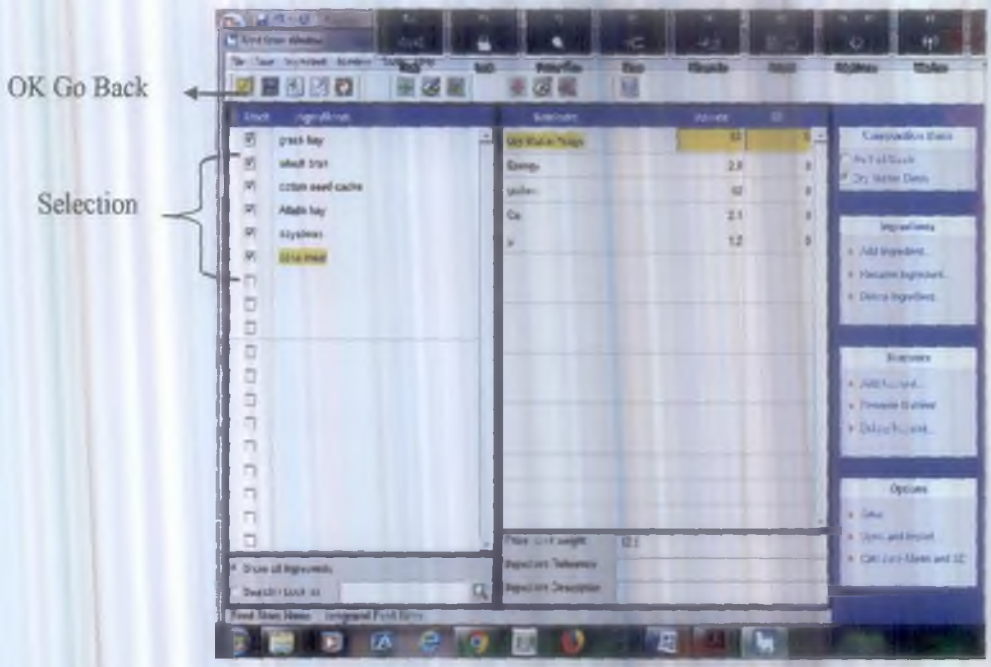


Then a box **'add new nutrient'** will be displayed and insert the **nutrient** name and its **content** and click **'OK'**. Continue with similar way to insert all nutrient contents of the ingredients



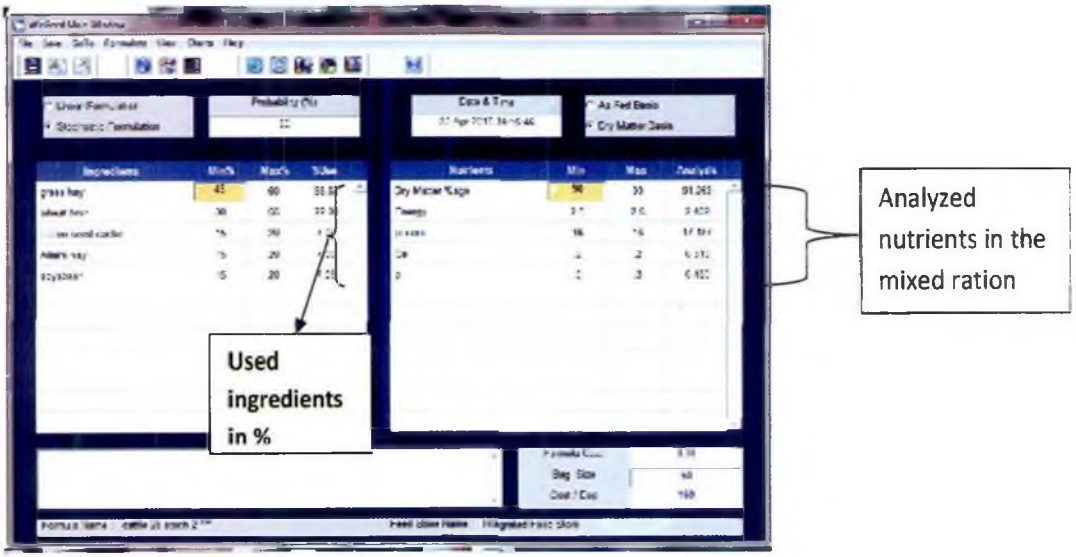
For each ingredients insert price on the **price box**

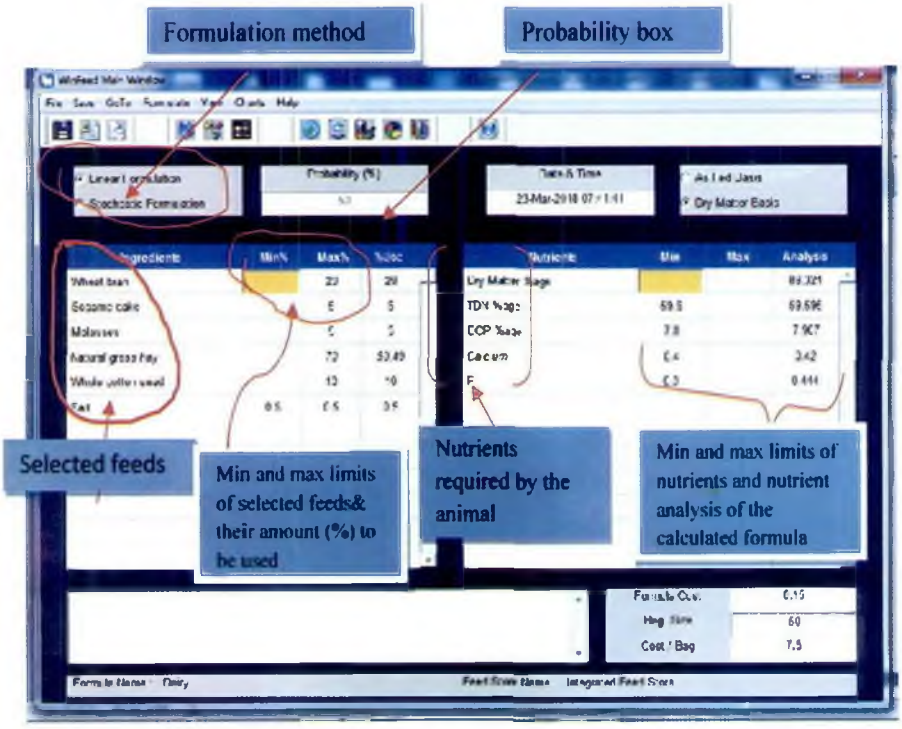
After you insert all ingredients and their nutrient contents and price of the ingredient; select the ingredients by clicking on the boxes in the left side colomun and click on the **'OK Go Back'** symbol



Then main window is displayed. Now fix minimum and maximum value both in the ingredient and nutrient boxes and click on '**formulate**' button on the tool bar or you can click on the **Green circle symbol** to have a formulated ration.

Now you will get the formulated ration





Eventually 56.63% grass hay, 22.09% wheat bran, 7.09% cotton seed cack, 7.09% alfalfa hay and 7.09% soyabean are mixed to produce one mixed ration having 91.26% of DM, 2.4Mcal of energy, 17.18% CP, 0.3 Ca and 0.48% P with a total cost of 169 unit price per one bag(50 kg).

Feed formulation:

- Nutrient requirement: free grazing , 50% requirements, NRC or tropical requirement, need further study on nutrient requirement:
- Grazing requirement should be defined
- Use ME, CP, P, Ca as feed requirement:
- Which one is best:
- Least cost/best cost:
- Free grazing:
- Training needed:
- Use feed available to formulate the ration:

KEY MESSAGE OF CHAPTER FIVE

- Targeted for beef cattle, this chapterhighlights the basic methods of ration formulation from locally available feed ingredients
- Nutrient requirement of target animal, nutrient composition of locally available feed and cost are key considerations in ration formulation.
- Among various ration formulation techniques, examples based on Pearson square method and computer assisted soft ware technique based on Winfeed 2.8are comprehensively described
- For this method to work, the desired level of nutrient should be a value between the compositions of the ingredients that constitute the mixture.
- Different situations for application of the Pearson square under various scenarios are described.
- The Winfeed 2.8 software has several advantages among which import the feed ingredient information from excel file, on-screen editing facilities, user friendly menus , capacity of handling up to 20 ingredients or 20 nutrients.
- Winfeed 2.8 works in two modes ie. linear mode, suitable for conventional feed formulation and Stochastic Mode: providing up to 99.99% assurance in meeting the nutrient requirements in the feed
- Example in formulating a ration using FeedWinsoftware is provided for better understanding and application

6 Feeding Management of Major Categories of Beef Cattle

6.1 Calves

Pre-ruminant calves

In pre-ruminant calves there is little or no placental transfer of maternal antibodies and the calf acquires passive immunity by intestinal absorption ofimmunoglobulin present in the first milk of cow (colostrums). Production of immunoglobulin by the calf itself is not great enough to meet its requirements till about 8-16 days after birth. The calf must obtain maternal antibodies soon after birth or it will have an increased susceptibility to diseases during the first 1-2 weeks of life. The calf must therefore be fed colostrums soon after birth and for the first 2-3 days of life. Colostrum also contains a factor which mobilizes free fatty acids from body fat depots and these acids are probably important energy sources during the critical period soon after birth.

Milk replacer ingredients from non-milk sources (e.g. soybean and fish flour) are used less efficiently than milk products and their inclusion in the diet is limited to the replacement of a portion of the total protein normally supplied by milk. Up to 4 weeks of age, the calf has carbohydrate enzymes capable of digesting lactose and glucose but polysaccharides by the young calf. Soybean concentrate has been successfully used to replace up to 70% of the total protein in milk replacers. Fish flour has a higher content of essential amino acids than soybean. Its composition and the availability of protein in the calf are however quite variable depending on oil extraction procedures in its manufacturing. It has been used successfully in replacing up to 40% of the dietary protein in milk replacers. A number of studies have indicated milk replacers should contain about 200 gm/kg of high quality protein and about 200 gm/kg of fat on dry matter basis. The DE content of a milk replacer with a fat content of 200 gm/kg DM is about 20.9 MJ DE/Kg DM and this allows the calculation of requirements for calves receiving the rest of the ration as whole milk.

When milk replacer rations are used, the calves are fed twice/day for the first 10 days and once/day up to the age of about 5 weeks. If access to high quality forages is allowed during this period rumen development is stimulated and the calves can then be weaned on to a dry concentrate ration (calf starter ration) at about 5 weeks. Generally, the younger the age at weaning, the lower the post weaning gain and the greater the difficulty in rearing the calf.

Calf starter rations

The source of protein in calf starter rations has comparatively little effect on growth rate except at high rates of feeding (and high gains) when high quality proteins (e.g. fish meal) seem to be used more efficiently. However, ground meal, soybean meal or other available high protein meals can be satisfactorily used. Usually, a CP content of 160 gm/kgis adequate to produce near maximum growth though satisfactory growth has been produced at lower levels.

Composition of selected by-products which can be used as protein or energy source to develop local calf starter rations are shown in Table 5. Actual nutrient composition of the selected local ingredients must be analyzed and adjusted during ration formulation.

Table 5. CP and ME values of selected by-products for use in calf starter ration (Seyoum et al 2007)

By-product	CP %	ME (MJ/kg)
Wheat bran	18.9	13.0
Wheat middling	19.3	11.9
Sorghum grain	11.0	14.0
Maize grain	11.4	14.5
Cottonseed cake	26.9	8.9
Noug cake	35.5	10.1
Sunflower cake	29.0	9.6

Alternatively, calves may be released to graze on pastures with supplementation at strategic times to overcome specific nutritional deficiencies. Calves which have been reared on their dams would normally be weaned at 5-10 months depending mainly on the nutritional and reproductive status of the dam. Early weaned calves have a lower live weight/day of age than late weaned calves and where ever possible calves are best left on their dams for as long as possible. However, it is good to note that the condition of a cow is dependent on the demands made for milk yield and forfeeding the calf and hence cows which are in poor condition and lactating are difficult to get earlier into postpartum estrous.

6.2 Heifers

Nutrient requirements for the maintenance and growth of heifers at pastures adapted fromKellaway (1973) and NRC (1970) recommendations is shown inTable 9. The NRC values for DE were increased by 50% since measurements on grazing animals have shown DE requirements are considerably higher than those calculated from housed cattle and used in NRC recommendations. DCP values have been increased to take account of the increase in metabolic fecal nitrogen losses associated with the higher levels of DE intake. It must be noted that the figures be used with precaution because of lack of general agreement on absolute values for requirement of DE and DCP for grazing cattle and the figures given should be used mainly as guide. Urea or fish meal could be used to provide any extra protein requirements and mineral and vitamin supplements. Calves may be fed on these rations up to 3 months of age when they may be fed roughage alone or roughage plus concentrates depending entirely on rates gains required,feed cost and availability of the various feeds.

Table 9. Digestible Energy (DE) and Digestible Crude Protein (DCP) requirements for the maintenance and growth of heifers at pasture

Live weight(Kg)	Gain (Kg/day)	DE (MJ/day)	DCP(gm/day
150	0.00	41.6	130
	0.25	50.8	250
	0.50	56.3	280
	0.75	60.9	320
200	0.00	52.5	160
	0.25	65.5	300
	0.50	75.6	380
	0.75	83.9	390
300	0.00	72.0	220
	0.25	88.6	250
	0.50	107.9	520
	0.75	119.0	620
350	0.00	88.5	270
	0.25	110.7	380
	0.50	133.7	550
	0.75	149.4	560

ME= 0.78DE (Blaxter et al 1966) DCP=0.899CP-3.25

6.3 Bull

Proper nutrition of bull is vital to ensure long term viability of beef/dairy cattle enterprise. The bull contributes one-half of the genetics to each calf crop. Therefore, proper and adequate nutritional management of breeding bulls is critical for the success and economic viability of the beef/dairy enterprise. Proper nutrition of bull is guided by basic consideration during life span of the bull which is a reflection of nutrient requirement for various physiological stages (Table 10) and feedstuff considerations.

Basic considerations

Key nutritional time frames exist in the life spanof the bull in the herd. The appropriate nutritional management of growing bull is a key componentto long term reproductive success of beef cow herds. Like much of the management of the beef/dairy cattle, the transition periods are management situations that can have significant effects on the success of the bull management program. During the transition periods prior nutritional status, current body condition and body weight or growth targets of the bull need to be considered when designing bull nutrition management. The well defined nutritional periods for breeding bull include 1) pre-pubertal pre-weaning, 2) pre-pubertal post weaning, 3) conditioning prior to breeding, 4) management during breeding season, and 5) management after the breeding season.

1. Pre-weaning: During this period, the nutritional management described for calves under section 6.1 can be used. At this stage, it is at the dam's side and nutrition during this period is

likely to be adequate to ensure normal growth and development except when the dam nutritional environment limits milk production such as during period of feed scarcity. Under normal circumstances, the plane of nutrition from dams' milk and forage should be adequate for normal growth rates of bull calves.

2. Post weaning: At this period, nutritional management should allow the bull to grow at a nearly the bull's genetic potential. The goal of this period is to grow the bull rapidly but avoid excessive fat development. The nutritional design of many growing programs or bull test station diet is a concentrate based low roughage and high energy diet. Under or over nutrition during this period can have detrimental effects on bull development, attainment of puberty and semen quality. Under-nutrition results in delayed puberty and over-nutrition can reduce semen production and quality. Typically many of the diets for post weaning usually contain 40 to 60 percent concentrate.A well designed nutritional management should allow bulls to express their growth potential without any deleterious effects on future performance.Yearling bulls should be in condition score of 6 (on a scale of 1=thin and emaciated; to 9= obese) before the start of the breeding season.Once body condition has been assessed, management is needed for over conditioned bulls and thin bulls. The general method of stepping down a portion of the concentrate in the ration with forage over several weeks until the bulls are consuming forage or forage plus a supplement. Yearling bulls should continue to gain 0.70-0.90 kg per day. Thin bulls should be put in a ration with higher level of energy to increase rate of gain. After removal from the cow herd, yearlings should be kept separate from the older bulls if possible. Yearlings need to be fed or graze on a good quality forage or pasture.

3. Conditioning to the breeding season: This period is the most important next to development phase. It is not only the growing bulls which need this conditioning but mature bulls need to be conditioned during the breeding season. Growing bulls once gone through the development phase (based on high energy diet) need to be cycled down to a conditioning or maintenance diet that is often forage based. The transition to forage based diet occurs when the bulls are losing their teeth. The conditioning period should be around 60 days. For well conditioned bull, this time frame will allow bulls to moderate their fat cover and harden up. Additionally the 60 day time frame provides adequate time for the sperm population to turn over and quality sperm to develop prior to the bull entering the breeding service (at body condition score of 5.6-6.5.

Fortwo-year-old bulls get in condition well before the start of the breeding season, start at least 100 days before the start of the breeding season to get these bulls in condition score 6. This may mean some grain or distillers may need to be fed to get them in condition. Starting early enough means that you will not need a lot of grain or distillers to get this accomplished. Two-year old bulls should have more of their mature size by breeding season as compared to yearling bulls. A 600 Kg 2-year-old that is slightly under-conditioned will probably only need to gain 0.5kg per day at this stage in his life. To do this, active bulls may need 16 kg of feed or more on a dry matter basis, of which 1 to 1.4kg should be concentrate. If body condition is well below the target, the amount of concentrate will need to be increased to near 0.5 to 1 kg or more per 100 kg of body weight. The diet will need to be about 12% crude protein. Depending on the forage available, this again may require protein supplement. Monitor the body condition of the bulls closely and make concentrate feeding adjustments to reach the body condition score of 6 before the next breeding season begins. After this age of bull finishes the breeding season, good quality

grass pasture should be adequate. Watch body condition and if they struggle to pick up condition they may need some supplement.

A. Nutrition during the breeding season: The nutritional management during this period is almost always the same as the cow herd. Bulls during the breeding season can lose 45-181kgof body weight which equates to a loss of 1 to 4 units body condition score.

B. Management after the breeding season: The bulls after the breeding season likely will need some attention to restore their bodyweight and body condition. The amount of bodyweight and body condition that needs to be replaced after the breeding season can be considerable depending upon how much bodyweight and body condition the bull mobilized. A 900 kg bull that loses 91 kg could require up to 544 kg of 65% TDN feed to fully regain all of the bodyweight that was mobilized.

Feedstuff considerations

Feedstuff selection for feeding bulls should be based upon the necessity of meeting the nutrient requirements of the growing bull and the unit/price of the important nutrients (energy, protein, minerals). For growing bulls, energy is most likely the nutrient that limits growth, thus feedstuffs that contain adequate energy concentration to support the desired level of growth should be considered. In most cases energy-dense feedstuffs will be some type of cereal grain or crop by-products (corn, oats,dried distillers grains). Fiber based energy supplying co-products are also acceptable feed choices (soybean hulls, citrus pulp).

Protein feeds can consist of any of the oilseed meals or selected co-products (soybean, cottonseed or dried distillers grains). Similarly, the need for roughage in the diet may necessitate the use of medium to good quality forages to support the desired growth level. The digestible protein in good quality forages can help offset the need for very high inclusion levels of protein concentrates.

A variety of roughage sources are fully acceptable as ingredients for bull rations. The selection of any particular roughage option will depend upon the age, bodyweight, and growth requirements of the bull. Common roughage sources such asnative grass hay can be used. The selection of hay should be based upon the performance goals for the bull with the objective of meeting the nutrient requirements. Silage from either corn or sorghum is also a great roughage source for feeding bulls. Silage is particularly useful during the development phase and can have application during the transition phase. Obviously, pasture is a primary choice for roughage in a bull diet. When pasture is utilized, a number of issues need to be considered including adequate pasture forage availability, adequate forage intake, and acceptable forage quality to meet the desired goals. An often overlooked consideration in allocating pasture for bulls is the difference in forage intake compared to cows. Bulls, in some cases can be 1.5-2.0 times as large as cows. Additionally, developing or reconditioning of bulls need higher quality pasture, and thus the opportunity to select higher quality pasture. Thus, bulls may need to be stocked at 1.5 to 3.0 times the land area of a cow.

In terms of mineral considerations, both organic and inorganic may be utilized effectively as mineral sources for bull development. Regardless of the choice to include organic sources or not, the use of well-balanced mineral and vitamin supplement to meet the bull's requirements is the main management consideration. The uses of organic minerals that may result in the greatest benefit include: zinc, selenium, and copper. Increased fertility measures for bulls offered organic zinc have been reportedand elevated concentrations of inorganic zinc were also noted to be as effective as the organic sources. Selenium is also implicated in sperm viability, quality, and overall reproductive health.The year-round use of organic minerals for bull production is not necessary. Similar to the overall conditioning period, the use of organic minerals should be implemented 60-90 days before initiation of the breeding season. The advanced time-frame allows for the turnover of sperm that may have been affected by any transient mineral deficiencies. The use of organic mineral supplementation can be continued into the breeding season if the cow herd is also being supplemented with organic mineral sources and it is believed that the bull will consume the mineral. Outside of the conditioning period and early breeding season the use of organic minerals is not likely warranted. What is important is to provide the bulls the same mineral supplementation program that any productive member of the beef herd should have. Depriving a bull from mineral nutrition for an extended period is not a sound management and will likely lead to longevity issues for the bull.

Table 10. Daily Nutrient requirement for growing beef bull calves (mature size of 900 kg)

	Body weight in Kg					
	272	318	363	408	454	499
Maintenance requirement						
NEmMcal/day	5.93	6.66	7.36	8.04	8.71	9.35
CP kg/day	0.38	0.43	0.47	0.51	0.56	0.60
Ca g/day	8.4	9.8	11.2	12.6	14.0	15.4
P g/day	6.4	7.6	8.5	9.6	10.7	11.7
NEgMcal/day						
0.91 kg/day	3.03	3.40	3.76	4.11	4.44	4.77
1.13 kg/day	3.87	4.34	4.90	5.24	5.68	6.10
1.25 kg/day	4.30	4.82	5.33	5.82	6.30	6.77
1.36 kg/day	4.73	5.30	5.86	6.40	6.93	7.45
1.47 kg/day	5.16	5.79	6.40	6.99	7.57	8.13
1.59 kg/day	5.60	6.28	6.94	7.58	8.21	8.82
CP for gain (kg/day)						
0.91 kg/day	0.41	0.41	0.40	0.37	0.34	0.31
1.13 kg/day	0.50	0.51	0.49	0.45	0.42	0.38
1.25 kg/day	0.55	0.56	0.54	0.49	0.45	0.41
1.36 kg/day	0.60	0.60	0.59	0.54	0.49	0.44
1.47 kg/day	0.65	0.65	0.63	0.58	0.52	0.48
1.59 kg/day	0.69	0.70	0.67	0.61	0.56	0.50
Calcium g/day						
0.91 kg/day	21.9	20.3	18.8	17.4	16.0	14.6
1.13 kg/day	27.0	25.0	23.1	21.3	19.5	17.7

	Body weight in Kg					
	272	**318**	**363**	**408**	**454**	**499**
1.25 kg/day	29.6	27.4	25.2	23.2	21.2	19.2
1.36 kg/day	32.1	29.7	27.3	25.1	22.9	20.7
1.47 kg/day	34.6	31.9	29.4	26.9	24.5	22.2
1.59 kg/day	37.1	34.2	31.4	28.8	26.2	23.6
Phosphorus (gram /day)						
0.91 kg/day	8.8	8.2	7.6	7.0	6.5	5.9
1.13 kg/day	10.9	10.1	9.3	8.6	7.9	7.2
1.25 kg/day	11.9	11.0	10.2	9.4	8.6	7.8.
1.36 kg/day	13.0	12.0	11.0	10.1	9.2	8.4
1.47 kg/day	14.0	12.9	11.9	10.9	9.9	9.0
1.59 kg/day	15.0	13.9	12.7	11.6	10.6	9.5

6.4 Pregnant or lactating cows

Maintenance requirement of mature cows at pasture is given in Table 11 while nutrient requirement of lactating cows with production level of less than 20 Kg is shown in Table12.

Table 11. *Nutrient requirement for maintenance of mature cows at pasture*

			During the last 2 months of pregnancy	
Live weight	**ME (MJ/day)**	**CP (gm/day)**	**ME (MJ/day)**	**CP (g/day)**
350	60.5	281.7	71.8	392.9
400	66.9	326.2	78.7	448.6
450	73.4	359.6	87.8	493.0
500	79.6	381.8	95.6	526.4

Source: Kellaway, 1973 based on NRC, 1970

Table 12. Nutrient requirement of lactating cows with production level of less than 20 Kg per day

Fat content of milk per litre(g)	**ME (MJ)**	**CP (g)**
30	4.02	48.11
40	4.76	54.78
50	5.48	59.23
60	6.20	65.91

It should be noted that the ratio of DCP to DE averages 3.37 for maintenance and 3.89 for maintenance plus pregnancy. This reflects the requirement for protein by the fetus during its final stage of growth. For milk production, the ratio is greater than 7.0 indicating the protein concentration in the feed has to be higher for milk production than maintenance.

To obtain high herd productivity, it is essential to have pastures containing species of high nutritive value and then to practice a system of grazing which allows lactating stock and weaner calves get access to young growing pastures leaving mature pastures for non–lactating or older stock. It is particularly important to maintain condition of lactating cows to enable them re-conceive and calve regularly.

In tropical pastures both DMD and voluntary feed intake decline with stage of maturity. The values for DMD for several tropical species do not vary greatly (Minson, 1972) and so the differences in feeding value between tropical species are mainly due to differences in intake (Milford, 1960). The CP content of pasture species usually declines with stage of maturity. At the young stages of growth, the grasses contain sufficient CP and ME to meet the requirements of most classes of stock, including lactating cows.

However,in the mature stages the CP contents are below 7%, the value below which voluntary feed intake of tropical pastures declines rapidly (Milford and Minson,1965) through lack of sufficient N for active rumen microbial growth.The low CP content of mature pasture is thus a second major reason for low levels of animal production and in many cases is the main limiting factor. This may be seen from data (Table 13) generated from a clipping study of natural pasturein Ethiopia (Zinash et al., 1995). The average CP contents during dry and wet seasons are 3.7% and 8.5% with respective average digestibility of 57.3% for wet season and48.7% for dry season. The respective ME valuesof natural pasture during wet and dry seasons are 8.03and 7.1 MJ/kg, resepectively.

Table 13.Chemical composition and nutritive value of natural pasture at different months of theyear in the central highlands of Ethiopia

Month	CP (%)	IVOMD %	ME (Mj/kg)
July	10.3	52.4	7.7
Aug	8.9	56.6	8.2
Sep	6.3	56.8	8.4
Oct	5.1	56.8	8.4
Nov	3.8	55.5	8.2
Dec	2.6	46.8	6.6
Jan	2.3	52.9	7.4
Feb	2.9	50.6	7.5
Mar	3.4	46.5	7.1
Apr	5.2	47.1	7.1
May	4.6	48.3	7.1
Jun	4.2	49.5	7.3

This low protein intake lowers the rate of digestion and consequently the level of voluntary intake. The DCP content of a pasture diet can be increased in any of the following ways:

1. Inclusion of legume in the diet
2. Use of nitrogen fertilizer
3. Feeding of nitrogen rich supplements direct to the animal

Including legume in both native and improved pastures have been noted to increase live weight gains of steers, the increase being proportional to the quantity of legume in the diet (Stobbs, 1966, Norman, 1970, Evans 1970). The CP content of tropical grasses can also be increased by the use of nitrogenous fertilizer but the CP content falls rapidly when they are allowed to grow to the limits of their N supply. Thus, 8-12 weeks after N fertilizer application, the CP content is similar to that of unfertilized grass. This practice is also expensive and can only be used economically only for specific applications.

The feeding of nitrogen rich supplements direct to the animal is considerably cheaper and is taken by Australia (for example) as practical method at present for increasing the nitrogen content of the diet of grazing beef cattle. Either a protein rich supplement eg. Cottonseed meal, groundnut meal, sesame cake, noug cake etc. may be used or a mixture with high energy feed (eg. Molasses) may be fed.

A source of readily available carbohydrate such as molasses is essential when feeding urea. This allows active microbial growth and rapid conversion of the urea to microbial protein without generation of excessive amounts of ammonia and consequent toxicity. Urea feeding to grazing animals is only successful when nitrogen is limiting in the pasture and generally such feeding converts a sub-maintenance diet to a maintenance diet is rarely a productive ration.

Deficiencies of minerals other than nitrogen can also limit productivity. Minimum requirements for various classes of beef cattle based on NRC (1970) are given in Table 14. By far the most important widespread mineral deficiency limiting beef production over large areas of the tropics is phosphorus. In phosphorus deficient areas, addition of P to the diet either through supplements eg.bone meal, dicalcium phosphate or through addition of P to the pasture will increase both weight gains and fertility of stock grazing tropical pasture.

Table 14. Mineral and vitamin requirements of beef cattle ration

Mineral/Vitamin	Unit	Calf milk replacer	Calf starter	Growing steers or heifers	Non-lactating cow	Lactating cow
Calcium	g	5.5	4.1	3.4	3.4	4.3
Phosphorus	g	4.2	3.2	2.6	2.6	5.3
Magnesium	g	0.6	0.7	0.8	0.8	1.0
Potassium	g	7.0	7.0	7.0	7.0	7.0
Sodium	g	1.0	1.0	1.0	1.0	1.0
Sulphur	g	2.0	2.0	2.0	2.0	2.0
Iron	mg	100	100	100	100	100
Cobalt	mg	0.1	0.1	0.1	0.1	0.1
Copper	mg	10	10	10	10	10
Manganese	mg	20	20	20	20	20
Zinc	mg	40	40	40	40	40
Iodine	mg	0.1	0.1	0.1	0.1	0.1
Molybdenum	mg	6.0	6.0	6.0	6.0	6.0
Selenium	mg	0.1	0.1	0.1	0.1	0.1
Carotene	mg	9.5	4.2	4.0	8.0	8.0
Vitamin A	Iu	3800	1600	1500	3200	3200
Vitamin D	Iu	600	250	250	300	300
Vitamin E	mg	300	--	--	--	--

Generally, the contents of sulphur, calcium and phosphorus is higher in legumes than in the companion grasses and animals grazed on legume based pastures have higher intakes of these minerals.

6.5 Feedlot or fattening of Begayitsteers

Experimental phase

Feed lot or fattening performance of Begayit cattle is not yet well known and there is an urgent need to generate baseline information and best practice on the way forward. Given the large body frame and expected fast growth rate of the breed, it is essential to provide an optimal plane of nutrition (best quality roughage and ideal supplement) to support maximum gain of the steers. It is therefore suggested to undertake a preliminary studyon feed lot performance of growing calves weaned at 9 months of age. The growing calves shall be fed on basal diet of Rhodes grass hay adlib and at three levels of supplementation (2, 3 or 4 kg concentrate per head per day) up to attaining average weight of 300 kg. Group feeding in pens which has roofed feeding and lying area and an open exercise yard where water is available can be used for this purpose. A group of 24weaned bulls shall be weighed, stratified by weight and randomly allocated to three experimental groups. The experimental animals shall be drenched and regularly sprayed against internal and external parasites. Concentrate mixture composed of 43% locally available protein source, 55% wheat bran and 2% salt shall be prepared and fed at 2,3 and 4kg per head per day. Initial weight and body weight gain of every 2 weeks shall be recorded for a durationuntil they attain 300 kg live weight.

Samples of basal feed and feed ingredients shall be taken prior to the experimental period and analyzed for chemical composition, *in vitro* digestibility and energy content using standard procedures. Feed intake (basal diet and supplement) shall be monitored and recorded daily and average daily feed cost shall be recorded for each experimental group. Average daily weight gain shall be calculated as a difference between initial and final body weight of the steers. At the end of experimental period, 2 animals from each group shall be randomly selected and slaughtered for carcass analysis. Feed conversion efficiency and economic benefits of the experimental diets shall be calculated to identify biological and economic optimum of for feedlot performance of Begayit steers. Field day shall be organized for the surrounding community (public, private, trained and organized youth) for wider sharing and possible scaling up of the findings.

Application phase

Based on the findings of phase1, fattening/feedlot of yearling steers of Begayit shall be carried out at community, trained and organized youth, private investors, ranch and sugar cane factory using alternative basal diets and supplements which are locally available. In addition to Rhodes grass improved forages such as Elephant grass, Alfalfa, Cow pea, Peajon pea can be used. In areas accessible to sugar cane factory,multi-nutrient block made of molasses, urea, source of escape nitrogen can be used to support feedlot performance of Begayit cattle.

6.6 Application of total mixed ration (TMR) for Bagait cattle

Application of TMR in ruminant nutrition under tropical environment is skewed towards dairy cattle. However, recent trends indicate that the beef consumer demands sustainability and efficiency calling for more efficient feeding systems. Available grazing acres are on the decline, and feeding byproducts to cattle of all ages has never been a more popular idea. Research continues to investigate the economic potential of full and semi-confinement for cow-calf operations. For example at university of Nebraska-Lincoln using Angus breed, a study on a semi-confinement system for lactating cows, which included dry lotting and grazing cornstalks, proved to be less expensive than traditional pasture grazing and protein supplementation.

A study undertaken in USA indicate revenue per cow per year in conventional operations was in the ranges of 220.00-258.50 $ against revenue ranging from $324.50 under semi-confinement to $363.00in full confinement for older cows. Research on managing cows in confinement will continue to trickle in, and more efficiencies in the cow-calf business will be discovered. One ofthose efficiencies delivers byproducts, feed waste reduction and increased cattle nutrition. Much of the efficiency gain from the total mixed ration (TMR) is very much related to the automation particularly related toTMR mixer. In view of the increasingly limited resources, application of TMR could be extended to Begayit cattle through adaptive research as deems necessary. Under Ethiopian contexts particularly for Begayit cattle TMR can be used in (1) feed lot operationsand (2) use of basal feed (hay) and supplement where animals are fed on semi-confinement after grazing. Ration formation described in chapter 5 and feeding management of various categories of Begayitcattle, which takes into account the use of hay and supplemental feeds canbe supported by application of TMR.

KEY MESSAGE OF CHAPTER SIX

- This chapter comprehensively describes feeding management of major categories of beef cattle i.e calves, heifers, bulls, cows and fattening or feed lot animals based on lesson drawn from tropical countries.
- Owing to the unique features of Begait and limited data set on feed lot performance, approach based on quick fix consisting of experimental and application phase is suggested to generate information
- In tropical pastures both DMD and voluntary feed intake decline with stage of maturity. Thus, the differences in feeding value between tropical species are mainly due to differences in intake .
- The low CP content of mature pasture is a second major reason for low levels of animal production and in many cases is the main limiting factor.
- The DCP content of pasture diets can be increased by Inclusion of legume in the diet and Feeding of nitrogen rich supplements direct to the animal.
- Strategic supplementation of the herd following body condition dynamics, basal diet quality, physiological stage and productivity is key approach in nutritional management
- Including legume in both native and improved pastures have been noted to increase live weight gains of steers, the increase being proportional to the quantity of legume in the diet. Such an approach would be used in realizing the desired nutritional and genetic efficiency of Begait cattle

7 Monitoring Feed and Animal Performance

Apart from genetic factor, animal performance by and large is a reflection of plane of nutrition. Expression of maximum genetic potential of Begayit cattle therefore relies on the capacity to ensure optimal nutrition both at microbial and host animal level. Optimal nutrition in turn is a function of feed quality and the science of feeding. Towards attaining maximum genetic potential, the following key performance indicators pertaining to feed and animal have to be monitored periodically to provide scientific guidance in attaining the set targets.

7.1 Monitoring of feed production, productivity and quality

Cultivated forages and grazing pasture or range

Productivity of cultivated forage and pasture is basically influenced by various factors such as genetics, environment and genetic by environment interaction. However, range and average productivity figures can be used as indicative figures for monitoring productivity at a particular site using particular management practices. Estimate of dry matter yield of cultivated forage or pasture can be done using quadrant sampling, taking fresh weight and drying in an oven at 65^0C for 72 hours. The dry matter content of partially dry sample can be used to calculate the DM yield per ha of particular forage for estimation of productivity and can be compared to the level indicated in Table15 below. Quality assessment based on key indicators of chemical composition (DM, CP, NDF) and nutritive value (IVOMD, ME) should also be made and compared against the the values reported so far under Ethiopian condition.

Table 15. Productivity targets for cultivated forage and pasture

No	Forage	Average Productivity (DM ton/ha/ year)	Highest productivity
1	Alfalfa	11	Harvest of every 3 weeks under irrigation is possible
2	Elephant grass	13	84.8 t/ha when fertilized with 987 kg N/ha/yr
3	Rhodes grass	8	25 t/ha with high N application and variable cutting frequency
4	Pigeon pea	12	
5	Cowpea	10	

Productivity and quality assessment of natural pasture should also be monitored towards mid ofSeptember using standard procedures of yield estimation (quadrant sampling) at representative sites to guide subsequent management practices. Quality assessment based on key indicators of chemical and mineral composition (DM, CP, NDF, major minerals) and nutritive value (IVOMD, ME) should also be made and compared against the desired values indicated in Table 16 below and standard nutrient requirement for minerals.

Table 16. Desired chemical composition and nutritive value of native pasture or hay

No	Parameter	Content
1	CP	>7.0 %
2	NDF	< 55.0%
3	IVOMD	> 55.00
4	ME	> 8.8 MJ/kg

Analysis of chemical composition of feed ingredients and compound feed should also be made periodically to monitor the quality of supplemental feeds based on standard procedures. The values obtained should be compared against the desired composition and quality of supplemental feed indicated in the ration formulation procedure. Visual inspection of feed ingredients and compound feed (changes in color, presence of mold etc.) should also be carried out for monitoring feed safety (Seyoum, 2015)

7.2 Monitoring of feed utilization and performance of major categories of Begayit cattle

Daily feed offer (supplemental feed) to a group of animals can provide general impression on supplemental feed offer and utilization. It is therefore of great help if feed utilization and performance of major categories of the herd is monitored based on the following guidelines.Quantity and quality of basal and supplemental feed of calves up to yearling should be monitored taking 8-10 calves from each sex group in individual feeding pen. Weight records of every 15 days should be taken for each calve to capture dynamics in growth.

Supplemental feeds offered to heifers and cows should also be monitored through group feeding in each pen and monthly weight records of individual animal and milk production of lactating cows.Reproductive performance such as age and weight at puberty and first calving of heifers and reproductive performance of cows shall be monitored and recorded.

KEY MESSAGE OF CHAPTER SEVEN

- This chapter is committed for setting the framework for monitoring the progress made in feed resource development and attaining nutritional efficiency of Begait cattle.
- From feed perspectives, production, productivity and safety/quality of basal /supplemental feeds shall be monitored against set standards.
- Analysis of chemical composition of feed ingredients / compound feeds supported with visual inspection are required to ascertain the desired safety and quality.
- Feed intake and animal performance of various categories shall be monitored using representative animals from each category and compared against set targets .
- The monitoring results shall be the foundation of corrective measures towards ensuring the set targets in feed resource development and nutritional efficiency of Begait cattle.

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