Plant and Animal Origin Protein Supplements on Overall Nutrient Digestibility, Growth and Reproductive Performances of Dairy Calves

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Abstract
This paper represents a review work on the different animal and plant sources of protein supplements for growing calves, comparative nutrient degradabilities and difference in growth and reproductive performances of calves fed with those protein supplements. Animal origin protein sources include meat and bone meal, blood meal, poultry by-product meal (poultry meal) and feather meal. These are all concentrated sources of protein and amino acids and some are also good sources of vitamins and essential minerals. There are many possible sources of plant protein for livestock rations. These include oilseeds, by-products of food production, arable and forage legumes. Animal origin protein supplements in general have better composition and balance of amino acids compared with plant origin proteins. Higher level of rumen undegradable intake protein fractions of animal sourced proteins has been demonstrated. The overall intake, digestibility and performance of calves fed either animal origin or plant origin protein supplements are comparable.
Keywords: Animal protein, plant protein; intake; digestibility, performance

1. Introduction

Proteins are required by the calf to maintain biological processes on a daily basis, as well as repairing tissues and forming blood. Proteins are also an integral part of growth, such as the laying down of muscle. Most protein synthesis takes place in other body tissues such as the liver and gut wall, which are actively concerned with processing nutrients to meet the requirements of the body. These metabolic functions include such things as synthesis of enzymes and hormones; cell division and cell repair, and so require a continuous supply of different types of protein and energy. The building blocks of all proteins are amino acids.

There are more than 20 specific amino acids needed by livestock. Feed protein is broken down by digestion into its individual amino acids, which the calf absorbs and then resynthesises for its maintenance and growth. The precise needs for specific amino acids are well known in non-ruminants such as pigs and poultry but there is little information available on the amino acid requirements of calves and adult ruminants. Because the milk-fed calf depends entirely on its diet to supply them, the amino acid composition of whole milk would probably match its specific requirements. To optimize production, growing calves are often supplemented with undegradable intake protein (UIP) to meet their metabolizable protein requirements. Using supplements with increased UIP protein values has previously been shown to increase gains in growing cattle (Wilson et al., 1999). The use of various protein sources offers the chance to consider the effects of digestible protein, rumen undegradable protein, metabolizable protein, or amino acids on growth. Metabolizable protein is a function of the rumen undegradability of the protein, the protein's digestion, and also how well the rumen degraded protein fraction is captured as microbial protein.

The objectives of this paper were to review

- The different animal and plant sources of protein supplements for growing calves
- The comparative nutrient degradabilities of animal and plant origin protein supplements and
- The difference in growth and reproductive performances of calves fed with animal and plant origin protein supplements.

2. Different Animal and Plant Origin Protein Supplements

2.1. Animal Origin Protein Supplements

Proteins are essential constituents of all biological organisms and are found in all body tissues of animals. Proteins are found in higher concentrations in organ and muscle tissue, and range from very insoluble types in feather, hair, wool, and hoofs, to highly soluble proteins such as those in serum or plasma (Meeker, 2009).

Animal products include meat and bone meal, blood meal, poultry by-product meal (poultry meal) and feather meal. These are all concentrated sources of protein and amino acids and some are also good sources of vitamins and essential minerals. During slaughter and processing, between 33 and 43 percent by weight of the live animal is removed and discarded as inedible waste. These materials, which include fat trim, meat, viscera, bone, blood and feathers are collected and processed by the rendering industry to produce high quality fats and proteins that have traditionally been used in the animal feed and oleochemical industries around the world. Meat and bone meal, blood meal, feather meal and poultry meal are suitable for use in feeds for a wide range of animal species, including fish and shrimp.

Poultry by-product meal - Poultry by-product meal (PBM) consists of ground, rendered, clean parts of the carcass of slaughtered poultry such as necks, feet, undeveloped eggs and intestines, exclusive of feathers, except in the mounts as might occur unavoidably in good processing practices. The label shall include guarantees for minimum crude protein, minimum crude fiber, minimum phosphorus, and minimum and maximum calcium. The calcium level shall not exceed the actual level of phosphorus by more than 2.2 times. The quality of PBM, including critical amino acids, essential fatty acids, vitamins, and minerals along with its palatability, has led to its demand for use in pet foods and aquaculture (Meeker, 2009).

Hydrolyzed Poultry Feather Meal (FeM) – Hydrolyzed poultry feather meal is pressure-cooked, clean un decomposed feathers from slaughtered poultry, free of additives and/or accelerators. Not less than 75 percent of its crude protein content must be digestible by the pepsin digestibility method. Modern processing methods that cook the feathers under pressure with live steam partially hydrolyze the protein and break the keratinaceous bonds that account for the unique structure of feather fibers. The resulting feather meal is a free flowing palatable product that is easily digested by all classes of livestock. 64 to 70 percent of its protein escapes degradation in the rumen and remains highly digestible inthe intestinal tract. A specific characteristic is its excellentsource of the sulfur containing amino acids, especially cystine (Meeker, 2009). Feather meals have protein contents ranging from 85 - 95%. Feather meals can not be utilized by animals unless it is treated. Hydrolyzed feather results from heat treatment of this by-product under pressure. It is deficient in lysine, methionine and tryptophan. The protein is about 75% digestible. It should be used at low dietary inclusion levels. Other by-products from animal origin supplying proteins include hatchery waste, insect meal, milk and milk by-products.

Blood meal - Blood meal flash-dried is produced from clean, fresh animal blood, exclusive of all extraneous material such as hair, stomach belchings, and urine, except as might occur unavoidably in good manufacturing processes. A large portion of the moisture (water) is usually removed by a mechanical dewatering process or by condensing by cooking to a semi-solid state. The semi-solid blood mass is then transferred to a rapid drying facility where the more tightly bound water is rapidly removed. The minimum biological activity of lysine shall be 80 percent. Blood products are the richest source of both protein and the amino acid lysine as a natural ingredient available to the feed industry. Processing changes have altered the product considerably. In the past, its use was limited due primarily to vat-drying procedures that produced blood meal with poor palatability and low bioavailability of its lysine. Newer methods of processing (ring or flash-drying) produce a blood meal with digestibilities that routinely exceed 90 percent with acceptable palatability. The principal nutritional interest in blood meal is due to its high protein content and as an excellent source of lysine. Its properties as a high rumen bypass protein have been highlighted in research findings in dairy, feedlot, and range cattle (Meeker,2009). Blood meal accounts for 7 - 9 % of the animal live-weight and so it can be harvested. Blood meal is essentially boiled and dried blood. The drying could be done naturally or artificially. Blood meal contains 80 - 82% protein and very little ash. The protein is very high in lysine but deficient in isoleucine. The processing temperature may affect the quality of protein. The protein contained in blood meal has a low digestibility. There is also the fear of disease transmission through the use of blood meal. Well processed blood is however safe for use. Blood meal should not be used beyond 8% inclusion level.

Fish meal - Fish meal is generally considered in the animal protein class of ingredients. Fish meal is the clean, dried, ground tissue of decomposed whole fish or fish cuttings, either or both, with, or without the extraction of part of the oil. It must contain not more than 10 percent moisture. If it contains more than three percent salt, the amount of salt must constitute a part of the brand name, provided that in no case must the salt content of this product exceed seven percent. Fish meal is usually an excellent source of essential amino acids and fat soluble vitamins. Digestibility of its amino acids is excellent, but as with other ingredients, highly correlated to processing. Fish meals can be used in all types of rations (Meeker, 2009). Fishmeal is made of dried, ground whole fish or fish cuttings with or without oil extraction. Fishmeal varies in protein between 54 - 75% with about 10% fat, making it a high protein, high energy feedstuff. Fishmeal protein is high in biological value, supplying all the known essential amino acids. It is also an excellent source of minerals including calcium (3 - 6%), phosphorus (1.5 - 3%) and micro-minerals. It is rich in vit B12. The main constraint to its use is its high cost. High dietary levels of high fat fishmeal may lead to problems of rancidity in the diet.

Meat and Bone Meal

Meat and bone meal (MBM) is a component of animal feed, generated from the low-value components of animal carcasses and used to supply essential amino acids to lactating and fast-growing animals (Buckley et al., 2012). Meat meal should be devoid of hair, hoof, horn, manure and stomach content. The typical meat meal has 50 - 55% of high quality protein. The level of protein varies with the amount of bone contained in the meal. If the phosphorus content of the meal is more than 4.4%, it is regarded as meat and bone meal and contains 45 - 50% proteins. Meat meal is used at about 7 - 10% dietary inclusion. Bone meal is a source of mineral. It is obtained by burning off the organic content of bone. Bone meal is a good source of both calcium (30%) and phosphorus (13%). Other minerals found in bone are also found in bone meal. It has the advantage of being available and can be produced by the local farmer.

Table 1. Amino acid composition of animal Origin proteins supplements

Item	Meat & Bone Meal	Blood Meal[b]	Feather Meal	Poultry Meal
Amino Acids				
Methionine, %	0.7	0.6	0.6	1.0
Cystine, %	0.7	0.5	4.3	1.0
Lysine, %	2.6	7.1	2.3	3.1
Threonine, %	1.7	3.2	3.8	2.2
Isoleucine, %	1.5	1.0	3.9	2.2
Valine, %	2.4	7.3	5.9	2.9
Tryptophan, %	0.3	1.3	0.6	0.4
Arginine, %	3.3	3.6	5.6	3.9
Histidine, %	1.0	3.5	0.9	1.1
Leucine, %	3.3	10.5	6.9	4.0
Phenylalanine, %	1.8	5.7	3.9	2.3
Tyrosine, %	1.2	2.1	2.5	1.7
Glycine	6.7	4.6	6.1	6.2
Serine	2.2	4.3	8.5	2.7

Table 2. Suitability of animal proteins to supply a portion of the protein in feeds for various animal species

	Meal			
Specie	Meat & Bone	Blood	Feather	Poultry
Chickens	Yes	Yes	Yes	Yes
Turkeys	Yes	Yes	Yes	Yes
Cattle	**No**	Yes	Yes	Yes
Fish	Yes	Yes	Yes	Yes
Shrimp	Yes	?	Yes	Yes
Dogs	Yes	Yes	Yes	Yes

2.2. Plant Origin Protein Supplements

Supplemental protein is available in many forms. Feedstuffs and formulated feeds containing from less than 10 percent crude protein to more than 60 percent crude protein are available. To complicate things further, crude protein may come from a natural protein source, a non protein nitrogen source, or a mixture of the two. There are many possible sources of plant protein for livestock rations. These include oilseeds, by-products of food production, arable and forage legumes. There are many examples of high quality plant protein sources available from by-products of food or drink production (Crawshaw, 2001).

Soybean meal- a residual product of the oil extraction process from soybeans, is the most used and preferred protein source in animal feed worldwide. This is due to its relatively high protein content of 44 to 50 percent, its consistent availability and constantly competitive price (Brookes, 2000, 2001). Not only does soybean meal have a high concentration of protein (44% to 49%), the 3 protein is highly digestible. Soybean meal is a rich source of lysine, tryptophan, threonine, isoleucine, and valine – the amino acids that are seriously deficient in corn, grain sorghum, and other cereal grains that are commonly fed to swine and poultry. However, the amino acids are not perfectly balanced; they tend to be low in methionine and cystine (Cromwell, 2011). Soybeans are characterized by high protein (380 g/kg dry matter) and lipid (200 g/kg dry matter) concentrations, which provide high energy density (1.1-1.2 UFL/kg dry matter). In ruminant feeding, soybean integral seeds could represent the only source of protein supplementation for cattle fattening. However, in dairy cows it is preferable not to exceed the dry matter administration of soybean seeds as it may modify fatty acid profile of milk fat and worse butter consistency and conservation. Soya bean meal like most other oil seed meal contain antinutritional factors such as protease inhibitors, phytic acid, allergens, lectins, saponins, antivitamins and phytoestrogens, which are chemical substances used by plants for self defence against invasion of disease causing or foreign organism. These anti-nutritional factors mediate their effect in farm animals by reducing protein digestibility, toxicity, binding with nutrients and causing precipitations or producing un-absorbable chemical forms (unusable) and may negatively impair the development of the gastro-intestinal tract in young animals. Protease inhibitors (trypsin inhibitor) and lectin (haemagglutinin) have a negative effect on digestion, absorption, efficiency of utilisation and metabolism of protein and growth rate in simple stomach farm animals fed on raw or poorly processed (undercooked) soya bean meal(Yin et al., 2011). There are different types of soya bean meal products used for animal feeding and these include solvent extracted, mechanically extracted, extruded, full fat, soya protein isolate, soya protein concentrate, soya oligosaccharides and fermented soya among others. The idea behind the various type of treatment applied to soya bean seed is to neutralise the effect of anti-nutrients present in these seeds and to improve the palatability, flavour and digestibility of soya bean meal products for animal consumption and utilization.

Sunflower meal- also called sunflower oilcake, is a biologically and economically useful protein source for cattle. It is the product obtained by grinding flakes after most of the oil has been removed by either solvent or mechanical extraction processes. In general, ruminants can utilise sunflower meal with its higher fibre levels more effectively than other species. Sunflower oilcake constitutes the fourth largest source of supplemental protein for livestock feeding after soybean meal, cottonseed meal, and canola meal. The nutritive value of sunflower oilcake depends on the oil extraction process and efficiency, variety of sunflower and the proportion of the hulls removed during processing. SFM is characterized contains Variable protein (23 to 39% CP) and fiber (11 to 29% crude fiber or 12 to 22% ADF) content. SFM has High degradability of protein into rumen (approximately 78%) (Todorov *et al*., 2007). Amino acid content of SFM is characterized with relatively high content of sulphur containing amino acids methionine and cystine, but low content of lysine. Sunflower meal is the by-product of the oil extraction process. Oil is the majority value of sunflower seed and meal is considered a by-product. Sunflower meal is an excellent livestock feed, especially for ruminants. Most ruminants need supplemental protein at some stage of production. Sunflower meal is very useful in many cattle rations. Nitrogen required by rumen microbes can be provided in the form of rumen- degradable protein from sunflower meal. Sunflower meal is more ruminally degradable (74% of crude protein) than soybean meal (66%) or canola meal (68%) (NRC, 1996). Sunflower meal is entirely adequate as the sole source of supplemental protein in dairy rations. Milk production was similar when partially dehulled (Schingoethe et al., 1977) or fully dehulled (Parks et al., 1981) sunflower meal replaced soybean meal in dairy cow rations. Cows fed an extruded blend of sunflower and soybean meal had a more desirable amino acid balance than cows fed soybean meal, indicating that a blend of sunflower and soybean proteins may be better than either protein source alone for high producing cows. Sunflower meal is also well utilized in young calves and growing heifers (Park et al., 1980). Weight gains and feed consumption were similar for calves and heifers fed sunflower meal or soybean meal. Digestion trials indicated that protein digestibility was the same for both meal rations (79 percent) but energy digestibility was slightly less for sunflower meal rations (73 percent vs.78 percent for soybean meal) because of the low digestibility of sunflower hulls (Nishino et al.,1980). Sunflower meal was equivalent to soybean meal for growing heifers. The 31 percent protein sunflower meal was as suitable as urea when fed to steers at up to 20 percent of the ration and as suitable as cottonseed meal when fed at 11 percent of the growing finishing ration (Richardson and Anderson, 1981). Feeding sunflower meal at 22 percent of the ration resulted in increased dry matter and crude protein digestibility and higher nitrogen retention

Rapeseed meal (RSM)- Canola meal, or rapeseed meal, is a by-product of the oil extraction of canola. The meal is produced by the solvent extraction process along with the oil. The processing method will influence the nutrient availability, the anti-nutritional factors (toxins) and thus the nutritive value of the meal. Solvent extracted canola meal is processed at lower temperatures to produce a high quality meal with low levels of the anti-nutritional factors. Canola meal can also be produced by the less common techniques of cold pressing and expeller extraction. There are some differences in the processes, which affect the nutritive value of the resulting meal. Cold pressed meal may contain higher levels of toxins, which will limit its inclusion into feeds

Seeds of rape, canola type, contain approximately 40% oil and 22% CP. Remaining after extraction of oil RSM contain between 32 and 40% CP depending on variety of rape, growing condition and processing the seeds (Yildiz and Todorov, 2014). Remaining oil in RSM varied from 2 to 4%, and crude fiber varied from 11 to 14%. RSM contains significant quantity of crude fiber (9.5%), ADF (20.8%) and NDF (30.1%) (Anonymous, 2011). Increasing the ruminal turnover rate from 2 to 5% and 10 %/hour reduced effective degradability from 79.3 to 65.2% and 56.9% respectively (Sadeghi and Shawrang, 2006). According data summarized by NRC (2001) rumen degradability of CP is 73% at low DM intake and 64% at 4 kg DM intake/100 kg body weight. Canola meal optimizes the amount of absorbable amino acids for lactating dairy cows by providing adequate amounts of rumen-degradable protein (RDP) that stimulates microbial protein production in the rumen. Microbial protein is a high-quality protein that accounts for as much as 60% of a dairy cow's metabolizable protein requirements for milk synthesis. The high rumen protein degradability of canola meal efficiently provides ammonia, amino acids and peptides, which are essential growth factors for rumen bacteria that can be readily incorporated into microbial protein (Brito et al., 2007).

Table 3. Amino Acid composition of plant origin protein supplements

Feed stuffs	Amino acid composition											
	Lys	His	Arg	Thr	Gly	Val	Ile	Leu	Tyr	Phe	Cys	Met
Canola meal	4.69	2.40	5.16	4.51	5.10	4.95	3.97	7.35	3.35	4.69	2.09	1.91
Corn gluten meal	1.55	2.21	3.19	3.25	2.91	4.22	3.64	14.1	5.19	6.80	1.73	2.43
Linseed meal	2.78	1.88	5.38	3.07	5.83	2.66	1.53	4.87	3.24	3.91	1.95	1.97
Soybean meal	5.41	2.64	5.94	4.00	4.52	3.97	3.60	8.16	3.90	5.42	1.67	1.51
Sunflower meal	2.96	1.84	5.29	3.63	5.56	4.13	3.04	6.67	2.44	4.65	2.02	2.90

2.3. Effect of Animal Origin Protein Supplements on Intake and Nutrient Degradability

Alam et al. (2012) reported that addition of fish meal in the concentrate portion of heifers diet results in an increase of total dry matter intake. 5%, 7.5% and 10% fish meal addition to the diet results in 7.7, 7.5, and 8.5 kg/day DMI. The same report showed that there is a tendency to increase digestibility when increase the fish meal contents. 53.7, 57 and 56.7 % crude protein digestibility were reported respectively for the same amount of fish meal additions. Klemesrud et al. (1998) reported daily DMI(% BW) of 2.08 and 2.08 for feather meal and poultry by product meals respectively in calves. In a study to evaluate the ruminal escape protein value and post ruminal digestibility of fish meal (FM) vs two high-bypass protein blends in an 88% concentrate finishing diet where, blend 1 (B-1) contained 5% fish meal, 25% meat and bone meal, 20% blood meal, and 50% hydrolyzed feather meal and blend 2 (B-2) contained 55% meat and bone meal, 25% blood meal, 10% fishmeal, and 10% feather meal. Ruminal indigestible intake protein values averaged 52, 69, and 71%, for FM, B-1 and B-2, respectively while post ruminal protein digestibilities of FM, B-1, and B-2 were 95.7, 77.6, and 87.0%, respectively. Typically 60–70% of the protein in fishmeal escapes degredation in the rumen and hence it is an excellent source of DUP. Gibb et al. (1992) reported that the true N digestibility of feather meal (FM) and meat and bone meal (MBM) as 89.8% and 96.7% respectively.

Addition of fishmeal increased the digestibility of DM from a mean of 0·708 to 0·744, digestibility of gross energy from 0·646 to 0·694 and that of N from 0·422 to 0·592 but had no significant effect on the digestibility of cellulose (0·766 vs 0·788 for treatments without and with fishmeal respectively (Thomas et al., 1980). The crude protein effective degradability of poultry by-product meal is lower than that of soybean meal (Kamalak et al., 2005) and rapeseed meal (Mustafa et al., 2000) with a ratio of 0.7-0.8, and higher than that of meat and bone meal (Klemesrud et al., 1997). Milk production is a livestock enterprise in which small-scale farmers can successfully engage in order to improve their livelihoods (Hemme *et al.*, 2005). There is considerable evidence that specific nutrients, level of feeding, and body condition may influence fertilization of ova or ease of conception (Cole and Cupps, 1977).

2.4. Effect of Animal origin protein supplements on Growth and Reproductive Performances

supplementation of fish meal (FM) with rice straw based diet can be the best options for feeding crossbred heifers to obtain better performances in terms of dry matter intake, digestibility, daily weight gain and reproductive performance especially estrus. The daily weight gain (g/d) of calves in a 90 days of experimental period was reported as 251.8, 225.9, 262.9 and 440.7 for a fish meal addition of 0%, 5%, 7.5% and 10% respectively in the diet (Alam et al., 2012). Isabelle *et al.* (1990) also observed that live-weight gain of heifers, were significantly higher at the higher plane of feeding through FM with straw based diet. Another study conducted by Rocha *et al.* (1995) showed that bulls assigned to fed FM had higher total weight gain. A linear effect of FM on average daily gain in steers fed grass silage supplemented with FM up to 6.4% of dietary DM concluded by Veira *et al.* (1994). Klemesrud et al. (1998) reported daily daily body weight gain(kg) of of 0.44 and 0 .43 for feather meal and poultry by product meals respectively in calves. Fishmeal substantially increased growth rate of calves fed with silage by 0.49 and 0.3 kg per day (Veira et al., 1998). In Holstein calves, supplementation with poultry by-product meal at 10 % results in higher growth performance and economic efficiency (Heuzé et al., 2011). Study were conducted to measure the performance of calves to three displacement levels of the imported feed ingredients, soyabean meal (SBM) and maize, with the locally available by-product feeds poultry by-product meal (PBPM) and broken rice, respectively. In the first experiment, calves on the PBPM diets up to 50 kg liveweight did not achieve the levels of growth obtained by those on the all SBM diets. At 0, 33 and 66 percents of crude protein displacement levels of SBM and PBPM pre weaning gains were 98 g/d, 44 g/d, and -20 g/d, respectively. This trend continued post-weaning with gains of 500 g/d, 381 g/d and 340 g/d for the respective diets. In the 50 to 100 kg live weight range, utilization of PBPM by calves improved, and gains of 805 g/d, 766 g/d and 798 g/d were obtained, respectively. In the second experiment, calves performed similarly on diets when broken rice displaced 0, 50, or 100 percent of the digestible energy contributed by maize in the concentrate formulation. Preweaning gains averaged 124 g/d, 120 g/d and 157 g/d for the respective diets. Post-weaning gains of 440 g/d, 461 g/d and 440 g/d were later almost doubled to 870 g/d, 822 g/d, and 883 g/d for the respective diets of calves in the 50 to 100 kg live weight range (Surujbally, 1992).

Addition of 10% and 5% fish meal results in 100% occurrence of estrus in heifers fed straw based concentrate (Alam et al., 2012). Staples *et al.* (1998b) reviewed several studies in which included FM in the diet of dairy cows. Burke *et al.* (1997) observed that every 0.5-unit increase in BCS at 58 day postpartum for cows synchronized twice, the rate of estrus detection increased more. Although cows with greater DMI have lower progesterone concentration, improving energy status by enhancing DMI increases peripheral concentrations of progesterone (Britt, 1994), which benefits reproduction. Conception rate at first service and pregnancy rate were 56.15, 75 and 76.92, 87.5%, respectively for 34 and 75 g/kg DM supplementation of poultry by product meals in dairy heifers (Yazdi et al., 2009).

2.5. Effect of Plant Origin Protein supplements on Intake and Digestibility

Soybean meal nitrogen intake averaged 57 g/day, which was 40% of the total nitrogen intake oin steers. Soybean meal nitrogen escaping ruminal digestion increased from 8.3 g/day for the unroasted to 16.5, 20.4, and 27.3 g/day, respectively, for steers fed the 115, 130, and 145^{o}c roasted meals. The SBM nitrogen escaping the rumen increased from 14.7% for the control to 47.3% for the 145^{o}c roasted meal (Stein et al., 2008). In a study to see growth and reproductive performance of calve with dietary treatments of cotton seed meal (CSM) plus maize gluten feed (MGF) as a control, Soyabean meal (SBM) and maize gluten meal (MGM), revealed that average DMI/head(kg) as 7.9, 7.12 and 7.29 for CSM+MGF, SBM and MGM(EL-Ganiny et al., 2010). Daily ration intakes (Kg) by growing heifers were reported to be 2.31 and 2.31 respectively for cotton seed cake and sunflower meals supplementations (Ahmad et al., 2004). Holstein calves were supplemented with rape-seed meal, sunflower meal, or soybean meal from birth to 14 wk of age. Each calf received alfalfa-brome hay ad libitum and up to 3.64 kg whole milk/day until weaned at 68.2 kg body weight. Daily starter dry-matter intake was lower for rapeseed, 0.67 kg/calf, than 0.92 and 0.99 kg for sunflower and soybean rations (Stake et al., 1973). Digestible dry matter of soybean and rapeseed was higher than sunflower: 75 and 74 vs. 68%. Protein digestibility for rapeseed, sunflower, and soybean meals were 79, 82, and 82%. When expressed relative to body weight, DMI of CSM, SBM and CGM were 2.65 2.53% and CGM (2.55% respectively (Zerbini and Polan, 1984). Apparent nitrogen digestibility of SBM, CGM and CSM were reported as 50.1, 61.4 and 53.8 respectively(zerbini and Polan, 1984). Substitution of soybean meal with rapeseed meal decreased total starter intake from 270.4 to 262.1 and 259.6 kg and increased hay intake from 53.7 to 55.1 and 62.7 kg (Fiems et al., 1984). A growth trial of 60 days with 16 male calves (10 to 11 months age) was conducted to investigate comparative efficacy of cottonseed meal (CSM) and sunflower meal (SFM). Cottonseed meal was substituted with SFM at 0, 12, 24 and 36% levels in four rations viz. A, B, C and D. Daily feed consumption was 5.07, 4.30, 4.17 and 3.20 kg while daily weight gain was recorded to be 0.98, 0.74, 0.57 and 0.33 kg under rations A, B, C and D, respectively. In the digestibility and nitrogen balance trial using eight calves, digestibility of organic matter was 63.2, 62.9, 62.1 and 61.7, respectively (Yunus et al., 2004).

2.6. Effect of plant origin protein supplements on Growth and Reproductive Performances

In a study to see growth and reproductive performance of calve with dietary treatments of cotton seed meal (CSM) plus maize gluten feed (MGF) as a control, Soyabean meal (SBM) and maize gluten meal (MGM), revealed that average daily weight gain as 1.09, 1.15 and 1.12 respectively for CSM+MGF, SBM and MGM(EL-Ganiny et al., 2010). In a 183 days supplementation of cotton seed cake and sunflower meals to Friesian calves resulted in a body weight (kg) gain of 0.849 ± 0.056, and 0.914 ± 0.027, while feed efficiency averaged 2.72 ± 0.172, and 2.53 ± 0.0.072, respectively Consumption of the CSM supplement averaged 0.43kg per head per day by nursing calves (Kunkle et al., 1991). Average daily gain (kg) and feed efficiencies (kg feed dry matter/kg gain) for calves fed rapeseed, sunflower, or soybean meals were .58, .64, .65, and 3.10, 2.96, 3.08(Stake et al., 1973). Feeding calf starters with 0, 10 or 20% rapeseed meal did not result in a significantly different average daily gain. Growth rate during 20 weeks averaged 0.80, 0.76 and 0.77 kg per day, respectively (Fiems et al., 1984). The growth performance of 18 Holstein and 20 Jersey heifer calves fed calf starter meals containing either cottonseed meal (CSOCM) or soybean meal (SBOCM) was compared. The diets were isonutritious in terms of crude protein and energy, and were fed from two weeks of age until two or three months of age to Holstein or Jersey calves respectively. Average daily gain of Jersey and Holstein heifer calves was 0.435±0.02 and 0.635±0.03 kg/day respectively (Bangani et al., 2000). Weaned calves have been shown to perform very effectively when canola meal is used as the protein supplement. Claypool et al. (1985) found that 45-day-old Holstein calves gained at rates of 0.6-0.9 kg per day when offered a canola meal-based starter ration during a seven-week pre-weaning and eight-week post-weaning period, respectively (Hill et al., 1991). The usual performance response observed with canola meal supplementation can often be attributed to the extra protein rather than the source of protein. Koenig and Beauchemin (2005) examined the efficacy of canola meal in corn-based feedlot rations. Canola meal resulted in similar weight gain as the iso-nitrogenous control (1.48kg/d vs 1.40kg/d, respectively). However, canola meal supplementation of the low protein diet increased weight gain from 1.29-1.48kg/d as would be expected.

Age at maturity for cotton seed cake and sunflower meal supplemented caves on averaged were 376.33 ± 16.83 and 333.67 ± 4.84 days, respectively (Ahmad et al., 2004). Dietary treatments of cotton seed meal (CSM) plus maize gluten feed (MGF) as a control, Soyabean meal (SBM) and maize gluten meal (MGM), resulted in a Testicular volume (cm3) of 208.05, 238.71 and 253.12 respectively (EL-Ganiny *et al*., 2010). Similarly, the average semen-ejaculate volume produced was 4.14, 4.25 and 4.10 (ml).

Table 4. Differences in apparent nutrient digestibility coefficient (%) of animal and plant origin protein supplements

supplements	DM	CP	Fat	Energy	sources
Animal origin					
Fish meal	67.77	88.84	80.36	95.46	Salim et al., 2004
Blood meal	56.85	71.90	75.30	59.55	Hussain et al., 2011
Meat meal	42.35	79.92	67.40	61.55	Hussain et al., 2011
Feather meal	5 5 .7	71.3	-	-	Blasi et al.,1991
Plant origin					
Sunflower	38.18	71.46	82.37		Hussain et al., 2011
SBM	70.51	92.81	95.36	90.63	Zhou et al., 2004
Rapeseed meal	58.52	88.97	93.71	83.07	Zhou et al., 2004

2.7. Differences in Ruminal Escape Protein Components Animal and Plant Origin supplements

Escape protein is protein that is not degraded in the rumen and thus escapes to the small intestine, were it can be digested. Protein concentrates of plant origin, such as cottonseed meal and soybean meal, generally contain 55 to 70 percent ruminally degradable protein and 30 to 45 percent escape protein (Mathis, 1997). In situ ruminal escape N of 25.2, 55.3, 86.7, and 98.9% for SBM, PBM, CGM, and BM, respectively were reported (Bohnert et al., 1998). Different studies have indicated that 82 to 92% of BM N (Titgemeyer et al., 1989) and 46 to 57% of CGM N (Stern et al., 1983) escape degradation in the rumen. Ruminal escape of PBM and SBM N was 40.6 and 13.7%, respectively (Bohnert et al., 1998). Similarly Klemesrud et al. (1998) also reported escape protein of FTH and PBM as 66.8% and 43.6% respectively. Feather meal protein is about 70 percent rumen undegradeable, but has a poor balance of amino acids (Guthrie and Joe 1991).

Table 5. Differences Rumen degradability and undegradability fractions of plant and animal origin protein supplements

Supplements	CP%DM	DIP (%CP)	UIP(%CP)	SolP (%CP)	NPN (%SolP)	ADFIP(%CP)
Plant protein supplements						
Canola meal	40.9	67.9	32.2	32.4	65	6.4
Soybean meal	52.9	80	20	33	27	1
Soypass	52.6	34	66	6.8	50	1
Brewer’s grains	29.2	34.1	65.9	4	75	12
Corn gluten meal	66.3	41	59	4	75	2
Animal protein supplements						
Blood meal	93.8	25	75	5	0	1
Feather meal	85.8	30	70	9	89	32
Fishmeal	67.9	40	60	21	0	1
Meat and bone	50	47	53	16.1	93.8	4.9

3. Summary

Protein from plant materials makes up the largest portion of the typical feedlot diet, and the quality of this protein will vary with the source. Another source of protein utilized by the ruminant is from animal sources. Typically, animal source proteins have high bypass characteristics. The oilseed crops such as soybeans, canola, sunflowers, safflowers and flax are processed to extract oil for food and occasionally for industrial purposes. The residual meals are excellent sources of supplemental proteins. Animal source materials, which potentially might be available for feeding, include blood meal and feather meal, fish meal, poultry by product meal etc. Typically, these materials are too expensive to be used in practical diets. Ruminant meal and bone meal are prohibited from being fed to ruminants. Failure to meet protein requirements during the early growing phase may lead to marked reductions in overall ADG and gain efficiency, increased carcass fatness, reduced yield grade.

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