

A SIX-DECADE REVIEW: RESEARCH ON CATTLE PRODUCTION, MANAGEMENT AND DAIRY PRODUCTS IN BANGLADESH

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ABSTRACT

Background: Historical changes in the demand of animal protein sources (milk & meat) for human consumption have been largely increased due to increased growth of human population, income and urbanization in Bangladesh. Research on cattle production and management especially cattle breeding, feeds and fodders, milk production and products have contributed to increase potential production and genetic gains of cattle. A comprehensive review on the published inland research reports on cattle production, management and dairy products are lacking in literature which is required for further research for the cattle development and production.

Objectives: An attempt to review on the published inland research reports on the advances in science and technology on cattle production, management and dairy products in Bangladesh

Materials and Methods: A systematic literature review of research articles on cattle production, management and dairy products published between 1962 and 2020 from Bangladesh has been reviewed. A total of 1185 research articles on cattle production, management and dairy products supported with some international related articles have been reviewed and analyzed.

Results: Research data on cattle production, management and dairy products are compiled from 1185 different research reports supported with some international reports. This review covers the status of cattle breeds and varieties with tabulated summary of 21 reports on draught cattle, 83 on fodder production, 97 on nutrition, feeds and feeding, 88 on trials of different feed formulations in non-dairy cattle and 68 on dairy cattle, 5 on the effects of heat stress on health and production, 39 on fattening of cattle, 27 on genetics and breeding, 75 on semen and AI, 20 on factors associated with conception rate (CR), 8 on oocyte and embryo collection, 9 on genotypes of dairy cows, 7 on management of smallholder dairy farms, 48 on milk production status of dairy cattle, 32 on economics of rearing cattle, 99 on productive and reproductive performances of cattle, 7 on estrus and pregnancy diagnosis, 7 problems of dairy farmers, 23 on preservative and adulteration of milk, 20 on constituents and methods of sweet preparation, 11 on cheese preparation, 9 on ice-cream, 56 on yoghurt, 4 on beef cattle production, 34 on birth weight, and 15 on calf rearing including calf milk replacer and calf starter.

Conclusions: Data based reports are important for priority setting and targeting with mandate for cattle development and increase production. Currently, one of the biggest gaps in the inland datasets on cattle research and this review addresses this gap by bringing together in a review and highlighting some of the major findings. Cross-breeding remains an attractive option for cattle improvement because of the quick results that can be obtained by its use and the potential benefits it has farmers. This review would serve as an archive of research reports on cattle production, management and dairy products for the concerned academicians, research scientists, organizations and government for future planning for education, research and extension on cattle production.

Keywords: Systematic review, Six decades, Cattle, Management, Production, Dairy products, Bangladesh

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INTRODUCTION

The livestock sector especially cattle production is rapidly changing in response to globalization and growing demand for animal source foods due to increase population growth, increase income and rapid rate of urbanization that changes in food preferences for people. The health and quality of animal is influenced by genetics, management practices, nutrition and environment. The main target of animal production includes good quality healthy animals that reach full production potential and a quality nutritious and safe food supply. Animal production is the science and art of rearing domestic animals with the subjects as animal behavior and management, genetics and breeding, reproduction, nutrition, meat science, dairy science and technology¹ The production of cattle for various purposes especially dairy, beef, hides and other products which can be primarily categorized into dairy industry and beef industry. Cattle domestication and production have a long history and recognized as a most important livestock species because of their production and role in human culture. Many breeds and varieties of cattle that differ in appearance, performance and environmental adaptation are kept on all inhabited continents but the historic origin of the diverse phenotypes is not always clear. Cattle production systems integrate responsible management strategies, environmental principles and stewardship of property and economic awareness and viability whereas management strategies are uniquely linked with forage production and nutritive value, herd size, housing systems and opportunities to match forages with animal requirements for production.² Cattle are the most common type of large domesticated ruminant livestock of the genus *Bos* under family *Bovidae*. *Bos indicus* and *Bos taurus* are the two distinct species of cattle. The *B. indicus* is the Indian sub-continent zebu (humped) cattle characterized by lower growth rate, smaller size, late sexual maturity, low production and comparatively more resistant to diseases, whereas the *B. taurus* (temperate cattle) is characterized by medium to heavy size, early sexual maturity and has high milk production potentialities. However, the farmers of Bangladesh have been rearing three types of cattle including indigenous, exotic pure breeds and their crosses for the three main purposes which include (a) milk production mainly from indigenous, some temperate and tropical breeds and their crossbred dairy cows, (b) beef production from fattening crossbred and indigenous bulls especially for Eid-ul-Azha and commonly reared both bull and heifers and also all types of culled cattle including cows and bullock and recently introduced Brahman beef cattle, and (c) draught animal power (DAP) mainly by using bullock and also cows.^{3,4} Bangladesh is primarily an agriculture-based country and the majority of the rural households adopt a mixed farming system by simultaneous cultivating crops and rearing livestock. Livestock contributes as protein food supply (milk & meat), source of income, asset saving, source of employment, soil fertility, livelihoods, transport, agricultural traction and agricultural diversification and sustainable agricultural production. The livestock sub-sector provides full time employment for 20% of the total population and part-time employment for another 50% in Bangladesh.⁵ Research is the most direct approach to improve the methods of animal health and production. It appears from the review of available literature that the first published research report on AI in cattle was made in 1964 from the then East Pakistan⁶ and an overview of livestock research reports of the twentieth century in Bangladesh has been reported.⁷ Later on the 50-year review on the prevalence of clinical diseases and disorders of cattle,⁸ review of pre-clinical and clinical research reports on small ruminants⁹ and review on research findings on buffalo health and

production¹⁰ in Bangladesh has been published. An up-to-date analysis shows that a huge number of research articles have been published on the different aspects of cattle production and management from Bangladesh. It is of value to look back and see where we have come from on the concerned research which would be required for the future planning of research especially on cattle production, management and dairy products. Therefore, an attempt was made to review and compile the up-to-date available research reports on cattle production, management and dairy products in Bangladesh.

MATERIALS AND METHODS

The research reports on cattle production published mainly in journals over the last six decades from 1964 to 2020 from the then East Pakistan and now Bangladesh have been reviewed and analyzed during the period for two years from 2019 and 2020 as described.^{9,10}

Research findings on cattle production

Bangladesh is a home to different cattle varieties and crosses but it is difficult to identify these animals as system has not yet been developed to keep record of cattle breeding at either farmers' or national levels and only they can be identified based on their phenotypical characteristics, history of animals and somewhat available of cattle at the regions. The most commonly found cattle varieties and breeds in Bangladesh are Red Chittagong cattle (RCC), Pabna variety, North Bengal Grey (NBG), Munshigonj (Mirkadim) variety, Madaripur type, Dinajpur Dwarf cattle (DDC), Non-descriptive native or local type, crossbred and some imported exotic breeds including Holstein-Friesian, Sahiwal, Sindhi and Jersey.¹¹⁻¹³ These so called varieties of cattle have neither been identified (either by phenotypic and genetic characterization) nor has any objective study been made on their conformation or productive and reproductive performance with larger sample sizes in-situ.¹⁴ There is no specific cattle breed has yet been established in Bangladesh but with long natural selection and occasionally imported bulls some improved deshi varieties of cattle exist in some districts in Bangladesh. The Holstein-Friesian, Jersey, Sahiwal, Sindhi, Haryana, Australian Sahiwal-Friesian have been imported in different times to improve the production potentialities of the local cattle. As a result of this program, some pure exotic breeds, their crosses and up-graded cattle are found in the government dairy farms, commercial private dairy farms, milk pocket areas and in urban and semi-urban areas of Bangladesh. With rapid expansion of crossbreeding and urbanization, the indigenous cattle genetic resources of Bangladesh are under threat of extinction.¹³ Major constraints for cattle rearing and development are mainly associated with lack of specific cattle breed, unplanned cross-breeding program, cost-effective feeds, morbidity and mortality of cattle, inadequate veterinary medical services and unregulated market price for cattle and its products in Bangladesh.

There are about 24.086 million cattle population in Bangladesh where about 6 million are dairy cattle and its 85 to 93.3% indigenous Zebu type (*Bos indicus*) and only 6.7 to 15% crossbreeds.^{13,15-17} Cattle are mostly reared by the smallholder farmers but the living standard of these farmers have not been improved enough as required may be due to rearing indigenous cattle.^{18,19} However, almost 75% women are involved moderately to high levels participation in livestock and fisheries activities in rural Bangladesh.²⁰⁻²²

Non-descriptive indigenous zebu cattle

Cattle in Indo-Pakistan sub-continent belonging mainly to species *Bos indicus* are also known as zebus or humped.²³ India is believed to be the center of origin of zebu cattle (*B. indicus*) which later spread to Africa and southeast Asia.²⁴ There are 43 registered native indigenous cattle breeds in India ranging from dairy to pure draught types²⁵ and about 75 different breeds of zebu cattle are known in the world.²⁶ The Indian indigenous cattle have been classified into three groups viz. (① Milch purposes (1000-1500 kg / lactation) e.g. Sahiwal, Red Sindhi, Gir and Deoni, ② Dual purpose (500-1000 kg / lactation) e.g. Ongole, Hariana, Kankrej, Gaoao, Tharparkar, Mewati, Ratti, Dangi and Nimadi and ③ Draught purpose (< 500 kg / lactation) e.g. Hallikar, Amritmahal, Khillari, Kangayam, Nagori and others.²⁷ Zebu cattle differ mainly in the shape and firmness of the hump, horn size, ranging from long-horned to very short-horned or even almost rudimentary horns and horn shape.²⁸ Zebu cattle have evolved under low levels of selection which has led to high adaptability of these breeds to harsh environment, resistance to tropical diseases and parasites and sustenance on low quality nutritional regimes. Pure zebu cattle can vary in color with coats ranging from red to grey. Their most distinctive features are their large hump, large horns, and even large ears that drop downwards. Zebu cattle are known to be less fertile and have lower levels of milk production than *B. taurus* breeds, but their better adaptation to the environmental conditions make them more likely to reproduce successfully in the tropics. Cross-breeds incorporate the environmental adaptation of zebu cattle with the higher production of *B. taurus* as well as the benefit of hybrid vigor.²⁹

Out of 24.5 million cattle population, of which 80.0 to 90.0% are of non-descript indigenous in origin zebu type having developed hump which are distributed all over Bangladesh (Table 1).^{13,30,31} There is no breed of zebu cattle of Bangladesh but it is assumed that they have evolved in this country over the centuries for natural selection and farmer's interest on draught power to perform agriculture practices.¹³ These indigenous zebu cattle are profitably reared with minimum climatic stress and thrive well in hot and humid temperature and maintaining phenotypic and productive performance in rural Bangladesh.³²

Indigenous cattle population of Bangladesh are mainly *B. indicus* type encompassing various cattle genetic resources like non-descript, RCC, Pabna variety, NBG, Madaripur and Munshiganj varieties are localized in some areas in Bangladesh.³³ These indigenous cattle have well adapted in the extreme tropical climates, ability to maintain body condition on low quality feed stuffs, reputed to give birth regularly, comparatively resistance to certain diseases with lower calf morbidity and mortality and suitable for hard working in hot, humid and rainfall condition. The varied morphometric, productive and reproductive traits of native cattle have been reported from Bangladesh.³⁴⁻³⁶ Some characteristics of indigenous cattle have been reported as (a) Small size and hence lower metabolic heat production, (b) Regular breeder, (c) Lower calf mortality (< 5 to 6%), (d) High variation in phenotypic performance, (e) Better utilization of low quality roughages and (f) Stabilize the existing production and marketing system.³⁷ The observed coat color of zebu cattle in Magura district have been reported as reddish (29.54%), black with white spot (25%), white (18.18%), black (11.36%), grey (9.09%) and ash (6.82%).³⁸ Some overall phenotypic characters of the indigenous zebu cattle have also been reported.^{13,32,33}

- Their coat color varies from red, grey, white, black or a mixture of them in different proportion.
- They have prominent humps, deep shoulders, well-developed hind quarters but the head is slim

with pointed and crescent-shaped horns.

- The forehead is prominent, convex and broad like a bony shield.
- The overhangs eyes in such as way they appear to be partially closed and the animal shows sloppy appearance.
- Ears are long and pendulous and folded like a leaf with a notch at the tip.
- Horns are curved turning back at the tip.
- They have moderately developed dewlap: males have a large and pendulous sheath.
- The tail is long and whip like, hooves are medium-sized, and hair is short and glossy.
- Skin is loose and pliable, hipbones are prominent, udder is well developed including teat tips are round.
- Adult weigh between 150 to 250 kg and yields 47 to 52% of its weight of meat.

The non-descriptive indigenous zebu cattle populations have declined due mainly to the mechanization in agriculture and the introduction of high yielding crossbreeding program.

Pabna variety cattle

Pabna variety of cattle, as the name suggests is from Pabna district especially found in Shahzadpur, Bera and Sathia upazila but it is also distributed in Sirajgonj district as well as areas in Tangail, Dhaka, Manikgonj and Bogura districts (Table 1). They are actually crossbred of imported Sahiwal, Sindhi and Haryana bulls with the native cattle and an intensive selection for milk production for long periods.³⁹ The main features of large size body than their native counterparts, live weight 250 to 400 kg and high milk production in comparison to other local varieties of cows. The coat color is usually red or gray or a mixture of both and mostly deep grey to white with different shades in male cattle. Their physical features like hump and shoulder are similar to zebu cattle. Skin pigmentation pattern have been reported as light red dominated for coat color in both cattle population while black color is most frequently observed in muzzle, eyelid, eyelash, horn, hoof, dew claw and tail switch.^{40,41}

The average milk production of indigenous cattle ranged between 0.50 to 2.50 liters per day while 4.79 liter / day in Pabna variety.⁴² Unique dairy cattle herd of different cross-bred are available in Baghabari region of Milk-Vita. The genetic admixture in dairy herd showed the combination of several breeds in which the frequency of Holstein-Friesian has the highest regarding predominant individual breed characteristics followed by Jersey and Sahiwal with local cows (mainly Pabna cattle). One of the major reasons of this admixture is random and unplanned AI between or among breeds which also affecting the performance of cattle population and such situation originated from non / zero-record keeping system.¹⁶

Red Chittagong cattle (RCC)

The RCC variety is found in the coastal plain zone of the Chittagong district as well as to a smaller extent in Noakhali and southern regions of Comilla (Table 1). The concentrated areas of RCC have been reported in Anwara, Raozan, Hathazari, Chandanaish, Patiya and Bashkhali upazila.^{11,43} They have distinct identity with attractive red body color, delicious milk and meat compared to other indigenous cattle make them to preferred in that region. The characteristic phenotypic features of RCC have been reported as: (a) Red coat color (deep to light), (b) Whitish red or brick red color muzzle, horn, hoof and eyes, (c) Narrow thin headed, (d) Flat forehead,

(e) Blocky as well as medium body sized, (f) Males are heavier than females, (g) Physical condition is very strong and stout, (h) Large tail with whitish switch, (i) Milk vein is compact and not so prominent, (j) Well developed hump in males but less prominent in females and (k) Prominent dewlap in males.⁴³⁻⁴⁵ The morphological measurements of RCC have been reported to be increased significantly ($p < 0.01$) with the advancement of age.³⁵

The average birth weight is 15.4 kg with highest live weight gained at 30 months (122.8 kg) and then declined the live weight of RCC.⁴⁶ A typical RC bull weighs 250 to 400 kg and cow 150 to 250 kg and 48 to 52% meat of its actual weight. Horn length and diameter for male and female have been reported to be 11.43 ± 1.17 , 11.68 ± 1.08 and 10.84 ± 1.13 , 9.187 ± 1.08 cm respectively. The body length, body height and heart girth of cow and bull have been reported as 107.13 to 114.34, 105.94 to 107.71, 136.90 to 130.85 and 131.44 to 134.0, 124.46 to 125.0 and 165.45 to 168.0 cm, respectively. They have medium sized udder with their teats 5.02 ± 0.03 cm in length and 5.84 ± 0.04 cm diameter.⁴³

Growth performance and reproductive potential of RCC based on phenotypic and genetic parameters have been reported.⁴⁷⁻⁵⁰ The productive and reproductive performance RCC is very much promising and appreciable than other non-descriptive indigenous cattle available in Bangladesh.^{43,51} The similar performance of RCC has been reported in both the intensive and traditional management system and equally suitable for both the systems of management.⁵² The RCC has been reported to have similar body weight and growth performance in farm and field conditions that indicates their equal suitability in both management systems.⁴⁶ The estimation of adjustment factors for standardizing age and season corrected 305 days milk and heritability and repeatability of standardized milk yield,⁵³ feeding and management practices,⁵⁴ economic values for different economic traits,⁵⁵ socio-economic status of RCC farmers⁵⁶ and farmers' attitude toward rearing RCC⁵⁷ have been reported.

North Bengal Grey cattle (NBG)

The NBG cattle are found scattered in the northern district of Bangladesh (Tista meander-flood plain and lower atria basin zone) especially in Rajshahi division (Table 1). This variety of cattle might have been originated from cross-breeding of local cattle with that of cattle imported from northern part of India for long period. A surveyed area of the north Bengal showed that about 54% of the total cattle population recognized as NBG variety.¹⁴ The body is small, compact and less fleshy. The coat color of NBG cattle mostly deep grey to white with differing shades. The head is small and the color of the muzzles, eyelids and hooves is black. The neck region of adult cattle has an ashy shade which is more prominent and increased with age. The horns are small to medium and curved inward with pointed tips. The ears are small and erect with a sideways orientation and have pointed tips. The face is small and narrow with a flat forehead. The skin is tight, the dewlap is medium and the hump is small in cow and developed in bulls. The tail is long and reached to below the hock. They possess good body size and some draft features and famous as a cart bullock in the market.¹⁴

The major threat to native cattle are scarcity of pure native bulls, indiscriminate national cross-breeding program, lack of conservation and development program and farmers interest for cross-breeding for high production.

Munshiganj variety cattle (MVC)

The MVC is also known as Mirkadim cattle get its name from an area in Munshiganj where they are farmed. However, this variety of cattle is distributed in Munshiganj, Manikgonj and adjacent region of the district (Table 1). These cattle are mostly of creamy to dull pinkish coat color with milk type body conformation have great demand as milk cow in the surrounding regions. Their skin are pigmented, muzzle, eye brow, hoof, horn and switch are black.⁵⁸ Some authors have presumed that this variety has evolved in the localities by selecting breeding and no authentic history of cross-breeding could be traced.⁴⁵ However, some authors reported that in addition to selective breeding since 1930's several attempts might also been made scatter to increase their production potential through infusion of foreign genes both sub-continental and temperate for different periods to improve the genetic resources of cattle.

The MVC is one of the recognized milk type varieties of cattle with good potentialities but its population is rapidly declining due to unplanned crossbreeding program with exotic genetic resources to produce high yielding crossbred cattle without any breeding policy, conservation and development of MCV.⁵⁹

Dinajpur Dwarf cattle

The dwarf cattle in Dinajpur district are comparatively smaller in size than most of the recognized varieties or types of indigenous cattle but their coat color showed remarkable variation. The average live weight of yearling bull is 91.32 kg, bull 109.10 kg, and cow 89.74 kg.¹² Dwarf cattle can be promising cattle type with low feed intake and high milk yield in harsh climatic condition in Northern part of Bangladesh. Morphometric traits have been reported to be smaller than almost all the cattle available in Bangladesh. Productive and reproductive traits are more or less similar with the other cattle. Major constraints of dwarf cattle production are lack of quality breeding, lack of feeds and their cost, disease outbreaks, lack of effective vaccines and medicines and fluctuating market prices.¹²

Exotic and crossbred dairy cattle

The then East Pakistan and Bangladesh government were imported different exotic cattle and semen to upgrade the indigenous cattle in different time. This cross-breeding program has been launched in 1958 by the Directorate of Livestock Service (DLS) with artificial insemination (AI) program which then strengthened during 1975-1976. In 1960s, the Central Cattle Breeding Station and Dairy Farm (CCBS & DF), Savar was established with Sindhi, Sahiwal and Tharparkar breed cattle to upgrade the native cattle. Later in 1973, some Holstein-Friesian and Jersey bulls were imported from Australia which was used for semen production for upgrading the local cattle. The AI service was then extended throughout Bangladesh for cattle development in 1975. A survey of homestead dairy cattle rearing status showed that highest percentage of rural farmers rearing deshi cows (90.0%) in comparison to Holstein-Friesian (5.80%), Red Sindhi cross (1.9%) and Jersey cross (1.9%) cows in Chapai Nawabgonj district.³¹ Dairy farmers' views on the rearing of improved variety of cattle have been described.⁶⁰ Productive and reproductive performances (potentialities) of the different crossbred have been reported to be varied.⁶¹

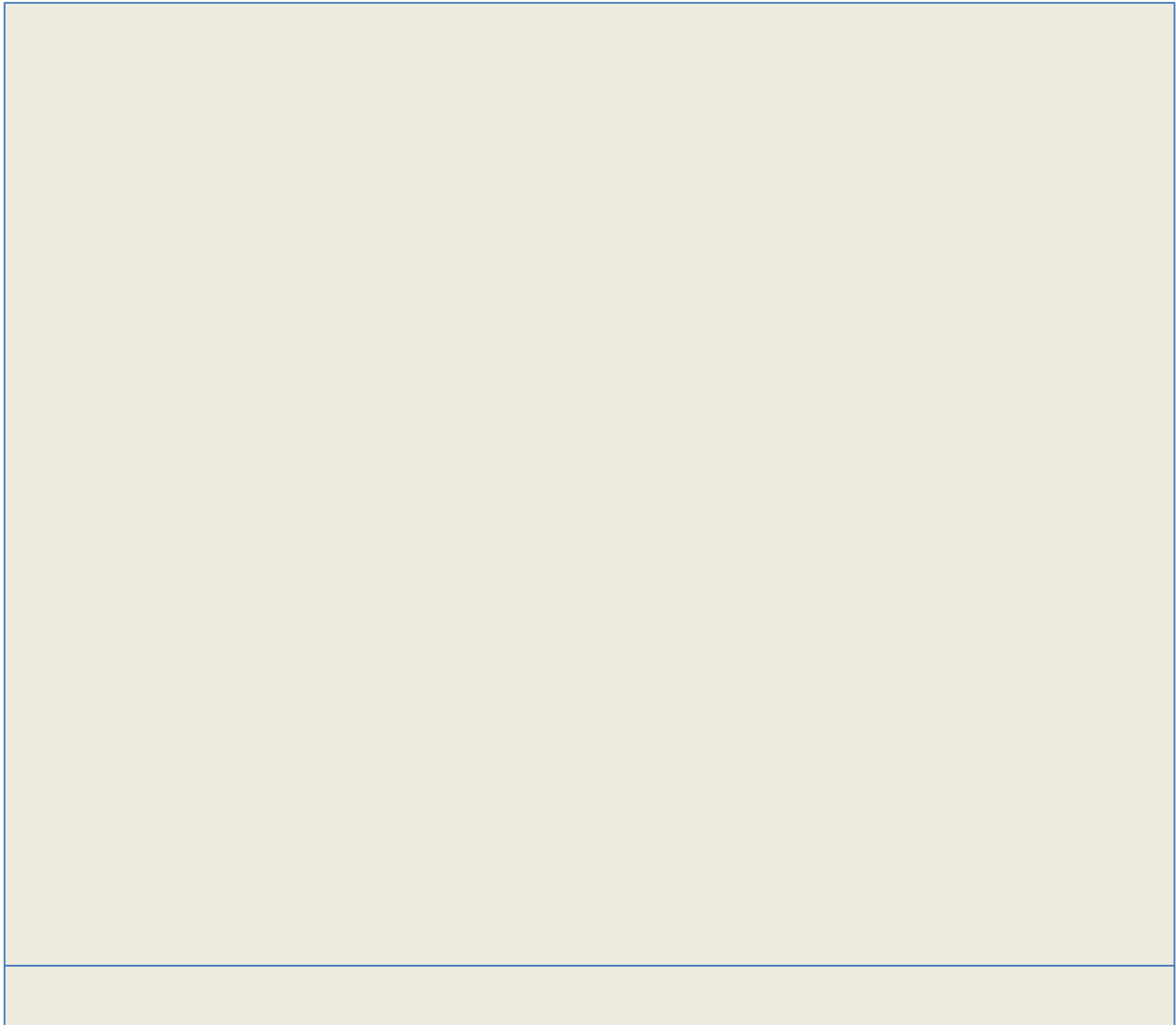
Cattle production, management and dairy products

Table 1. Distribution pattern of different available cattle genetic resources in Bangladesh ^{13,62,63}		
SN Cattle breed & variety	Geographical distribution	Agro-ecological zone/region
1 Non-descriptive deshi	Throughout Bangladesh	All agro-ecological (30) zones
2 Pabna variety	Sirajgonj and Pabna district	Active Brahmaputra and Jamuna flood plain
3 Munshigonj variety	Munshigonj an Manikgonj district	Young Brahmaputra and Jamuna flood plain
4 North Bengal Grey	Northern region (Rajshahi division)	Tista meander flood plain& lowers atria basin
5 Red Chittagong cattle	Chittagong district & CTG Hill tract	Chittagong coastal plain

Morphometric measurement (MM) of native cattle

The MM of animals is usually conducted for the assessment of carcass quality as well as to characterize breeds of animals. Eight different MM of cattle have been described (Table 2) which include: ① Wither height- vertical distance between the fetlock and the point of wither, ② Hip height- vertical distance between the fetlock and the point of hip bone, ③ Body length - distance between points of shoulder to pin bone, ④ Chest diameter - diameter surrounding the heart girth, ⑤ Chest width measures as the broadest portion of the chest, ⑥ Hip width - distance between two hip bones, ⑦ Thurl width - distance between pin bone to hip bone and ⑧ Rump length - distance between parts of base of tail to hip bone.³⁵

Table 2. Body measurement of different varieties and types of adult cattle in Bangladesh					
SN Measurement (cm)	Types	Variety of cattle (Mean ± SE)			
		NDD ³³	RCC ^{11,35*,43,64}	NBG ¹⁴	PV ⁶⁵
① Wither height	Bull	-	125.00 ± 0.87	92.88 ± 2.35	-
	Cow	-	107.71 ± 0.93	93.91 ± 1.13	-
	Overall	100.32 ± 7.79	112.21 ± 0.56 *	-	118.21 ± 3.25
② Hip height	Bull	-	-	-	-
	Cow	-	-	-	-
	Overall	-	109.82 ± 0.49*	-	-
③ Body length	Bull	-	134.00 ± 1.63	99.64 ± 3.48	164.39 ± 2.36
	Cow	-	114.38 ± 1.56	105.16 ± 1.21	-
	Overall	105.78 ± 5.36	110.60 ± 0.45*	-	-
④ Chest diameter/ hearth girth	Bull	-	168.00 ± 1.67	122.23 ± 4.67	-
	Cow	-	139.85 ± 1.63	126.95 ± 1.53	-
	Overall	129.26 ± 6.12	137.22 ± 0.48*	-	147.56 ± 1.70
⑤ Chest width	Bull	-	-	-	-
	Cow	-	-	-	-
	Overall	-	28.82 ± 0.45*	-	-
⑥ Hip width	Bull	-	-	-	-
	Cow	-	-	-	-
	Overall	-	30.69 ± 0.50*	-	-
⑦ Thurl width	Bull	-	-	-	-
	Cow	-	-	-	-
	Overall	-	37.95 ± 0.48*	-	-
⑧ Rump length	Bull	-	-	-	-
	Cow	-	-	-	-
	Overall	-	33.26 ± 0.49*	-	-
NDD = Non-descriptive deshi		RCC = Red Chittagong cattle	NBG = North Bengal Grey	PV = Pabna variety	
* >66 months of age cattle					



Live cattle body weight measurement

Live body weight of livestock species especially cattle is the basis for determining ration amount and supplement, trait to evaluate breeding value, to decide the slaughter weight, to detect the correct dose of drugs and fundamental importance for research works. There are different live weight measurement techniques are employed in animals, some of which are Weighbridge, Weigh tape, Rondo tape, Schaeffer's formula, Agarwal's formula and calculator method. Weighbridge is the standard calibrated weighing scale which provides accurate body weight but less preferred by dairy producers because it is cumbersome, time consuming, costly and stress full to the animals. However, it can be used as a reference value to compare for other techniques. Evaluation of the techniques showed that Schaeffer's formula is the most reliable of all these techniques to estimate live weight of cattle.⁸⁵

Schaeffer's formula to detect BW in cattle

The equation is used for calculating live weight; $W = (L \times G^2 / 300)$, where W is body weight in lbs, L is the length of the animal from point of shoulder to pin bone in inches and G is the chest girth of the animal in inches. The final weight can be converted into kg by $[1 = 0.453592]$. Prediction of live weight of cattle fitted regression lines⁸⁶ and prediction of live weight for Brahman crossbred cattle using linear body measurement⁸⁷ have been reported from Bangladesh.

Feeds and feeding practices of cattle

Cattle is one of the important ruminant animals that convert large quantities of pasture forage, harvested roughage and by-product feeds as well as non-protein nitrogen (e.g. urea) into high quality meat and milk for human consumption. Due to lack of pasture land in Bangladesh, most of the cattle are mainly reared by the smallholder rural farmers and their animals are maintained on crop residues and other agricultural by-products. However, the available animal feed resources in Bangladesh traditionally are grouped into four categories which include ① Forages including grasses and tree leaves, ② Crop residues e.g. rice and wheat straw, ③ Agro-industrial by-products e.g. concentrate and ④ Non-conventional feed resources. Different reports indicate that there is a wide ranging deficit of all these categories of feed resources based on the daily requirement of the animals in Bangladesh. The feeding system of ruminant animals practiced in Bangladesh can be categorized into three which include ① Traditional feeding system, ② Feeding system in the milk pocket areas and ③ Feeding in farming condition.

① Traditional feeding system

Three categories of feed sources e.g. dry feeds, green feeds and concentrates are usually supplied to the ruminant animals. The dry feeds include paddy, wheat and rice straws and dry grasses. The green feeds include road side grasses, weeds, natural vegetation of homestead, forest grass, tree leaves, aquatic weeds and cultivated forages like Napier, German, guinea and maize fodders, grazing or tethering fallow or harvested land and vegetable wastes. Concentrates are seldom fed to the animals which are usually consisted of rice polish, wheat bran and oil cakes. The traditional feeding system for smallholder dairy cattle is based on the use of rice straw, natural grasses supplemented with a little or no concentrates.³⁰

② Feeding system in the milk pocket areas

Mostly the Milk vita operated regions especially Bhaghabarighat, Sirajgonj, Takerhat and Faridpur are considered milk pocket of Bangladesh and during the winter season especially in the Sirajgonj and Pabna bathan areas, mostly the dairy cows are grazed on developed pasture mainly composed of matikalai, mug beans, chickling vetch and Bermuda grass and varieties of natural weeds. During rainy season and flooded areas, animals are kept in the permanent animal shed and allowed to stall-feeding mainly with rice straw, water hyacinth and excess amount of poor quality by-products such as rice polish, wheat bran and oil cakes and occasionally fed with Napier grasses grown in the high land.⁸⁸

③ Feeding in farming condition

Dairy cattle of the organized government and non-government dairy farms are usually maintained by feeding both roughage and concentrates. Fodder crops are grown in the farming areas and concentrate are purchased from local market for feeding these animals.

Challenges in feeding rice straw

Rice straw is a major agro-residue feed which satisfies 90% of the roughage needs of large ruminants in Bangladesh³⁰ but feeding only rice straw does not provide adequate nutrients to the cattle even for maintenance due to low nutritional values (low protein content and poor digestibility) with highly lignified material containing high concentration of anti-nutrition factors like lignin, silicates and oxalates.^{89,90}

Paddy straw contains 25 to 45% cellulose, 25 to 30% hemi-cellulose and 10 to 15% lignin with low nitrogen, vitamins, minerals and high quantities of silica which hinder the nutrient availability to rumen microbes and eventually limits the necessary nutrients uptake for a satisfactory performance of the animals.⁹⁰ The presence of anti-nutritional factors like silicates and oxalates in rice straw with low nutritive value, poor palatability and limited ruminal degradation render paddy straw as non-maintenance type of fodder, so it cannot support nutrient requirement of the animals when fed alone.

The cellulase, hemicellulase and ligninase are required to break down the cellulose, hemicellulose and lignin predominantly present in the cell wall of the rice straw. However, the cellulase and hemicellulase are produced by rumen microorganisms but lignin cannot be breaking down in the rumen due to lack of ligninase. Rice straw has a very high silica content (5 to 15%) which is indigestible phenolic substance that also decreases digestibility of the feed. This high concentration of silica reduces the palatability and the degradability of rice straw in the rumen due to its direct action in preventing colonization by ruminal microorganisms.

The crude protein of 3.0 to 4.7% on a DM basis in rice straw requires protein supplementation to meet the nutritional requirements of most cattle. The high oxalates in rice straw decrease the absorption of calcium. Since rice straw does not contain enough sugars, amino acids and minerals for efficient microbial growth, feeding ruminants with only rice straw without any supplementation of other required nutrient sources will result in poor performance of the animals. There are technologies that have been developed to increase the nutritive value, nutrient digestibility and utilization of rice straw, such as physical processing, pre-treatment using chemicals and /or biological treatment.

① **Physical treatment-** grinding, soaking, chopping or pelleting to reduce the particle size or can be treated with steaming pressure and gamma irradiation. Physical treatment of rice straw aims to improve the palatability and increase intake as well as improve the potential digestibility of ruminants. Soaking straw overnight in water which brings softness between the lignin and cellulose component which promotes higher intake of the animal as well as nutrients digestibility. Grinding, chopping or pelleting has beneficial effects in breaking down the cell wall contents of rice straw which reduce the particle size of the straw and the retention time or passage rate of the ingested treated straw that causes negative effect on decreasing the nutrients digestibility of straw because of the less time exposure of the feed materials for rumination and for microbial fermentation in the rumen.⁹¹ Many of these treatments are not practical for use on small-scale farms, as they require machines or industrial processing.

② **Chemical treatment-** most commonly used chemicals in treating rice straw to improve its palatability, intake and digestibility are sodium hydroxide (NaOH), ammonia and urea. The mode of action of these chemicals is to break the links between the lignin-cellulose structures of

the straw which are sensitive under alkaline or acid conditions. Chemical treatments appear to be the most practical for use at farmer's level, the chemicals are relatively cheap and the procedures to use them are relatively simple but safety precautions are needed for their use as these chemicals themselves are not harmless.

③ **Physico-chemical treatment-** NaOH / pelleting, urea / pelleting, lime / pelleting, chemical / steam, NaOH / temperature.

④ **Biological treatment-** white rot fungi, ensilage with agro-industrial by-products or fortification with proteins, greens or enzymes, probiotics and herb. Among these methods, biological treatment is a much favourable option and is believed to be more environmental friendly and safer.⁹⁰ Suitable treatment techniques in combination with nutrient supplementation could result in improved utilization of rice straw with better benefits.

On a straw diet, supplementation of small amount of green grasses is often recommended for optimization of rumen environment or even to meet the maintenance requirement of animals. Dairy farmers are recommended to feed 1.0 kg concentrate for 2 to 3 kg of milk yield and the concentrate feed contain rice polish, wheat bran and oil cakes under local conditions.³⁰

Bangladesh has mainly two types of dairy cattle, cross-bred and indigenous dairy cattle. The cross-bred cows are usually stall fed while the native cows generally allowed for grazing in day time and fed rice straw *ad libitum* basis. The grass supplied to the cross-bred cows composed of roadside grass, on-farm fodder, weeds of crop fields, aquatic weeds, tree leaves and other browse which varies from season to season. Local dairy cows are supplied to a maximum of 1.0 kg concentrate daily whereas the cross-bred cows are supplied with 2 to 3 times higher than local cows and composed of rice polish, wheat bran, bran of legumes and oil cakes.^{92,93}

Research on feeds and fodders

Approximately 68.0% of the farmers involved in crop production and 6.5% involved in livestock rearing in Bangladesh.⁹⁴ Livestock farming is crucially important for provision of animal-based food products for the population and as a source of income for mainly rural smallholder farmers in low income countries including Bangladesh. Recently the demand of livestock products has increased greatly due to increased human population and economic growth in Bangladesh. However, the main constraints to livestock development in Bangladesh are the scarcity of quality and quantity of feed supply (88.1%) and diseases.⁶²

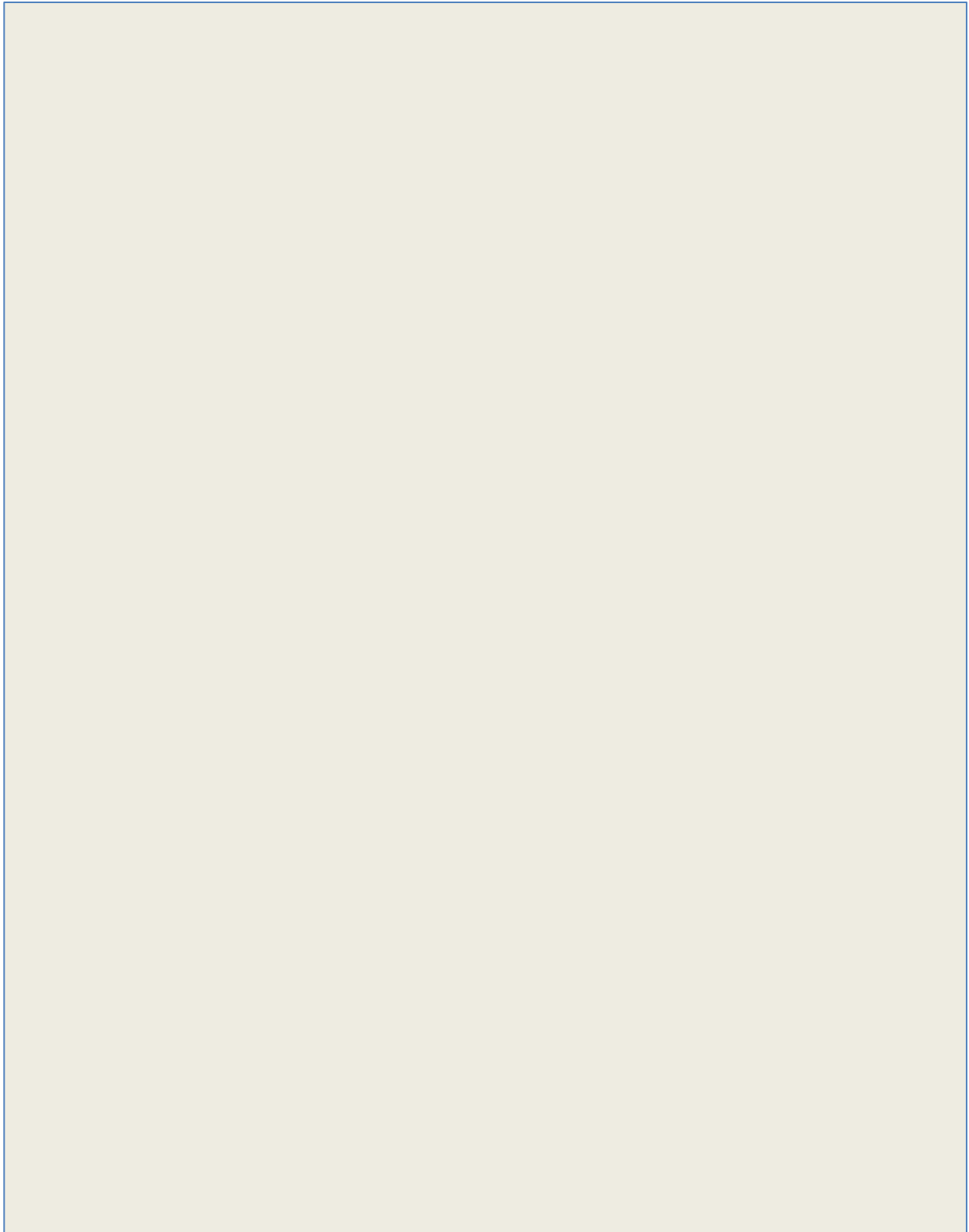
Large ruminants are mainly fed on low quality roughages including natural grazing and agro-industrial by-products like cereal straw, sugarcane feed by-products and other similar products in developing countries including Bangladesh. The smallholder cattle farmers are usually supplied with green grasses mostly grown on fallow lands, crop field boundaries, embankments and side of roads. These feeds are deficient in protein, energy, minerals and vitamins. Sometimes seasonal influence also deteriorates the grazing and browsing that cause to decline lactation unless supplements are offered. Addition of foliage from tree leaves and supplementation with seed meals, urea-molasses multi-nutrient blocks are used to improve the utilization of low quality roughages mainly through the supply of nitrogen to the rumen microbes. Cereal milling by-products, grains and oil cakes are the three major types of ingredients constitute concentrate feed

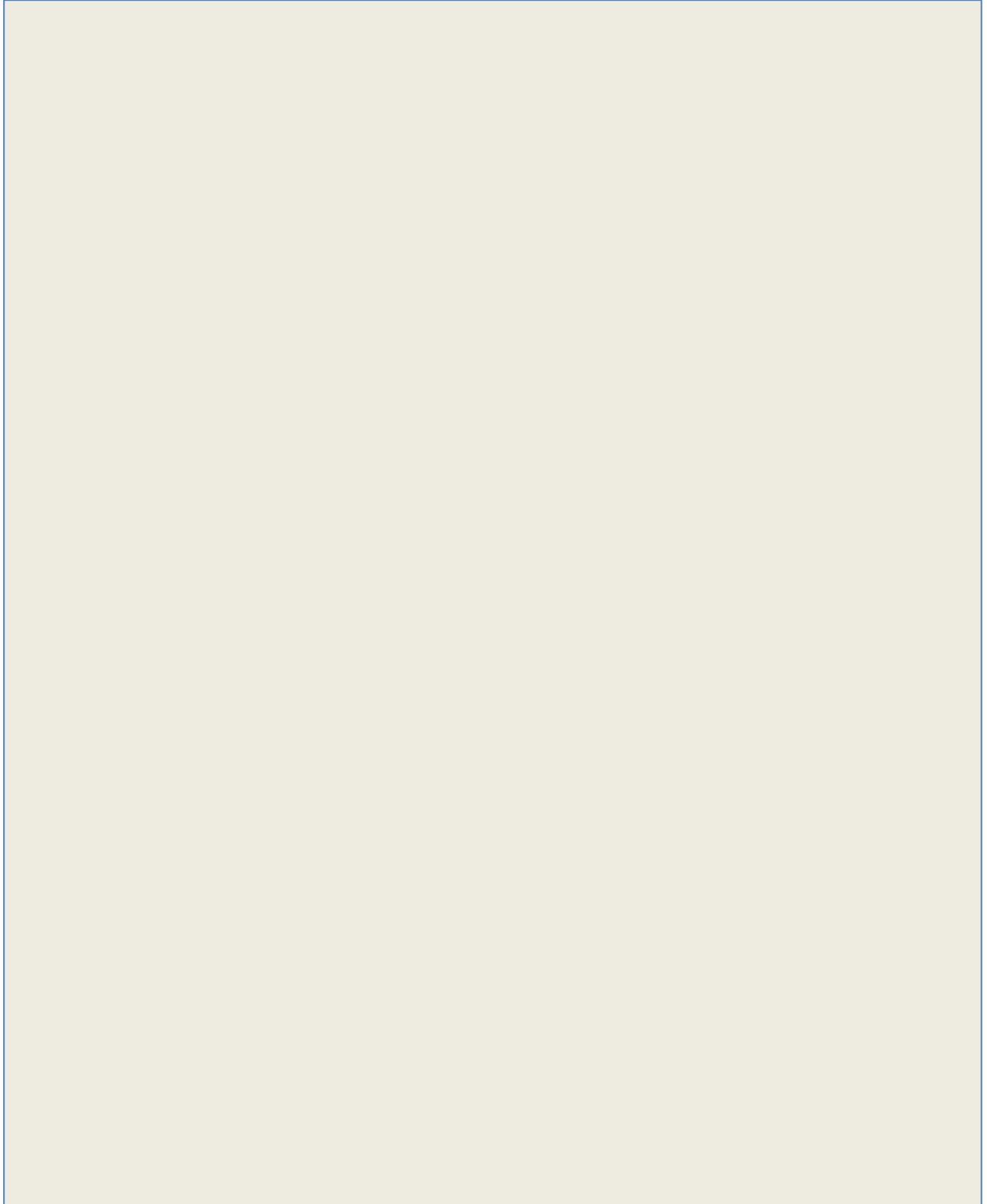
and the total demand is met only 19.4% in Bangladesh.⁹⁵ However, an average 56.2% deficit of roughage DM and 79.6% of concentrate DM results in a very poor plane of nutrition for farm animals in Bangladesh.⁹⁵ There is a requirement of 70 million metric tons of green grasses for cattle feed per year but produced only 24 million metric tons. Thus, there is about 60% deficit of animal fodder feed which hampering the livestock development in Bangladesh.⁹⁶

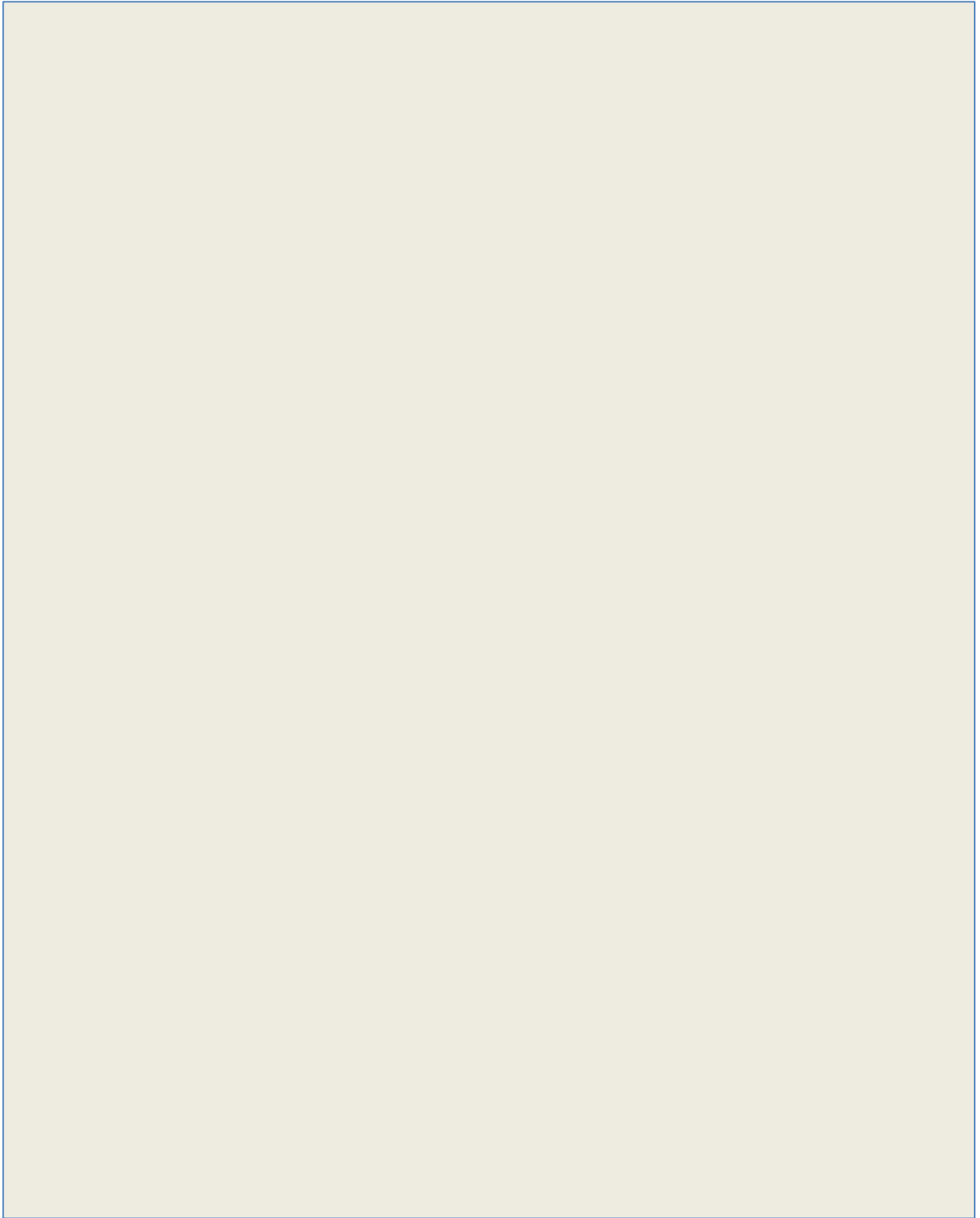
Fodder production

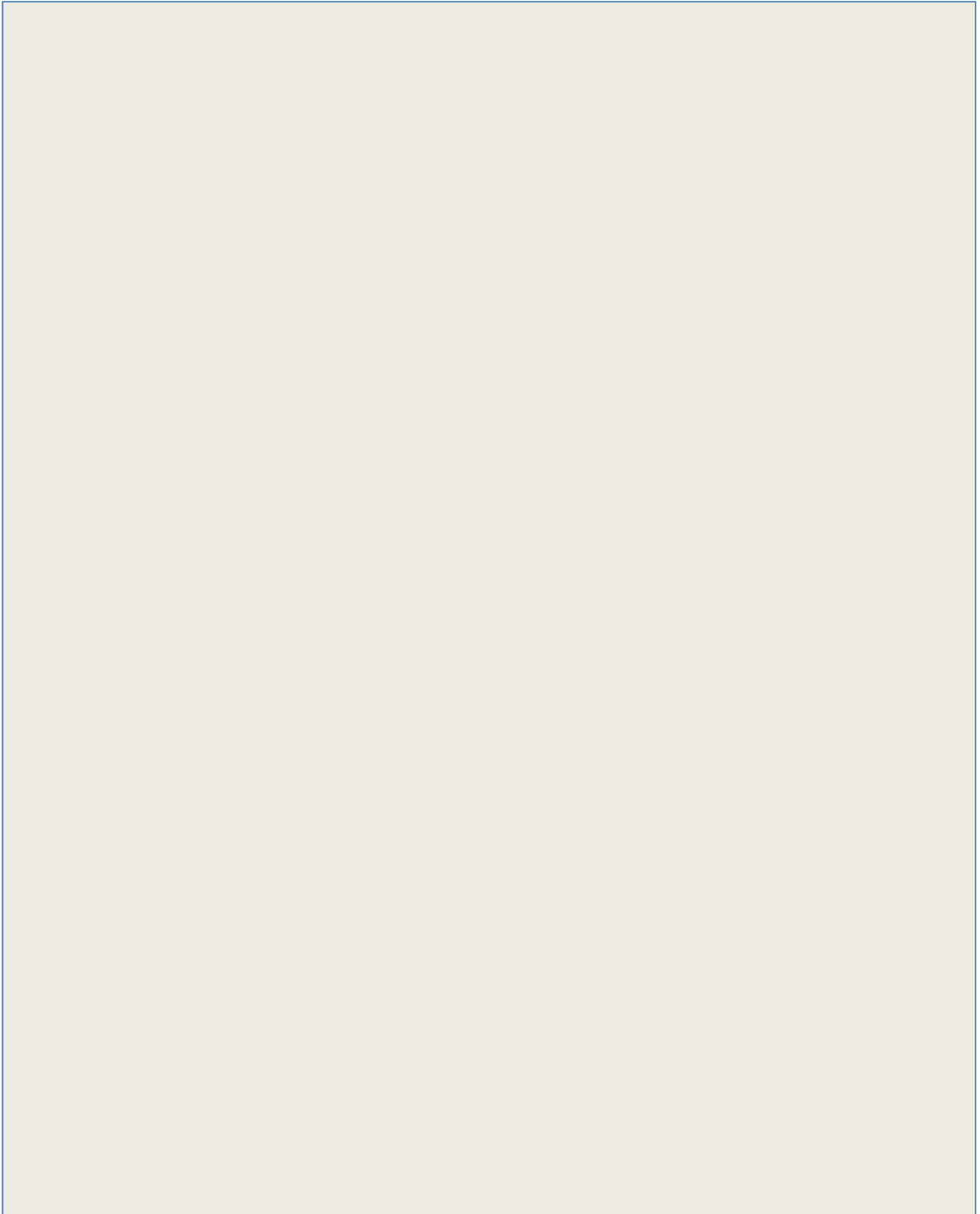
Fodder is any agricultural foodstuff used specially to feed domesticated livestock. Fodder crops are crops that are cultivated primarily for animal feed. Natural grasslands and pastures are included whether they are cultivated or not. There is a lack of pasture land and huge shortage of green fodder to feed large ruminants in Bangladesh. In 1960 a fodder crop, namely pangola grass (*Digitaria eriantha*) was imported from USA and propagated in a limited area of the then East Pakistan and proved to be high yielding fodder crop suited for local condition. However, the land scarcity, lack of extension services to encourage farmers for fodder cultivation and absence of fodder feed bank have been considered as the main reasons for green fodder shortage in Bangladesh. Recently interest has been grown among the scientists to provide livestock farmers with a suitable variety of fodder crop which could be cultivated abundantly and preserved as hay as well as silage to feed the animals during scarcity period. In addition to different varieties of fodder experimentally cultivated in Bangladesh and even hydroponic fodder has also been tried under experimental condition (Table 4).

Table 4. Research findings on fodder production and fertilizer used in Bangladesh				
Year	Fodder grass cultivated	Fertilizer used (@ kg / ha)	Results (Total harvested /DM produced)	Reference No.
1968	Pangola grass	N + P + K fertilizers	Reported some mineral composition of the cultivated fodder	97
1972	Sorghum	NPK 200/Varity	Honey sorgo (V-4) produced highest fodder yield (119339 kg/ha)	98
1972	Para grass	Urea 0, 30,60 lb/ acre land	DM yield 4380.0, 4894.5 and 6958 lb. with 58.87% increased with used / acre group.	99
1974	Pangola grass (PG)	3 rates of N & P, 2 rates potash	N & P application has increased yield significantly but little effect with potash	100
1975	Para grass	Urea 0,34, 68 ; TSP 0,34, 68 & MP 0, 34	The N and P application has progressively and significantly increased the grass yield at all stages of cutting.	101
1975	German grass	Urea 0, 22,45 & 67	Total yield of forages / ha on both PG & DM basis increased progressively & significantly with the increase in fertilizer level.	102
1975	Pangola grass	TSP 0, 30 & 60	TSP fertilizer progressively increased total yield of PG and DM with increased level of TSP application	103
1986	Different fodder -		Potential crop mixture for fodder production has been described.	104
1986	Tama Rye grass	Application of mefluidide and PP-333	Mefluidide has reported more effective than PP-333 on growth of the grass	105
1987	German grass	NPK 10,20,40; MN 2,4,8 & Mo 2, 4	Highest yield (17 kg/plot) & highest protein content (17.62%) reported with NPK, Mo1 & Mn2.	106









2017	Napier fodder	To assess the economics of fodder production for dairy farms	Fodder production along with dairy cattle rearing has been reported highly profitable. Higher profit has been reported with fodder crop cultivation in the same land.	178
2018	Napier-4 fodder	Production on loamy & sandy soils at 3 rd cutting	BLRI developed Napier-4 showed better performance in loamy than sandy soil at 3 rd cutting	179

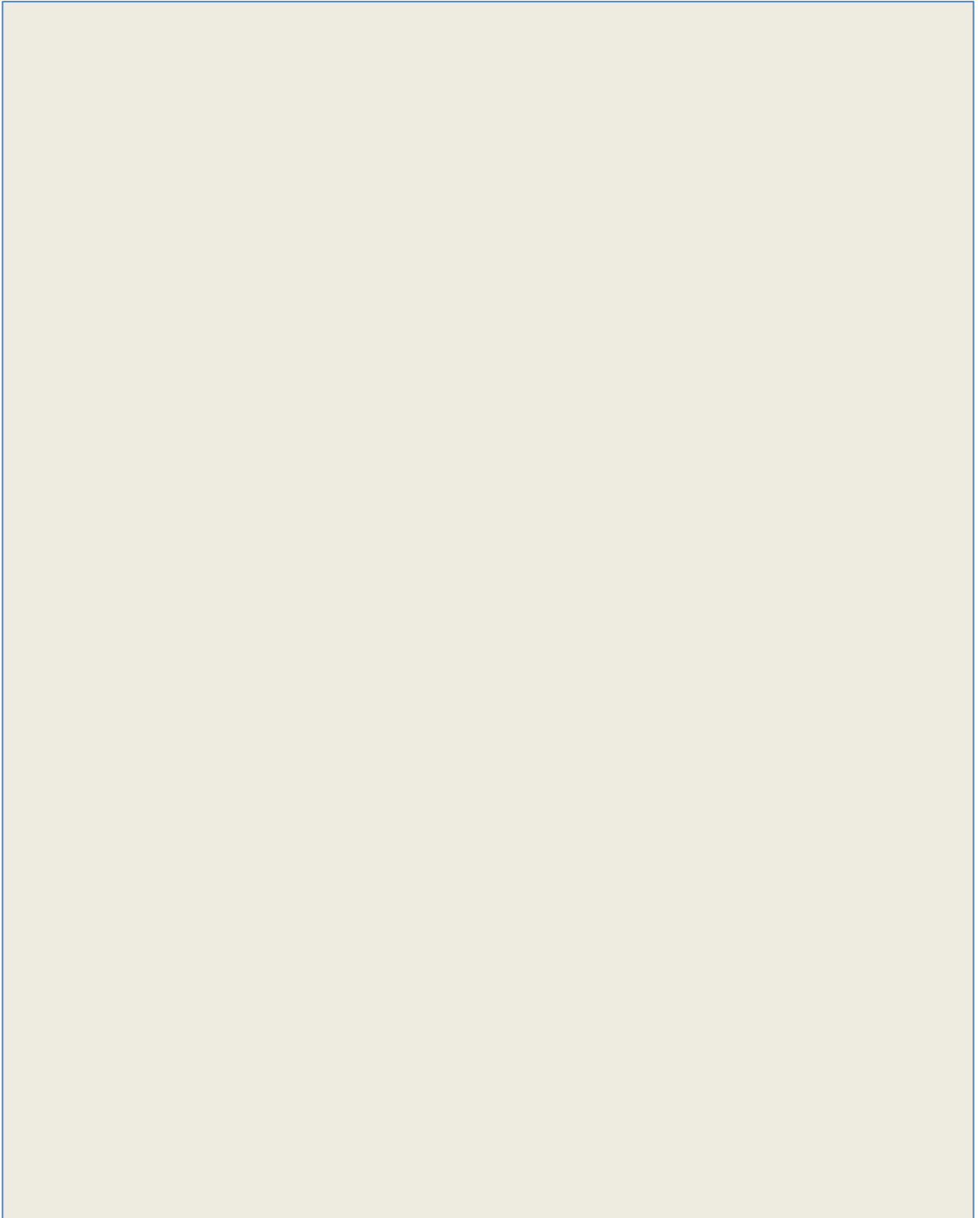
NPK= Nitrogen (urea), Phosphorus (TSP) and K (muriate of potash) Mn = Manganese sulfate Mo = Molybdic acid
 90S = Summer only +@ 25g/ kg seed Intercropping = Khesari, Cowpea and Berseem with maize
 DS = Dried slurry (ton / ha) Fertilizer* = Not available in the main text

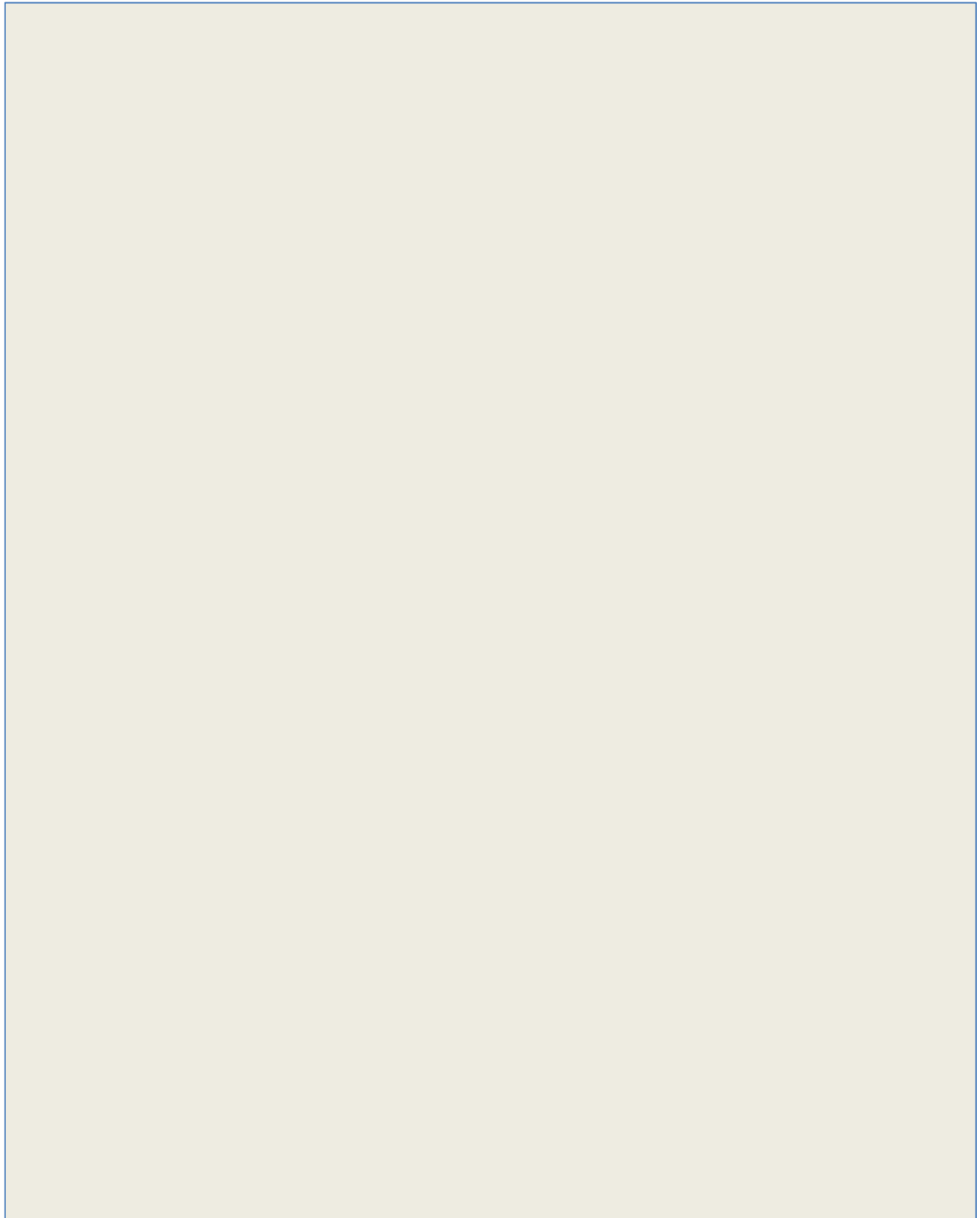
There are approximately 30 species and varieties of fodder have been cultivated and evaluated in Bangladesh for feeding large ruminants (Table 4). Highest number of research reports have been published with Maize (n = 17) and Napier (n = 14) forages (Table 4). However, intercropping Maize and Kashari production reported best results,^{134,139} Oat forage has reported superior than Maize forage as nutrient values,^{138,148} German fodder showed best result in respect of nutrient values in comparison to Para and Dhal grasses,^{162,163} moreover, German grass can be produced in floating bed but not Napier grass.¹⁷³ In addition, triticale has been reported to be a dual-purpose crop for grain and forage biomass, which is a non-traditional cereal that grows well during the cool and dry rabbi season (November to March) when small-scale dairy farmers face a severe shortage of fodder. Winter has considered as a lean season for the growth of the popular fodder including Napier and Para in Bangladesh. To meet the shortage of green fodder in the rabbi season, triticale can be produced 6-15 t/ha fodder, followed by grain yields that are similar to those from wheat for poultry feed.^{137,153,154,161}

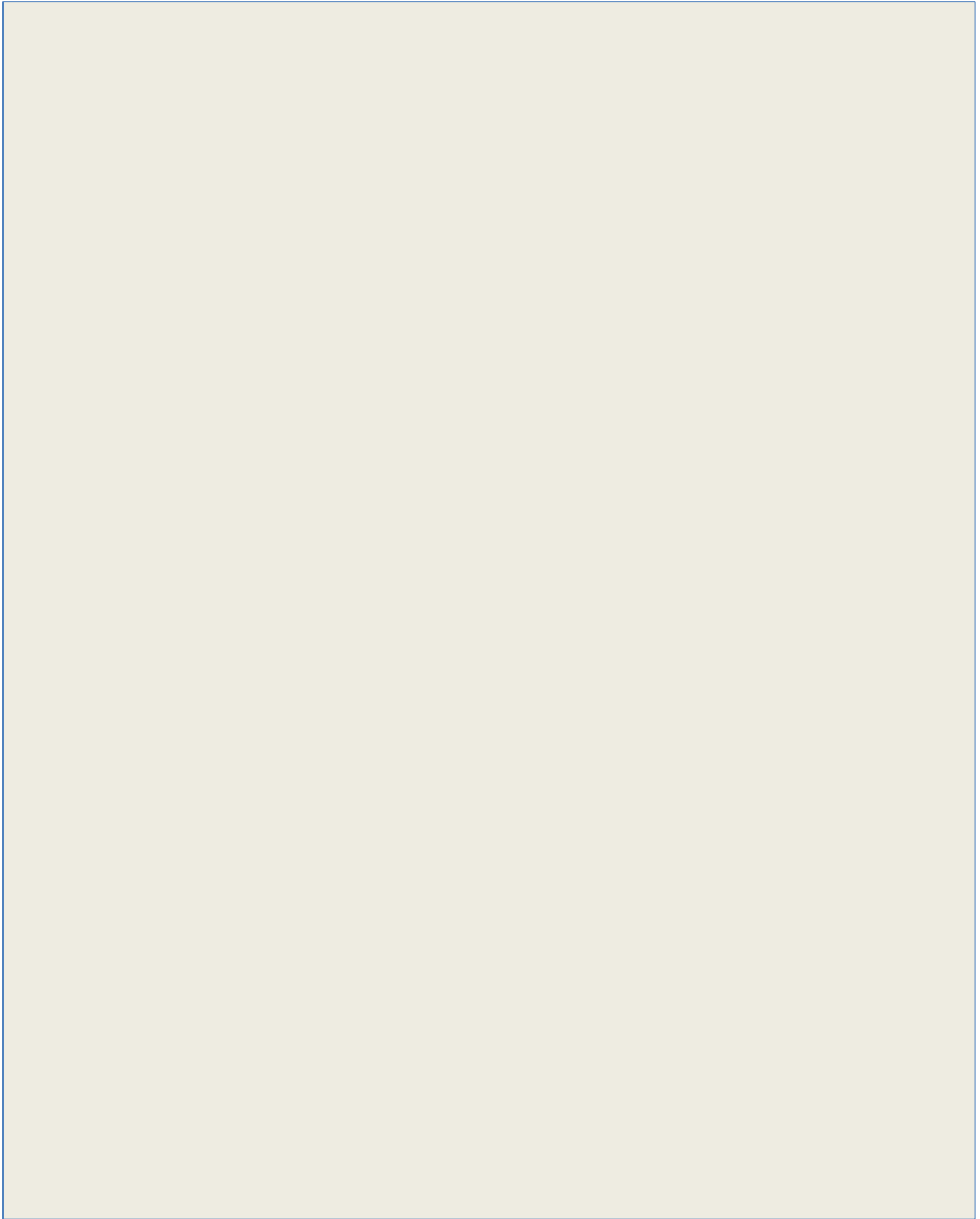
Cattle nutrition, feeds and feedings

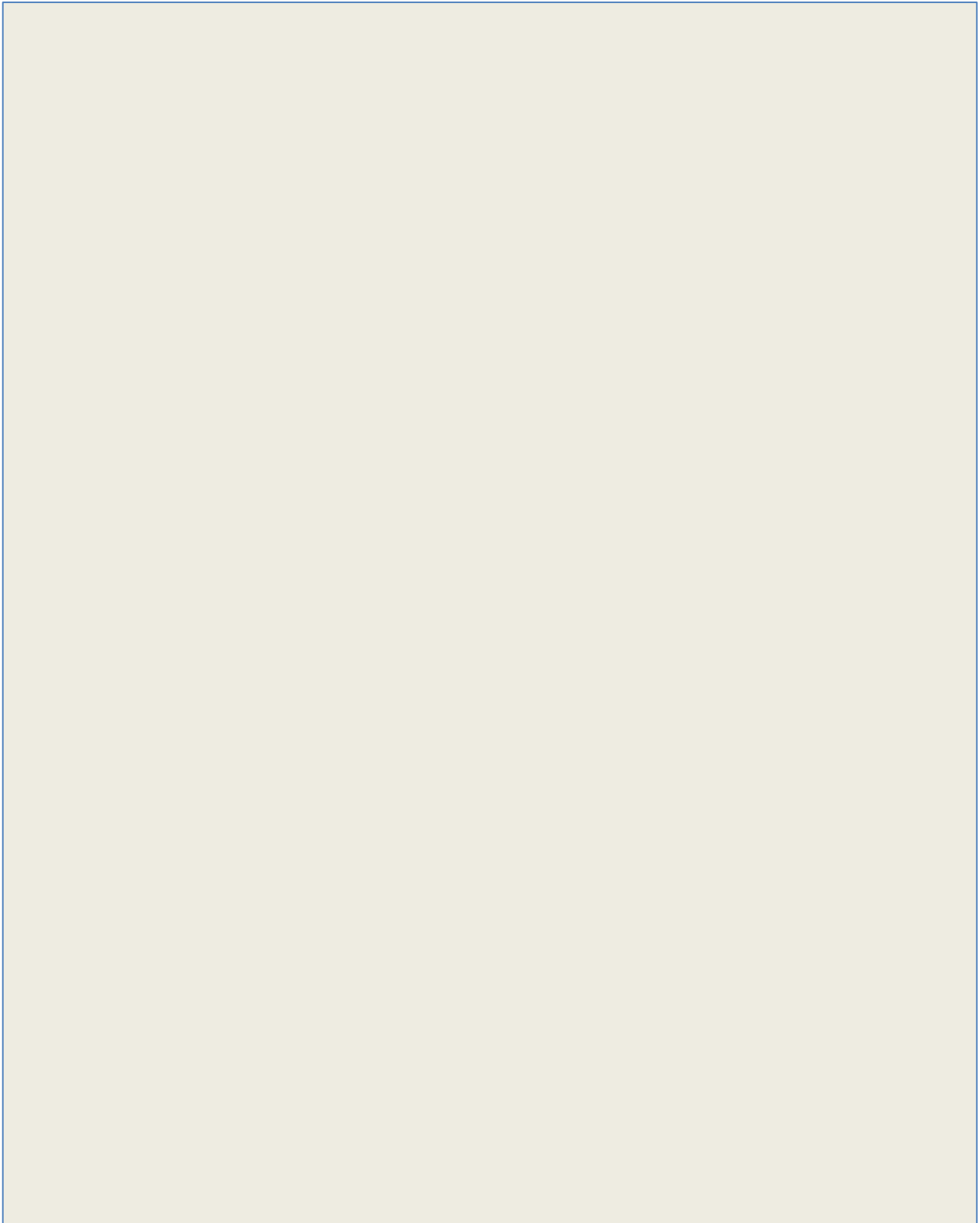
The research reports on the cattle nutrition, feeds and feeding practices have been reviewed into three sub-headings which include (a) nutrition, feeds and feeding practices, (b) feeding trials on non-dairy cattle and (c) feeding trials in dairy cattle (Tables 5,6,7). A balanced ration should provide protein, energy, minerals and vitamins from dry and green fodders, concentrates, mineral supplements and others in appropriate quantities to enable the animal to perform optimally and remain healthy. Inadequate and imbalance feeding may results in: (a) low milk production than their genetic potential, poor growth and reproduction, (b) shorter lactation length and longer calving intervals, (c) dairy cows more prone to metabolic disorders milk fever, ketosis, (d) slow growth in growing animals and delayed age at first calving, (e) shorter productive life and lower profit to farmers.¹⁸⁰ A software has been developed by NDDDB, India to supply the balance ration of their animals using locally available feed resources¹⁸⁰ that system could be used for the development of cattle industry in Bangladesh.

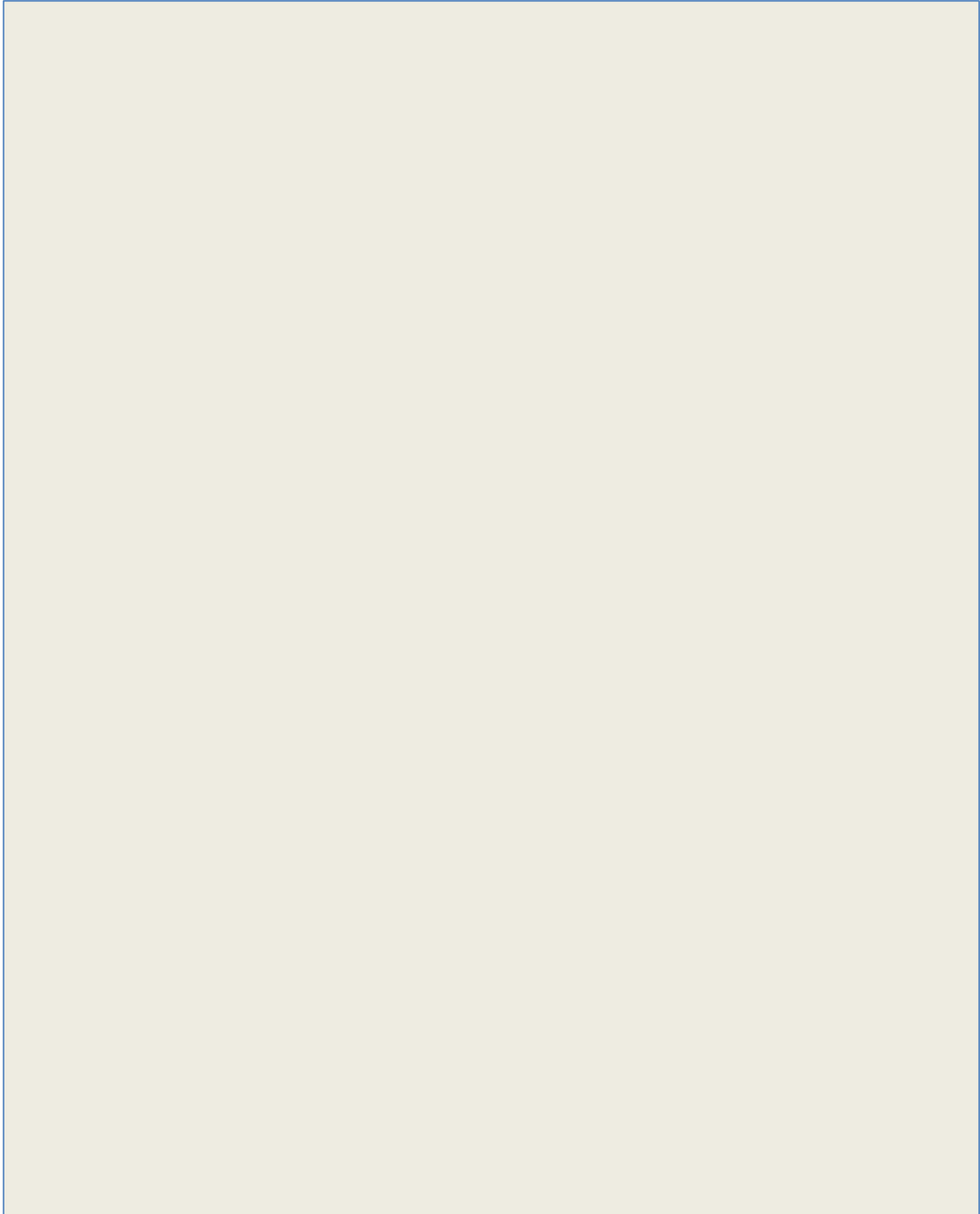
Year	Research objectives	Major findings	Reference
1965	Use of urea-molasses	Utilization of molasses and urea-molasses as a livestock feed.	181
1968	Nutritive values of four forages	Significantly varied nutritive values of four forages at the different stages of maturity and both the TDN and DOM. Varied within the same species of fodder	182

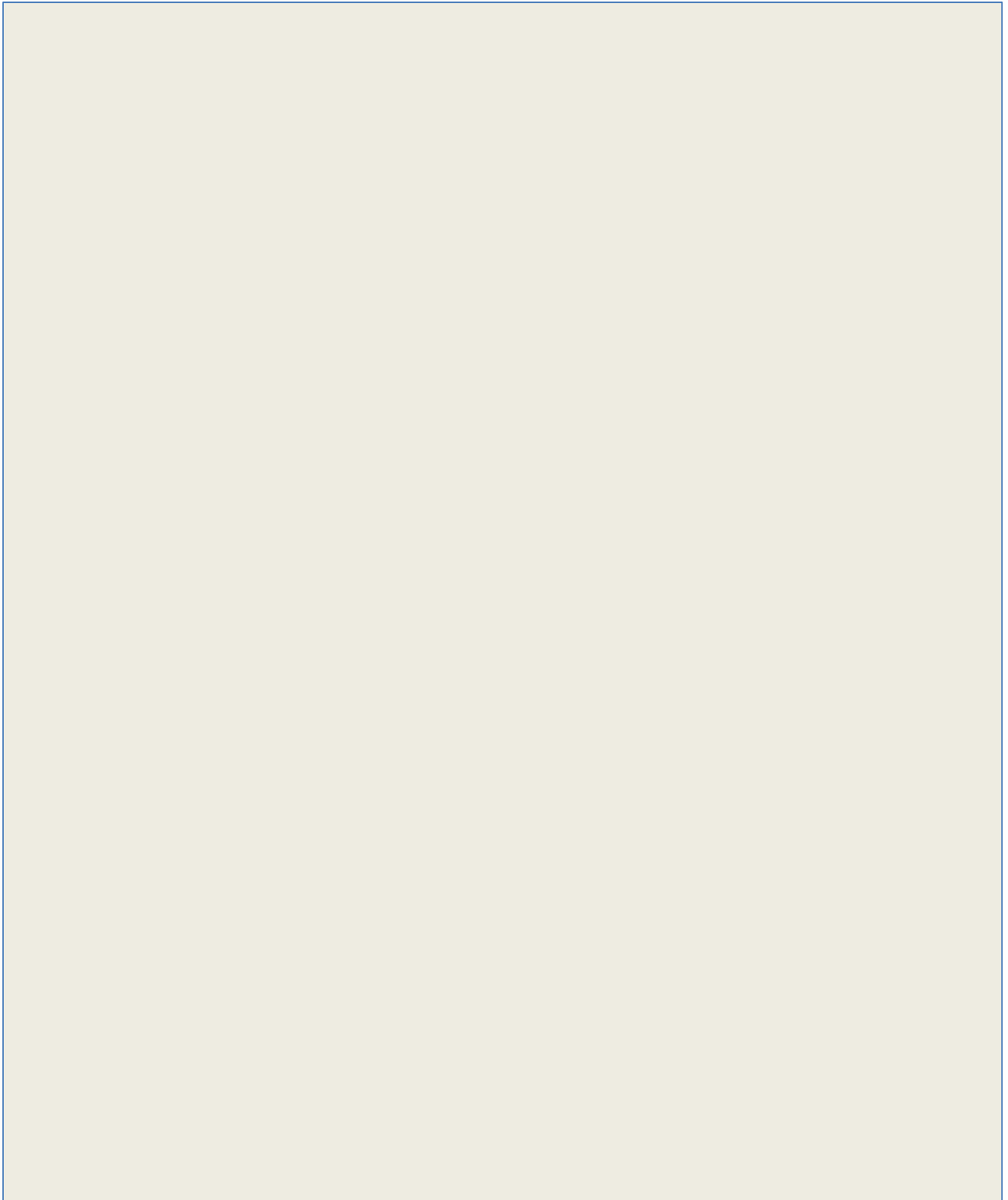








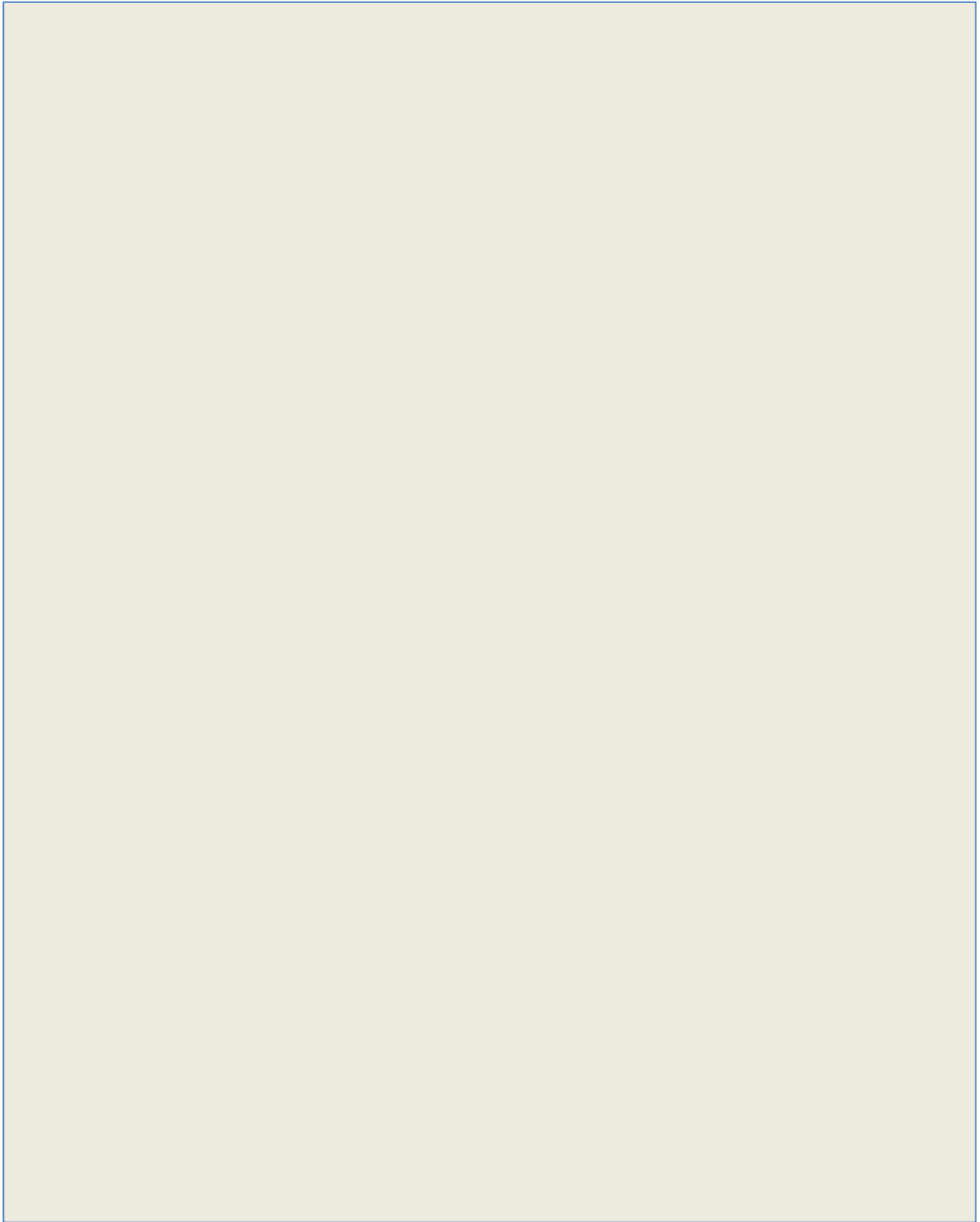


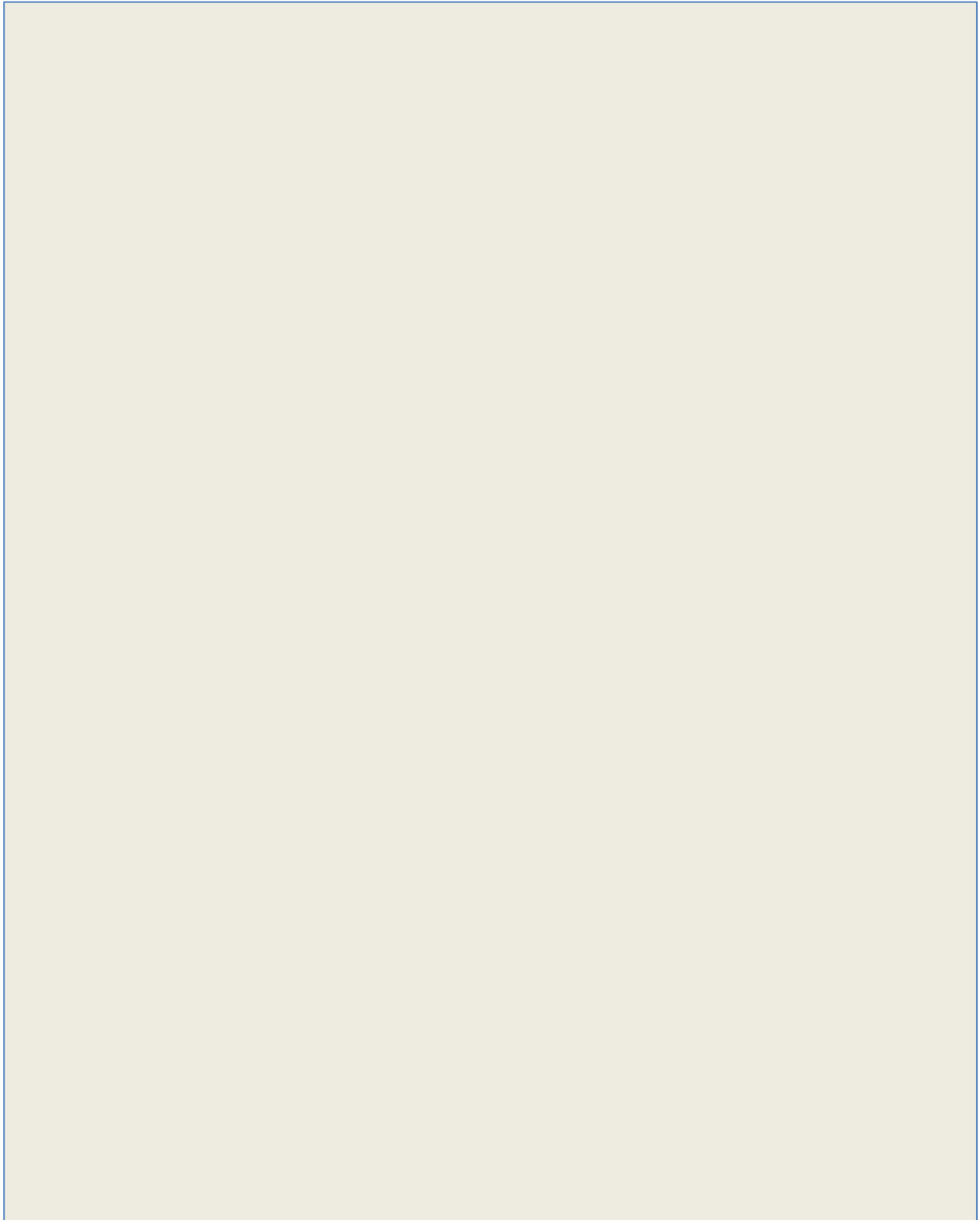


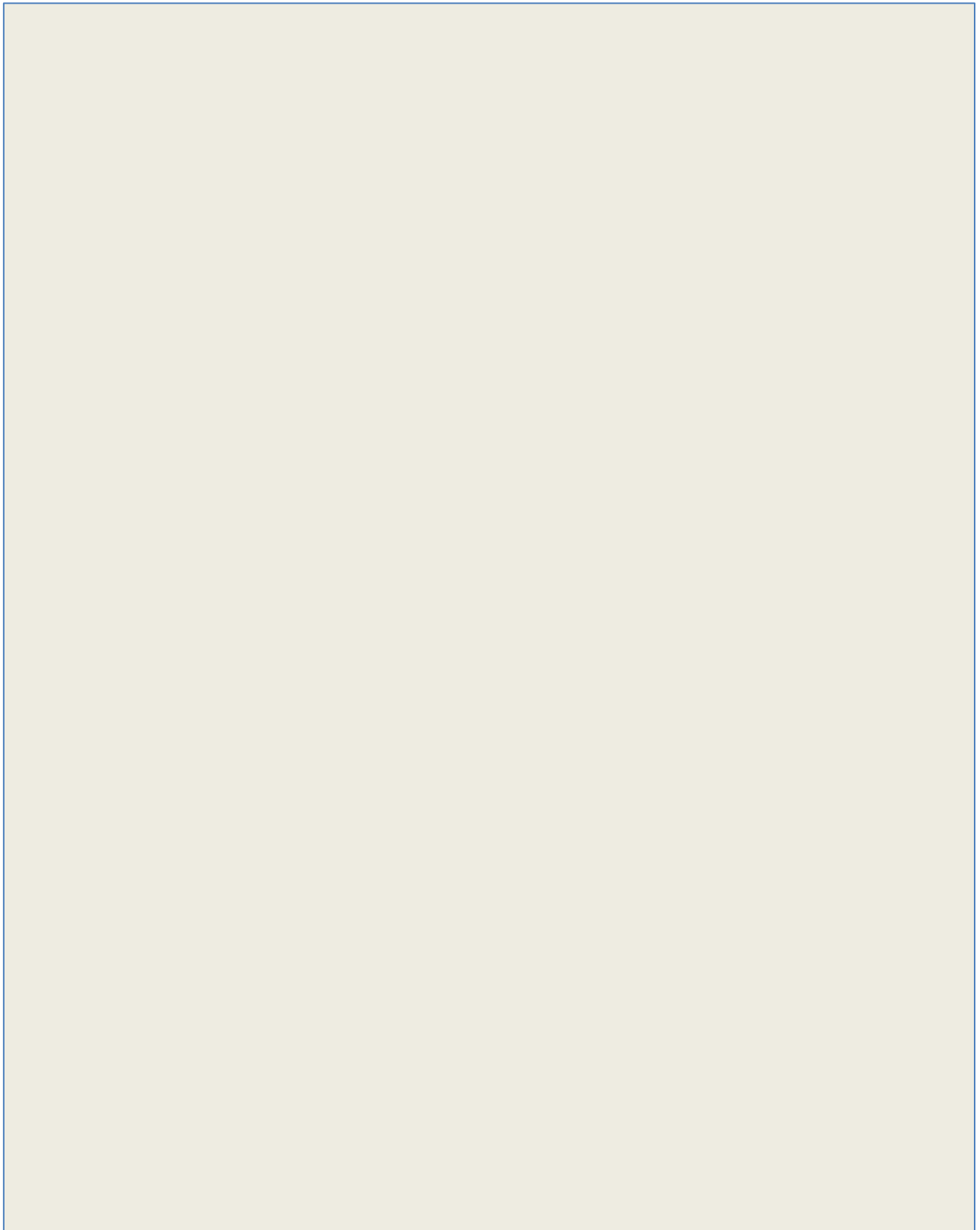
Cattle production, management and dairy products

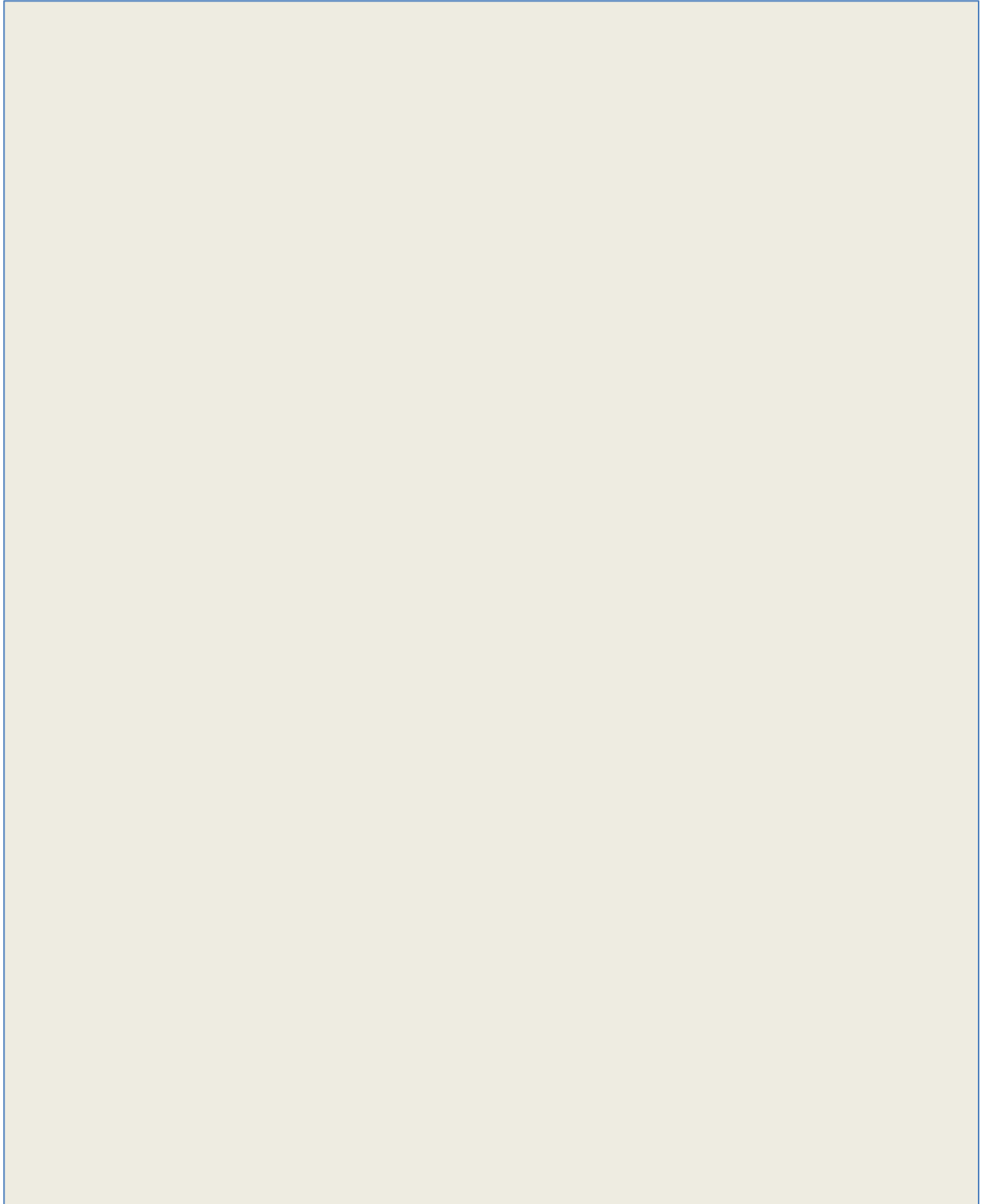
2018	To select best combination of roughage & concentrate based on TMR, better rumen environment & RMF in cattle	The best combination of roughage to concentrate ratio (30:70) has been reported in T5 group (30:70) for better N utilization to achieve maximum performance through proper feeding which might reflect the gross return of cattle production	276
2018	Preparation of ensilage with WRS treated with BGS and ensiled with molasses to increase nutritional and preservation of straw	Among all the treatments, T ₂ (5% BGS= Biogas slurry) and T ₃ (10% BGS) have been reported acceptable for preparing ensilage. Ensilage of WRS (wet rice straw) with BGS not only reduced waste disposal and pollution problem but also provide inexpensive feed components for ruminants	277

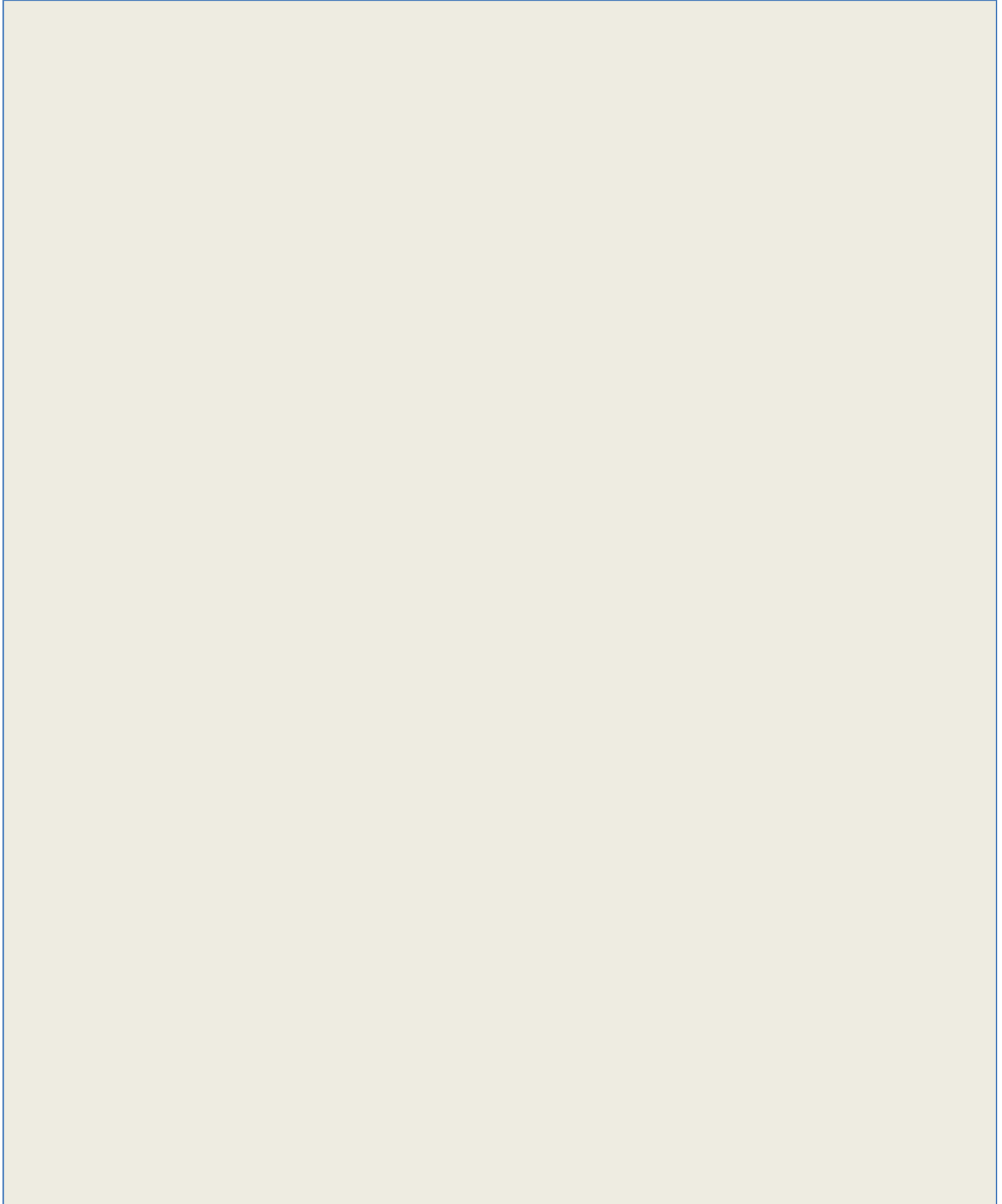
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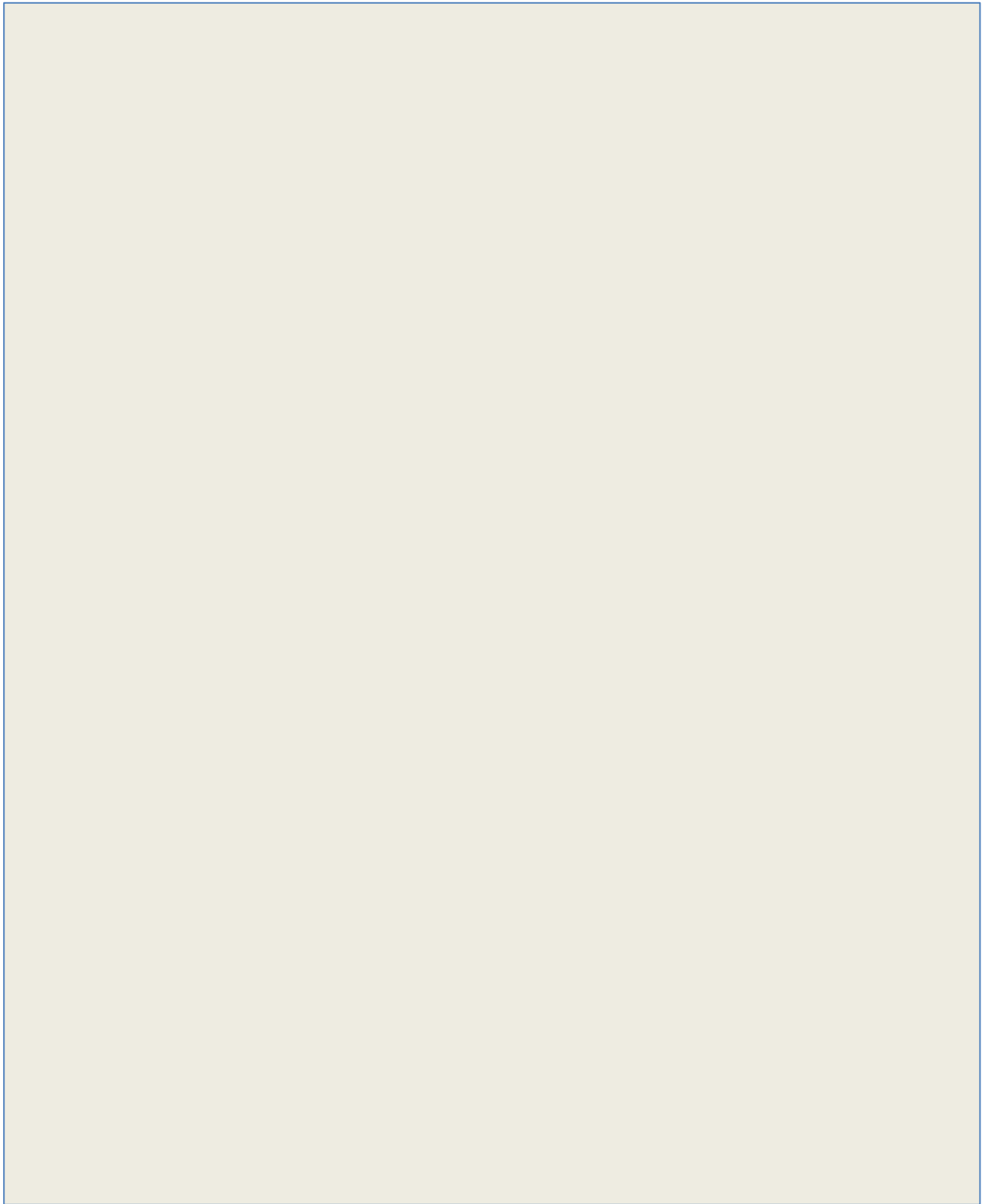






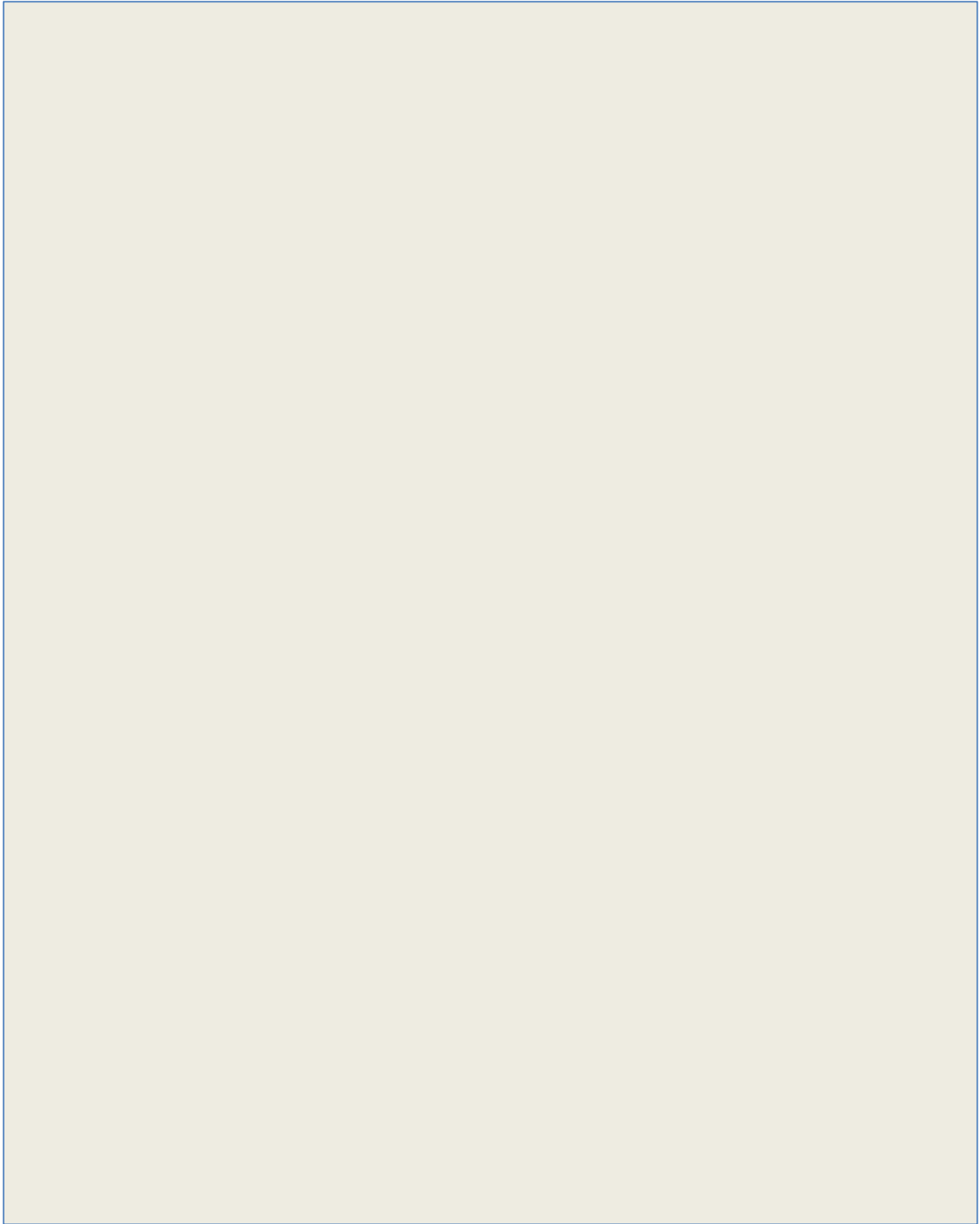


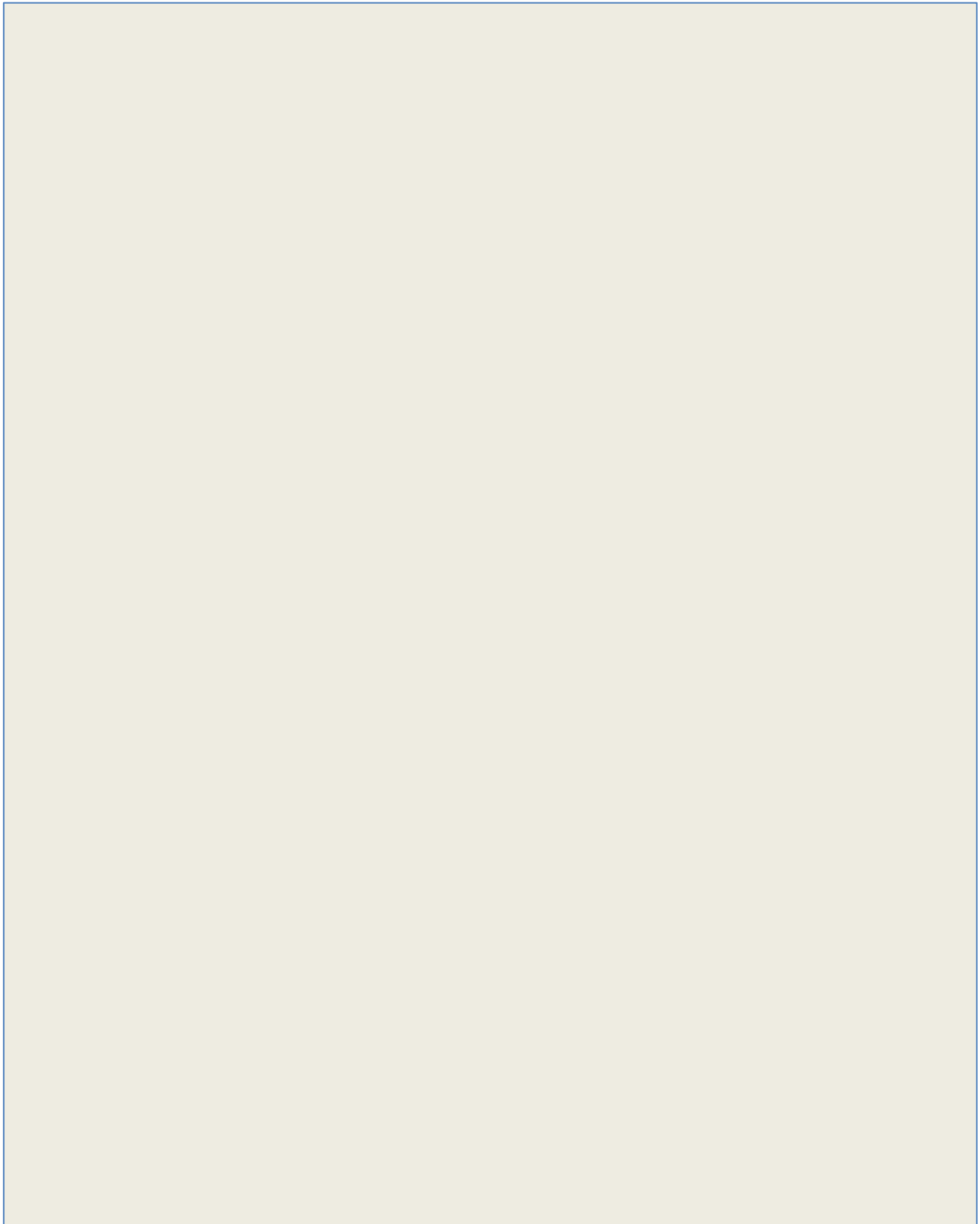


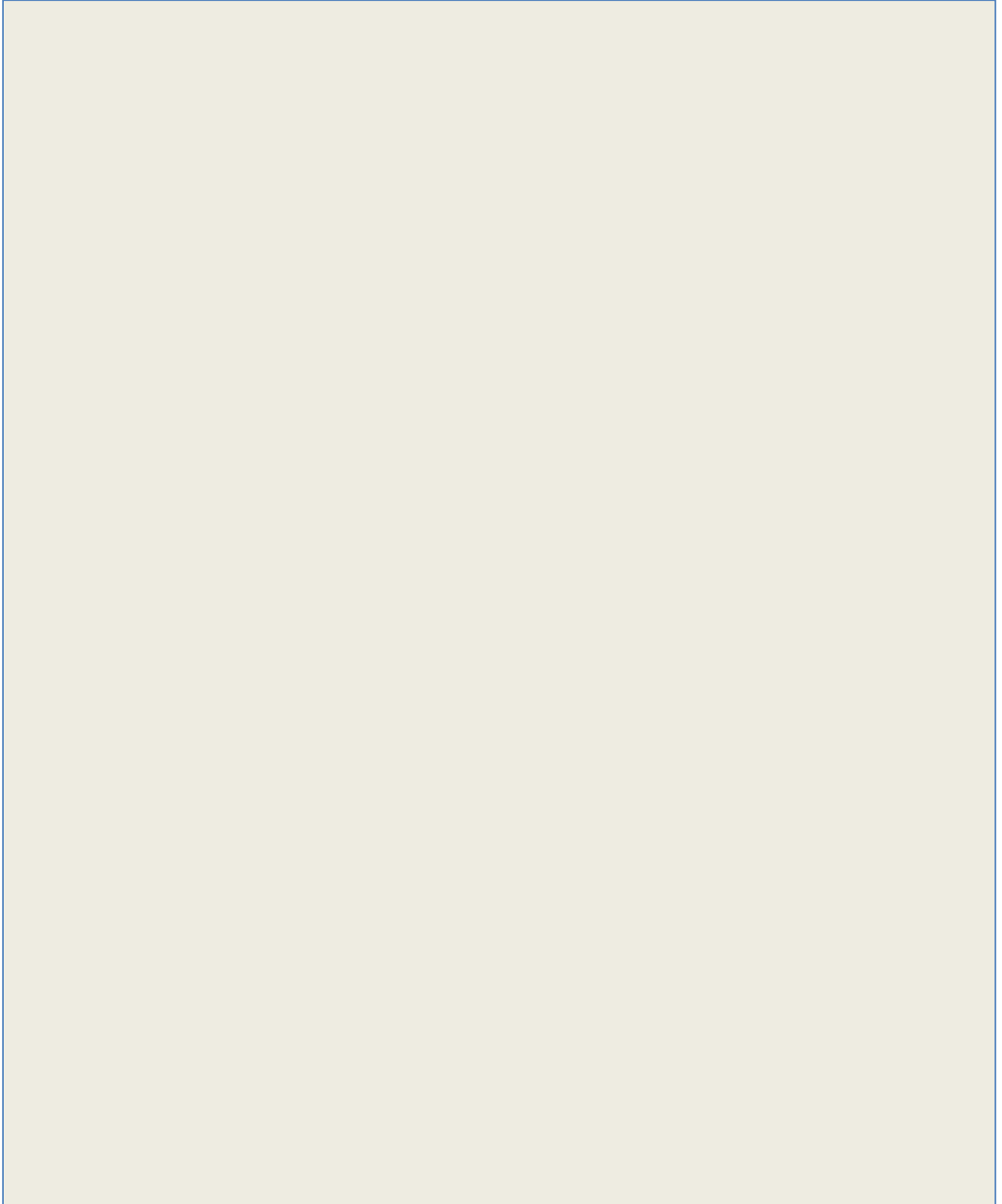


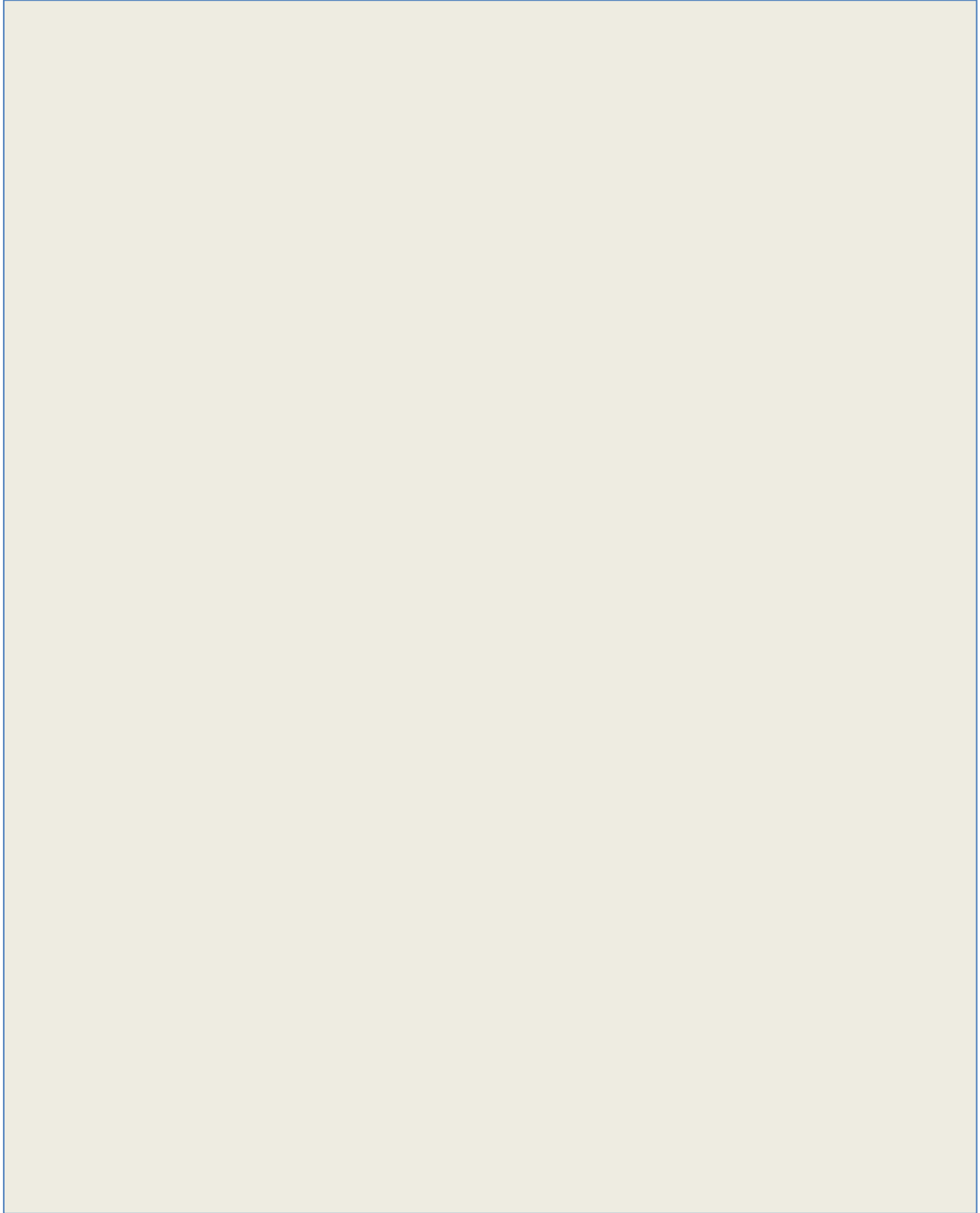
2015	To detect the effects of genetic and non-genetic factors on growth traits of crossbred calves	Both the genetic and non-genetic factors like season, sex, year of birth, had no significant effects on growth traits in crossbred dairy cows. But year of birth and dams' milk yield capacity have been reported to be played significant role for the considered growth traits of calves.	354
2016	To detect anthelmintic efficacy of neem & ata leaf & effect on milk yield & LWG in cows	The anthelmintic efficacy against gastro-intestinal parasites in lactating cows in order of albendazole > neem leaf > ata leaf. Increased milk yield has been reported significantly (p < 0.01) after 28 days of treatment. No significant differences on LWG in the three treatment groups	355
2017	To find out the suitable ration/diet for the rapid growth and fattening of the cross-bred bull calves	Highest LWG (25.33kg) in crossbred bull calves has been reported with a ration (g/100g DM) composed of rice straw (16.45), green grass (29.62), crust maize (29.62), wheat bran (3.62), rice polish (3.62), mustard oil cake (13.15) and common salt (3.92).	356
2019	Effect of protein rich ingredients into conc. diet on BWG in heifers	Feeding of soybean meal and mustard oil cake added in concentrate with para and German grasses as basal roughage resulted 16% higher LWG than control heifers. Protein supplement also increased the growth measurements and blood serum status.	357
2020	To evaluate the effect of conc supplement on growth, milk yield and reproductive response in crossbred cows	Results showed that supplying an additional amount of concentrate to the cows before and after two months of freshening had a positive influence on milk production as well as reproductive performance. Basal diet – 22 kg green fodder (Para : German = 2 : 1) and 2.0 kg conc (wheat bran 82.28, mustard oil cake 13.72, salt 3.7 and DCP 0.3%)	358

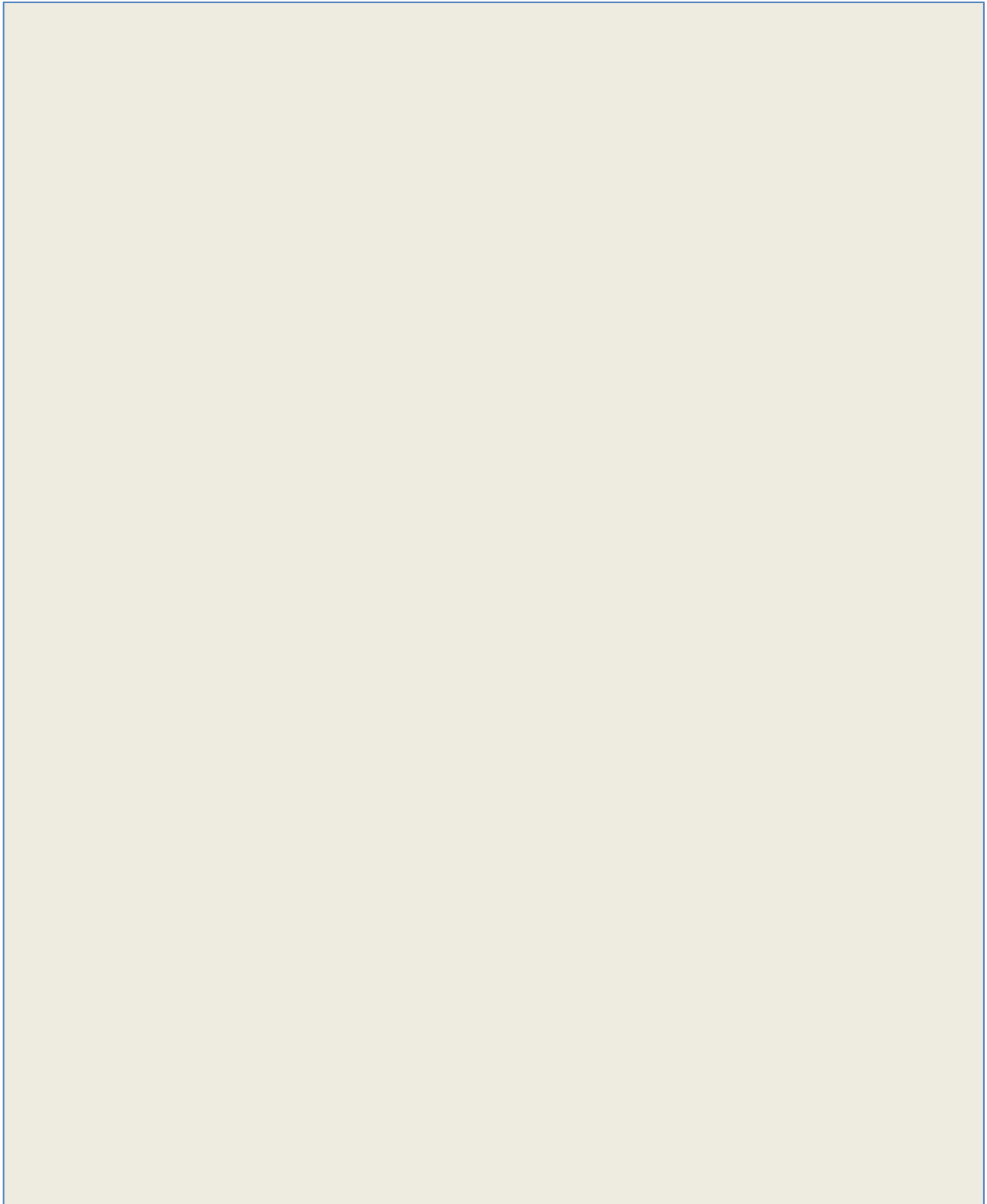
Table 7. Effects of different feed formulations on productive and reproductive performance of dairy cattle			
Year	Research objectives	Major findings	References
1969	To evaluate the economical limited roughage feeding	Limited roughage feeding would be economical provided a certain minimum level (1% hay equivalent) of roughage in the ration of lactating cows is maintained.	359
1974	Effect of voluntary roughage intake and its economic influence on milk yield in cattle and buffaloes	The DM intake and feed efficiency of Murrah buffalo have been reported to be higher than cattle both the Sahiwal and Red Sindhi breeds. The feed cost in buffaloes in terms of milk production has not that much high which could possibly compensate higher feed cost.	360
1980	To compare the effect on milk production in lactating cows fed 3 different grasses	German, napier and para grasses have been fed ad libitum to lactating cows to detect their effects on milk production. Feeding of German grass caused better result in respect of quality and quantity of milk in comparison to Napier and Para grasses	361
1982	Effect of feeding UTS on Milk yield composition in lactating cows	The milk yield and milk fat (%) increased due to feeding UTS in lactating cows but it has no effect on solids-not-fat (%) and total solids (%). Feeding of UTS has increased digestibility, utilization of straw and as a source of NPN.	362
1984	Effect of feeding urea-treated rice straw (5%) on milk constituents of Pabna variety cows	Two groups (A & B) of cows, of which cows of group A fed urea-treated rice straw and group B fed untreated rice straw. Higher fat (%) has been reported in urea-treated cows (5.7%) in comparison to cows fed untreated straw (4.76%). The SNF and total solids did not differ significantly.	363
1987	To detect the effect of fish meal supplement on milk of lactating cows	Fish meal has been supplied in three different groups of cows resulted higher final LW (kg) and milk butter fat (g/kg) in cows fed 600g (198kg; 50g), followed by 500g (161kg; 49g) and 400g (178k; 41g) fish meal, respectively.	364











2018	To evaluate the concentrate supplement on the performance of lactating RC cows	The farmers' diet (63%) plus formulated concentrate to meet 100% requirements of lactating RC cows significantly increased the milk production (4.82 vs 2.4kg/d), milk fat (5.45 vs. 4.32%) and decreased the post-partum anestrus period (62 vs. 104 days) and service/ conception.	422
2018	To monitor the influence of green grass-based diet on growth & reproductive performance in dairy heifers	Heifers fed with green grass, soybean hay and concentrate had significantly higher heart girth gain, serum Ab, urea and BUN than the heifers of other groups. Supply of green grass especially a mix of leguminous and non-leguminous have been reported to be advantageous in heifer feeding.	423
2018	To investigate the effect of different types of silage on milk production in dairy cows	Maize or chopped Napier silage have been reported to be an effective alternative to green fodder during fodder scarcity for continuing milk production in dairy cows. Maize silage found better than Napier silage and chopping napier silage reported better than whole Napier silage.	424
2018	Effect of pre- and post-Partum conc supplement-Action in crossbred cows	Results showed that offering superfluous concentrates (25% of total conc) during pre-and post-partum resulted positive impact on milk yield, milk protein and post-partum heat period.	425
2019	Effect of mixed or block Form ration in milk yield Native cows	Total mixed ration (TMR) either in block (3.61 L/d) or mash (3.61 L/d) forms resulted significantly higher milk yield in native cows for the period of 45 days. TMR & block ration consisted of Maize stover 50% & roughage 50% & conc. included wheat bran (8%), kheshari bran (4%), soybean meal (25%), molasses (10%) and salt (0.5%).	426

Review of research of reports on the nutritional trials on native male cattle reveals that three major types of feed formulations have been tried based on basal roughages to evaluate the growth performances since 1965 in Bangladesh.³³³ These three categories of the evaluated rations include (a) dry straw, (b) urea-molasses-straw and (3) Fodder & silage based diets (Table 8). In Bangladesh, 27 to 49% of cattle feed is based on rice straw, only Sirajgonj and Chittagong districts have limited, periodic grazing facilities, fodder (Napier) cultivation has been reported are in practice in Sirajgonj and Satkhira and fodder availability increased milk production and decreased disease occurrence.²⁴³

Ration increased milk production

- In addition to rice straw, feeding of 22 kg green fodder (Para : German = 2 : 1) and 2 kg concentrate (wheat bran 82.38%, mustard oil cake 13.32%, common salt 3.7% and DCP 0.3%) in lactating cows increased milk production and reproductive performance.³⁵⁸
- German, Napier and Para grasses have been fed *ad libitum* to lactating cows but German grass caused higher milk production in comparison two other grasses.³⁶¹
- German grass + concentrate mixture + 2.5% soybean based calcium salt of fatty acid has reported to be produced highest milk production in comparison to other groups.⁴¹⁹
- The milk production has been reported to be increased in Pabna variety lactating cows supplemented with 20% legume forage to rice straw-based diet.³⁹¹
- Dhaincha (0.7kg/day) and Ipil-ipil (0.8kg/day) have been suggested to be used as alternative sources of protein for ruminants, which resulted in better weight gain, milk yield and reproductive performance during post-partum period in indigenous cows.⁴⁰⁷
- The oxalate content of the Napier grass and its silage has been reported to be high in comparison to other fodders as 3.77% of the DM. Soluble oxalate can bind with calcium in the

rumen and intestines that formed insoluble calcium oxalate and excreted in feces at a higher level and even in the blood to form insoluble CaO crystals, lowering blood Ca levels.^{413,416}

Table 8. Effect of feeding different diets on growth of native male cattle

S/ N	Feed type & comparison	Conc. %	No. of animals /diet	Days on feed	Daily intake of total nutrients / head			Initial live wt. kg	Daily gain g/head	FCR	Ref. No.
					DM, kg	ME	CP, g				
I. Feeding effects of straw and supplement											
A.	Straw + grass + concentrate	9.0	4	56	4.1	-	480	127	420	10.2	402
		9.0	4	56	4.09	-	486	127	442	09.39	
		9.0	4	56	4.18	-	496	126	457	09.43	
B.	Straw + Conc.	39.7	4	60	4.65	-	-	123	473	-	403
C.	Straw	0	4	60	3.84	20.1	110	276	-19	-	294
D.	Straw + Conc.	0	4	28	4.74	21.95	246	264.5	-186	-	404
		29.6	4	28	6.08	31.47	568	267.8	346	-	
		42.2	4	28	6.41	36.9	1070.8	264.8	554	-	
E.	Straw + Conc.	46.6	4	43	6.43	-	563	281	669	9.63	220
F.	Straw + Conc.	0	4	120	4.26	-	-	145	204	-	304
II. Feeding effects of urea-molasses-straw (UMS)											
A.	UMS	0	4	93	4.66	41.2	341	263	233	26.0	217
B.	UMS	-	5	60	-	-	-	319	982	-	403
C.	UMS	0	4	60	4.81	27.64	113	272	292	-	294

Evaluation of feeding of urea-molasses treated straw in cattle

Rice straw is the major sources of roughages for cattle which are characterized by low level of CP and high level of structural polysaccharides that affect the DM intake, digestion and ultimate performance. This low quality roughage can be improved by physical, chemical and biological methods and treatment with nitrogen sources of ammonia and energy. In Bangladesh, research reports on different methods of feeding urea in cattle have been published. Some of these are: Urea-treated rice straw (UTRS),^{294,296,298,305,315,327,343,362,369,370,376,379,381} Urea water soaked straw (UWSR),²⁹⁴ urea-ensiled straw (UES),²⁹⁴ urea-molasses straw (UMS),^{325,352,385,392} urea molasses block (UMB)^{297,303,335,340,341,373,377,388,394,401,402} urea-molasses solution (UMS),²⁹⁸ and urea-molasses-mineral block (UMMB).^{318,322,384,386,387,394,392,398,399,404} The UMS which is usually enriched with 3.0% urea and 15.0% molasses on dry matter basis whereas UMMB usually consisted of urea 10%, molasses 39%, rice polish 20%, wheat bran 20%, calcium oxide 6% and common salt 5%.

- The LWG has been reported with feeding UTRS in growing bull calves³⁴⁰ but it has been reported that feeding of UTRS found not suitable to breeding bulls because it decreased quantity (3.0 / 3.7 ml) and quality i.e. motility of spermatozoa (58.6% / 68.4%).³⁸⁵
- The supplementation of UMMB @ 250g/cow/day with normal ration in local post-partum cows reported increased LWG and milk yield³⁹⁷ and decreased calving to 1st service, calving to conception and calving interval.³⁹⁸ whereas the supplementation of UMMB with normal ration in heifers has significantly increased LWG from 49.45 to 64.24 kg but the ovarian activity has delayed.³²²

- The urea level in the milk of lactating cows fed with UTRS (35.29 mg/dl) and UMMB @ 250 mg/cow/day increased significantly in comparison to untreated control cows (24.16 mg/dl).^{375,386} In addition, better milk composition in only concentrate fed cows in comparison to UMMB supplement has been reported.³⁸⁵
- The UMMB supplement @ 250g/head/day reported a positive effect on the productive and reproductive performance of cross-bred lactating cows⁴⁰⁴ but urea feeding in dairy cows reported that it may adversely affect early embryonic development.⁴²⁷
- Review of these reports reveal that the breeding bulls and dairy cows including lactating cows are not suitable for feeding any forms of urea-molasses straw preparations.

It appears that the lack of pasture land with shortage of cattle feeds is one of the main constraints for development and production of cattle in Bangladesh. The cattle feeds and feeding practices have been suggested to be enhanced by biotechnology to develop better cattle nutrition packages. The ultimate goal of using nutritional biotechnology in animal feeds and feeding systems is then to improve the plane of nutrition through the feeding of urea-molasses treated rice straw other than breeding and dairy animals, roughage improvement using non-toxic fungus especially white rot fungi due to its ability to dignify the plant materials, produce genetically modified fodder crops, use of genetically modified micro-organisms to enhance rumen fermentation and thereby increase nutrient availability to the host cattle and use of enzymes to improve the availability from feed and to reduce the wastage of the feed. However, the application of nutritional biotechnology in cattle feeds and feeding practices has limited value due to current status of technology, prevailing environmental and social constraints in Bangladesh.

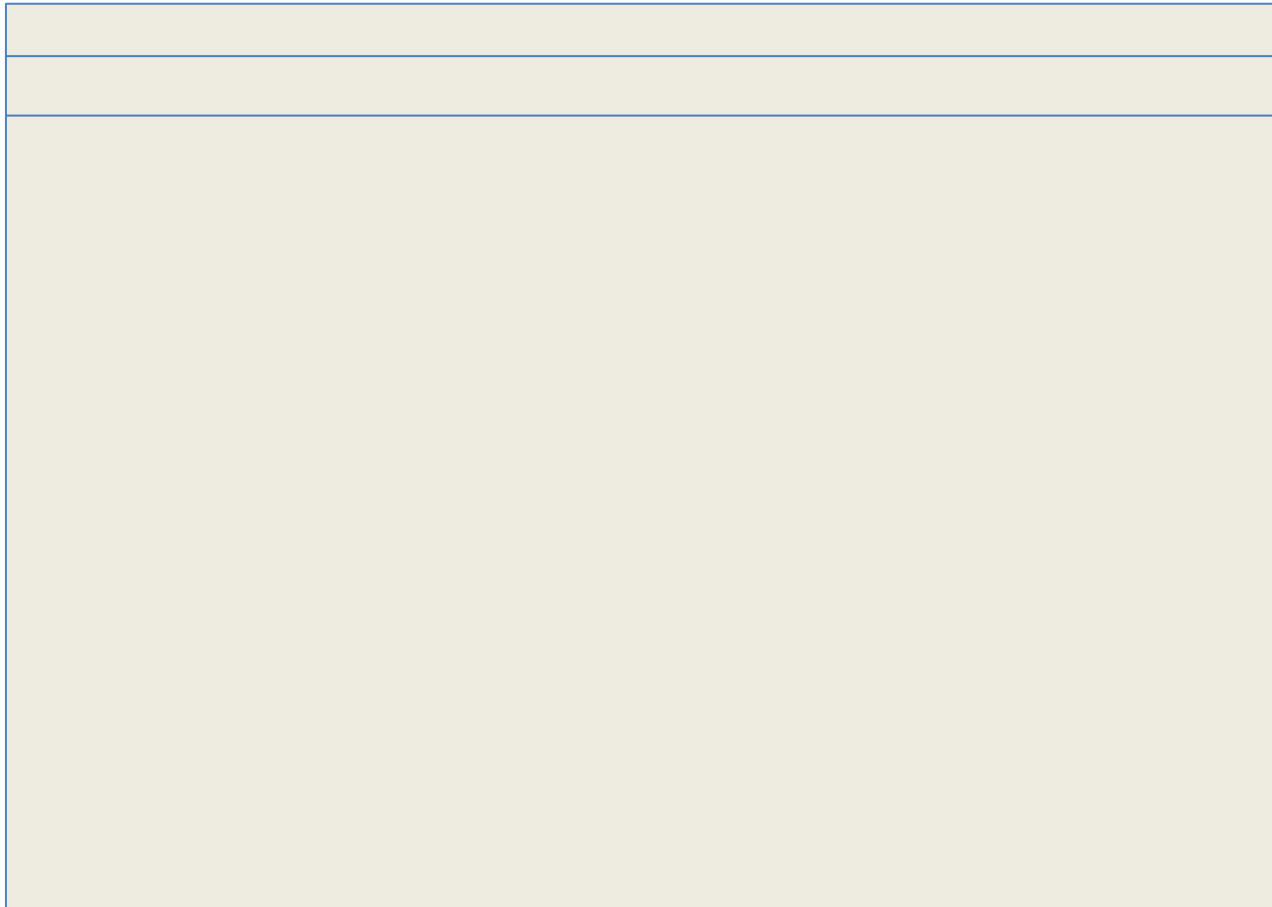
Effects of heat and transport stress in dairy cattle

Stress may be considered as anything that is applied to an animal from an outside source that has an effect on that animal's normal physiological activity. Stress can be categorized into four major types as: ① Environmental stress- toxic metal pollutants, chemical fertilizers and pesticide contamination, ② Physiological stress- heat stress, advanced pregnancy, dehydration and cold stress, ③ Nutritional stress- acidosis, bloat, hypocalcaemia, ketosis, hypomagnesaemia, and mycotoxin / plant toxins and ④ Managemental stress- handling and transportation and seasonal changes. Among these stressors, heat stress causes more losses to dairy cattle.⁴²⁸ High environmental temperature and high relative humidity is the primary factors that cause heat stress in dairy animals.

Temperature humidity index (THI)

The combined effect of temperature and humidity can be measured by the use of THI, which is calculated by the formula: $THI = 0.72 (W + D) + 40.6$ where, W = Wet bulb temperature °C and D = Dry bulb temperature °C

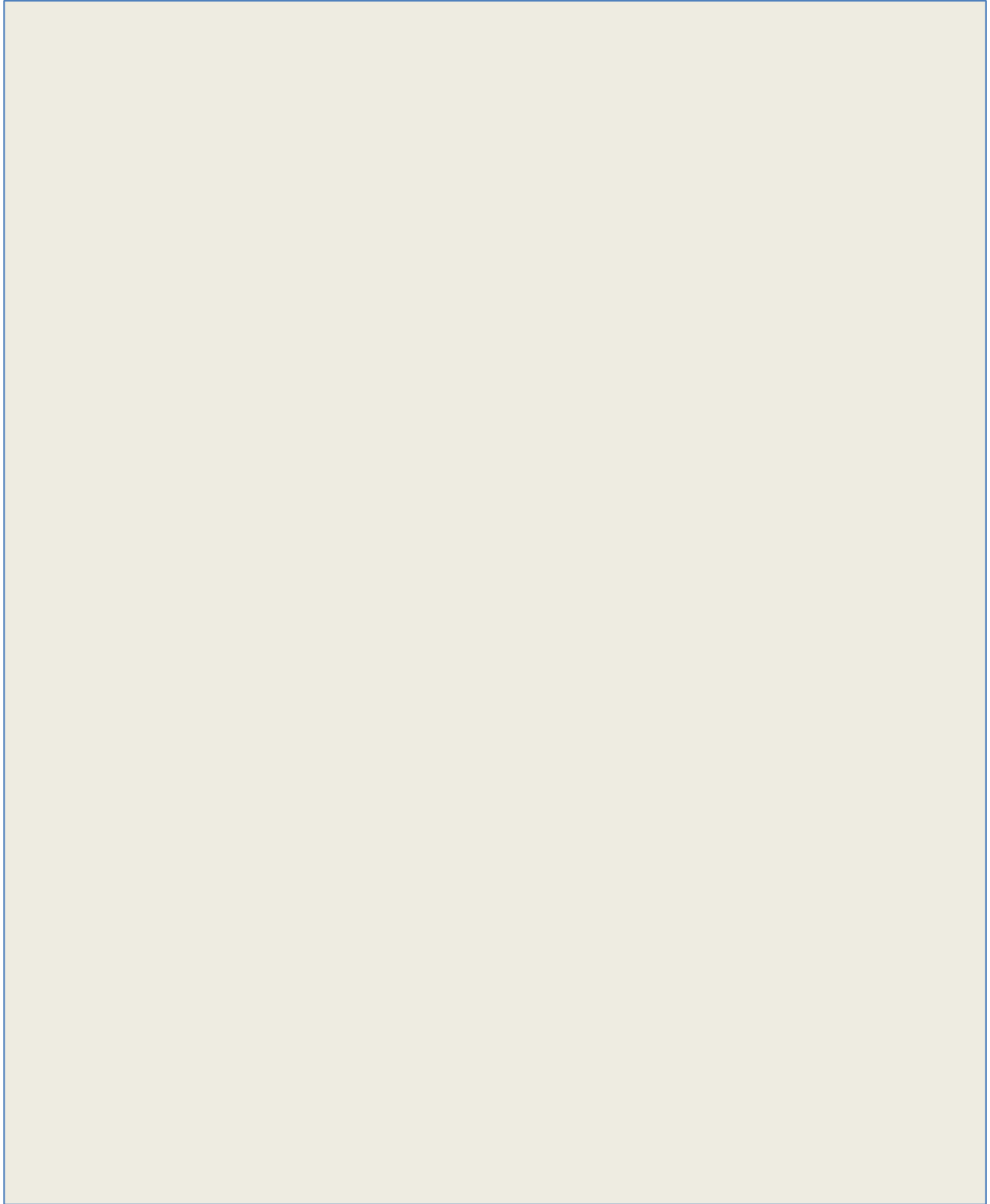
The THI values of ≤ 70 are considered comfortable, 75 to 78 stressful and a value > 78 causes extreme distress with lactating cows being unable to maintain thermo-regulatory mechanisms or normal body temperatures. It appears that the stress caused by heat and transportation in cattle have been reported from Bangladesh (Table 9).

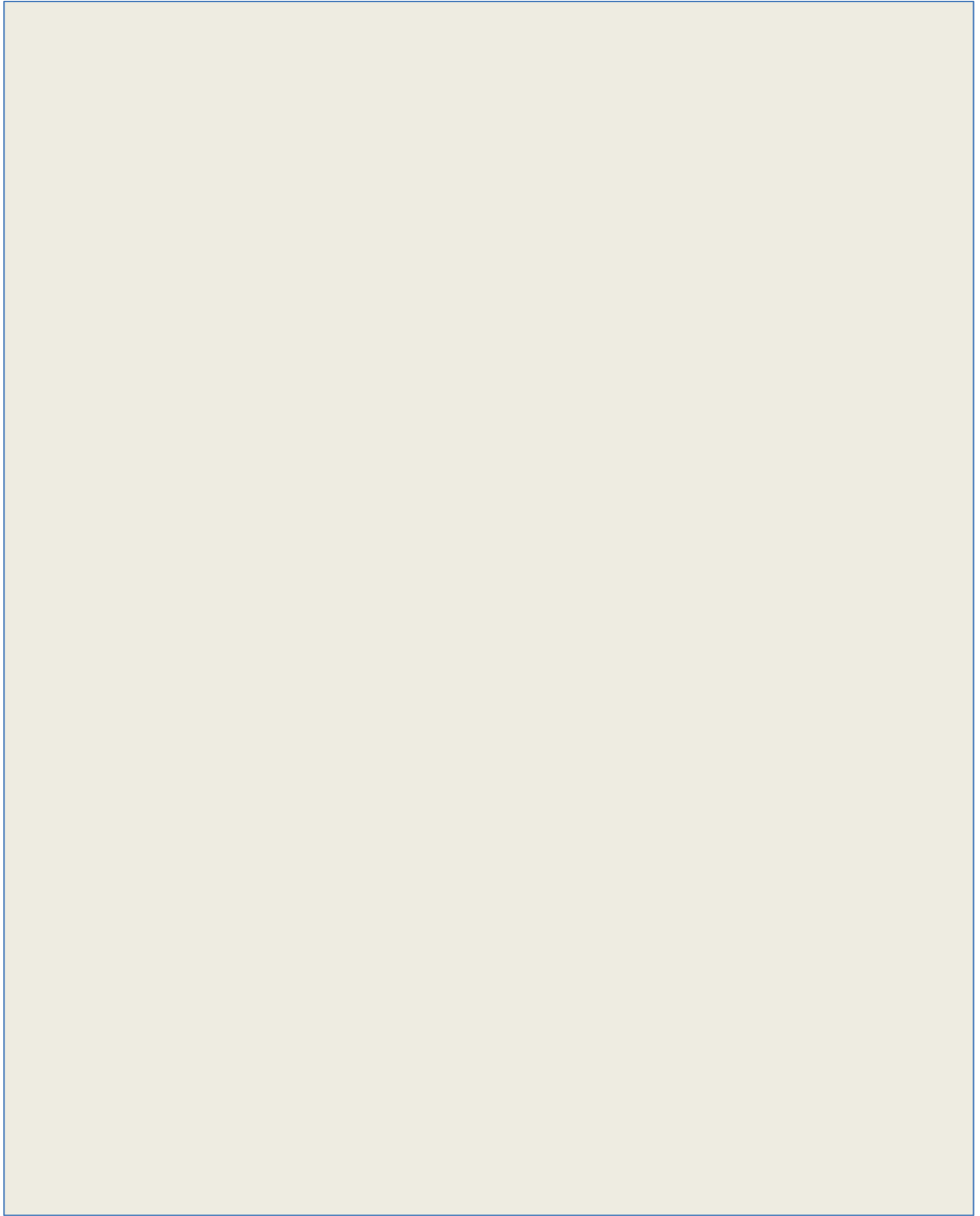


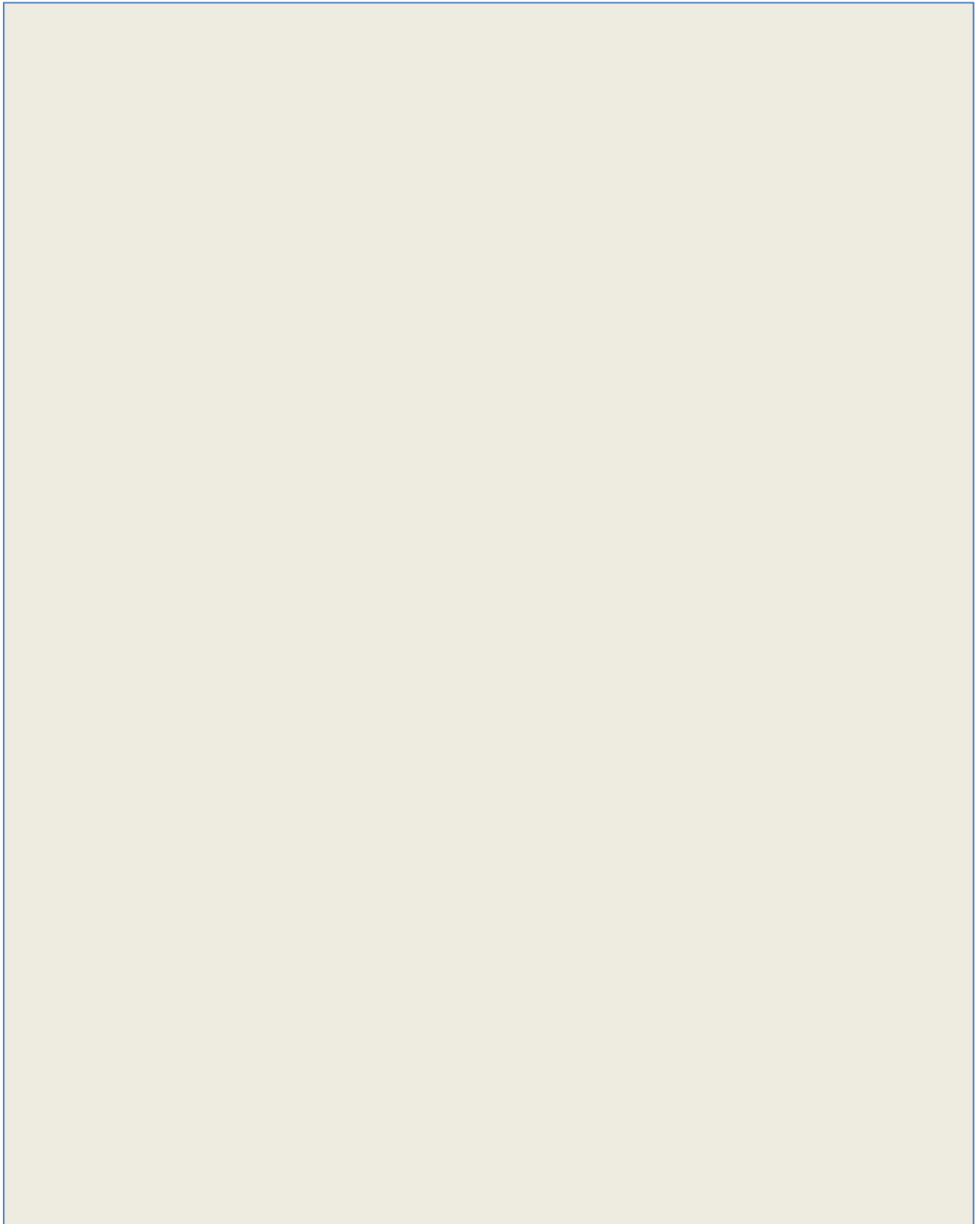
Research findings on cattle fattening

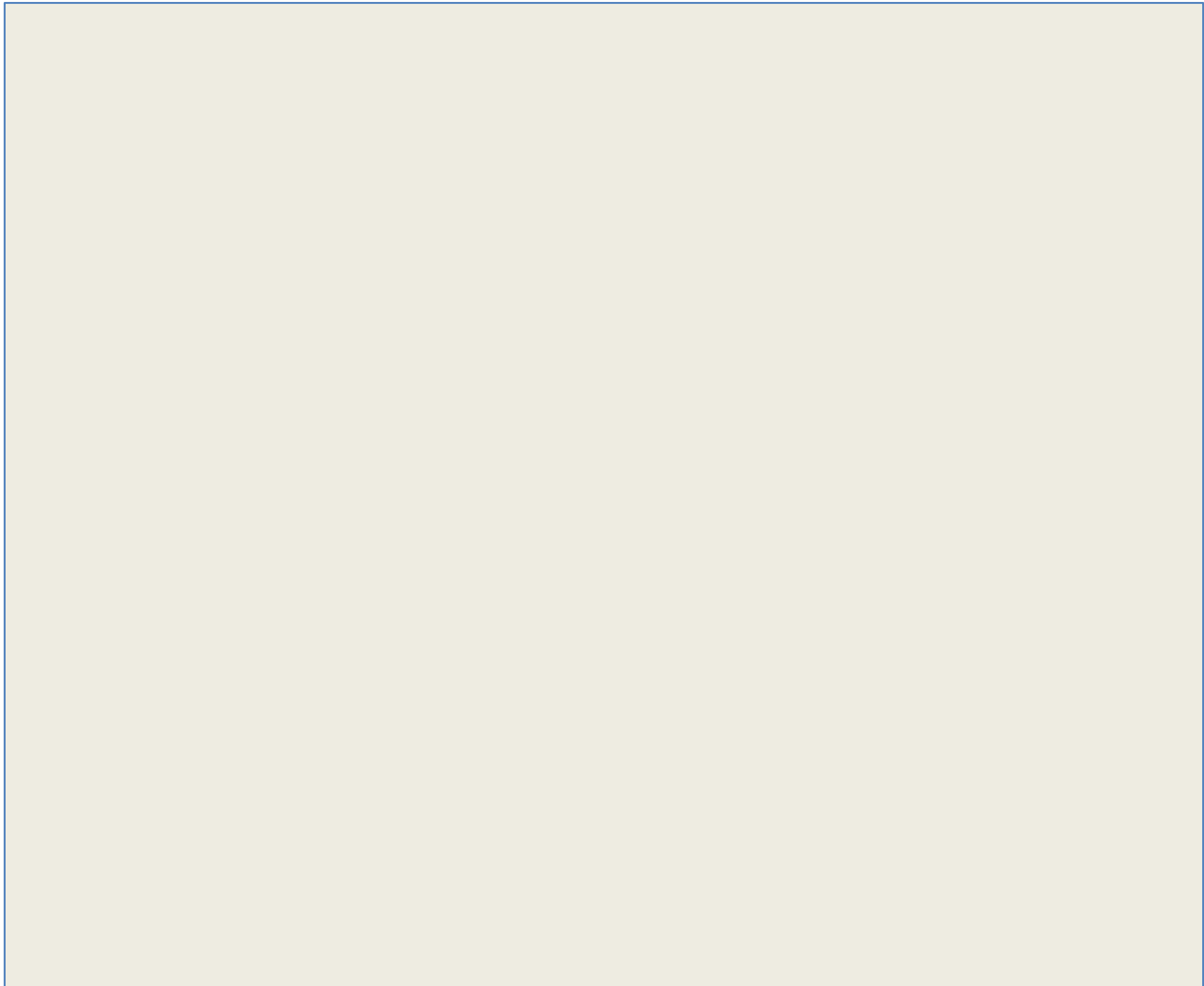
Cattle fattening for beef production have become an income generating important business of the smallholder farmers in Bangladesh.⁴³⁴ Majority of the cattle fattening farmers involved in cattle fattening just before 3 to 5 months of Eid-ul-Azha, when they sell the animals with profitable price.^{435,436} Feeding of urea molasses treated rice straw in beef cattle resulted higher body weight, dressing percentage and also in better carcass quality than feeding untreated straw (Table 10). Farmers are usually used three years old cattle for beef fattening and maximum growth rate between 1.1 to 1.4 years age for a period of 4.5 months.⁴³⁵ It contributes in poverty reduction, creation of self-employment opportunities in rural areas and animal protein supply. However, the problems and prospects of small scale beef cattle fattening program have been reported as lack of training, high cost of vaccines, limitation of knowledge and inadequate veterinary medical services.⁴³⁶

Table 10. Trials of different feed formulations (rations) for fattening of cattle			
Year	Research objective	Major findings	References
1969	To detect the optimum dose of urea with efficient utilization in calves	A mixture of rice polish, wheat bran and til oil cake in addition to rice straw and urea-molasses @ 45g/200lb BW showed better BWG @ 0.929 lb / day / head in comparison to other groups.	437





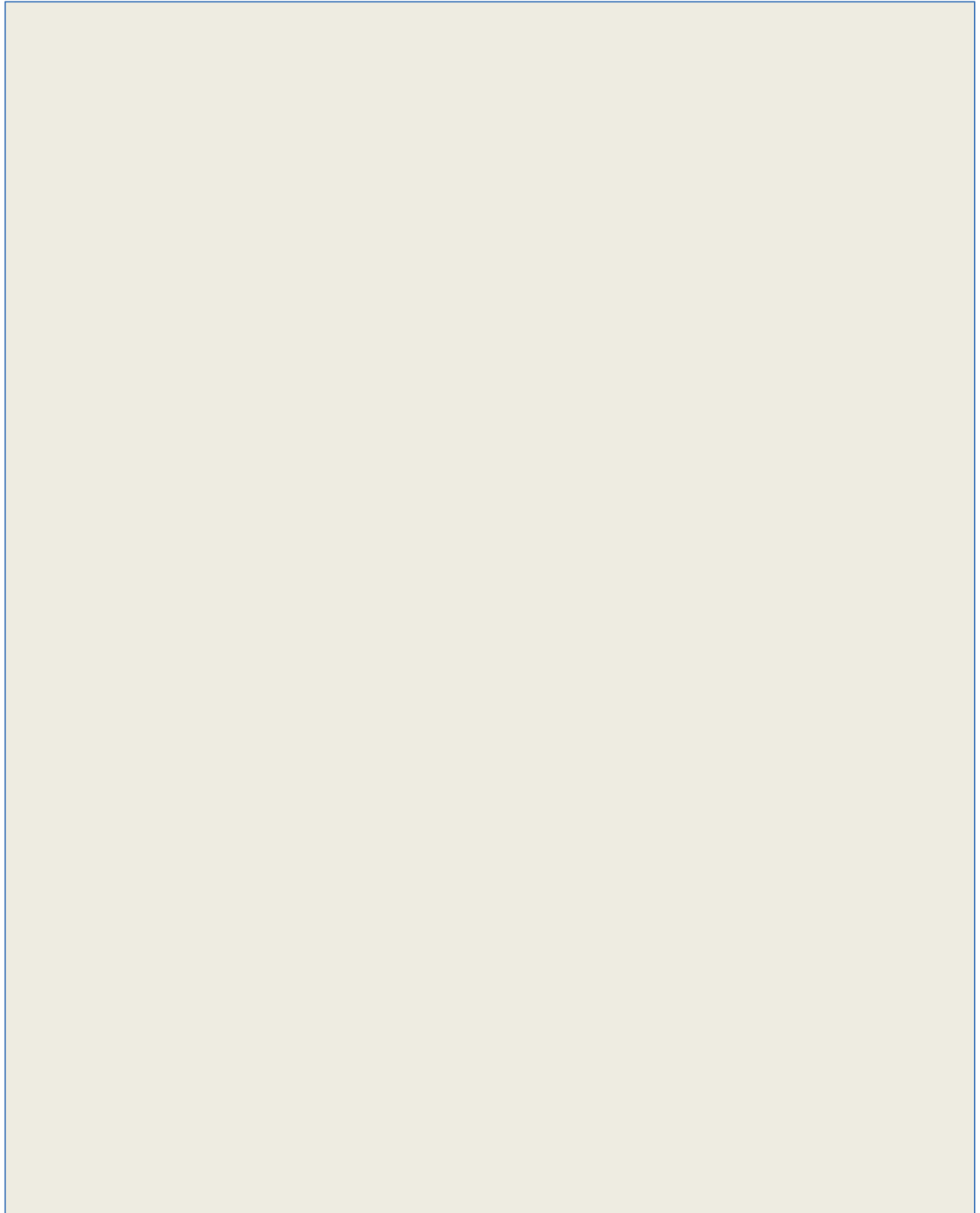




Research on cattle genetics and breeding

Genetics is the science of heredity which is concerned with physical and chemical properties of the hereditary material, how the material is transmitted from one generation to the next and how the information it contains is expressed in the development of an individual. Genetic make-up of animals control their structural configuration and productive abilities either via single genes or by multiple genes situated in different loci. Genes are composed of nucleotide sequences packaged into chromosomes in the nucleus. Milk production is largely affected by a combination of factors namely, genetic make-up in terms of the use of improved breeds selected for milk production, a favorable nutritional environment and improved managerial practices.⁴⁷¹

Some traits of cattle are under genetic control (heritable) and can be exploited to increase herd profitability. Traits that are economically important and are heritable should be included in the breeding objective of the beef or dairy herds. Variation for economically important traits occurs within breeds and between breeds and some variation can be created by crossbreeds. All sources of genetic variation should be considered when planning a breeding program.⁴⁷²



Cattle production, management and dairy products

2016	To find out the reproductive performance of native cows with using Brahman crossbred bull	The overall 63.11% CR and 90.96% calving rate of native cows breeding with Brahman semen have been reported. Satisfactory reproductive performance of indigenous cows has been reported by using frozen semen of Brahman crossbred bull	498
2019	To estimate ratio factors and regression coefficient to extend milk yield for 300 days in RCC	Results showed that both ratio factors and regression coefficients estimated have been suggested to be used more accurately to estimate 300 day milk yield for the indigenous cattle including RCC in Bangladesh	499
2019	To estimate the genetic evaluation of RCC	The high estimates of heritability reported except average daily milk yield indicates that the genetic improvement of these traits can be achieved through selection and breeding in RCC	500
2020	To estimate the genetic (heritability & correlation) and breeding value of Brahman crossbred cattle	The high magnitude of heritability estimates for growth traits reported indicates that the selection can be highly effective in changing growth traits in Brahman crossbred cattle. Strong genetic and phenotypic correlation of growth trait indicated that selection for one trait will improve the others simultaneously	501

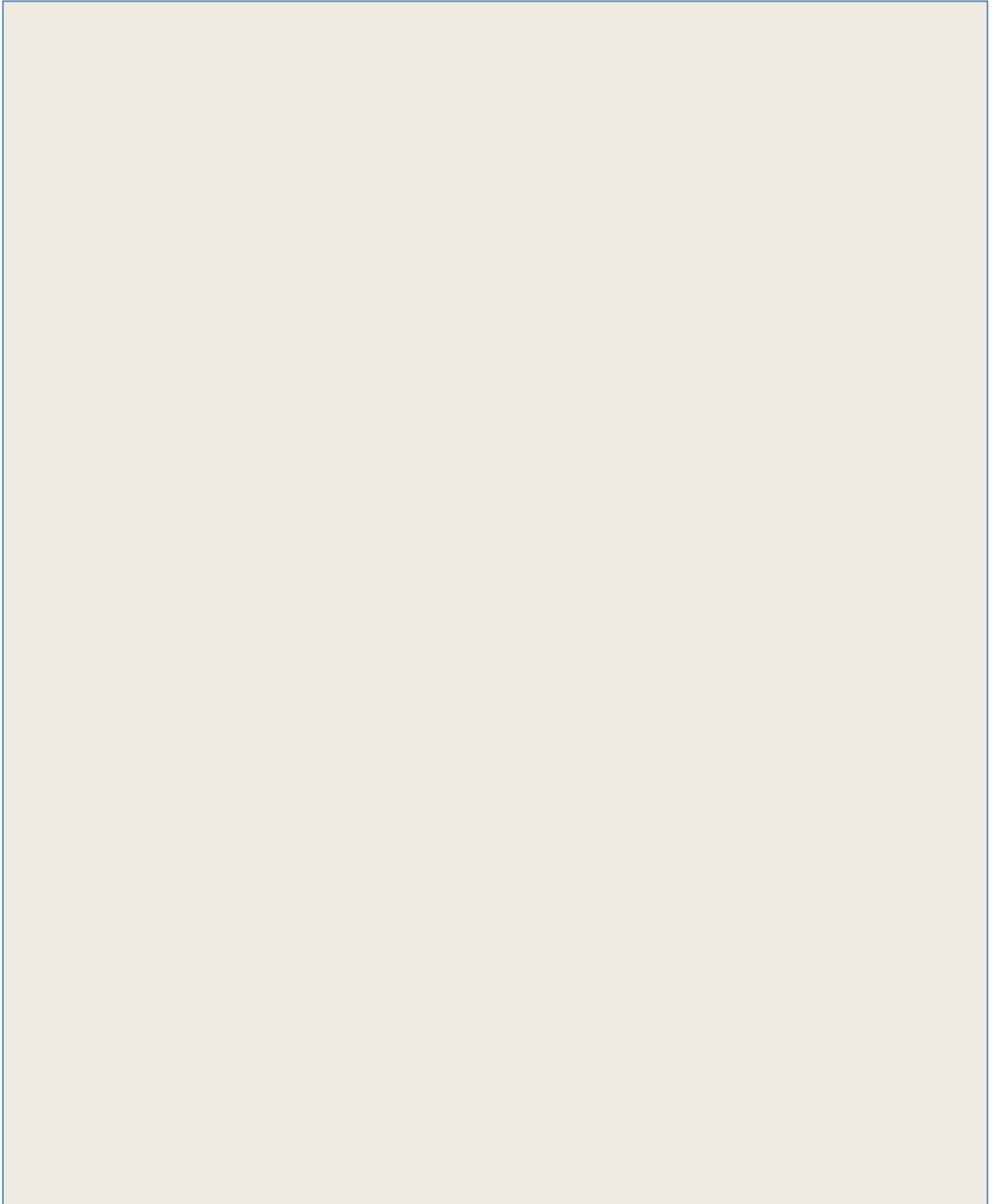
Semen collection and crossbreeding by using artificial insemination

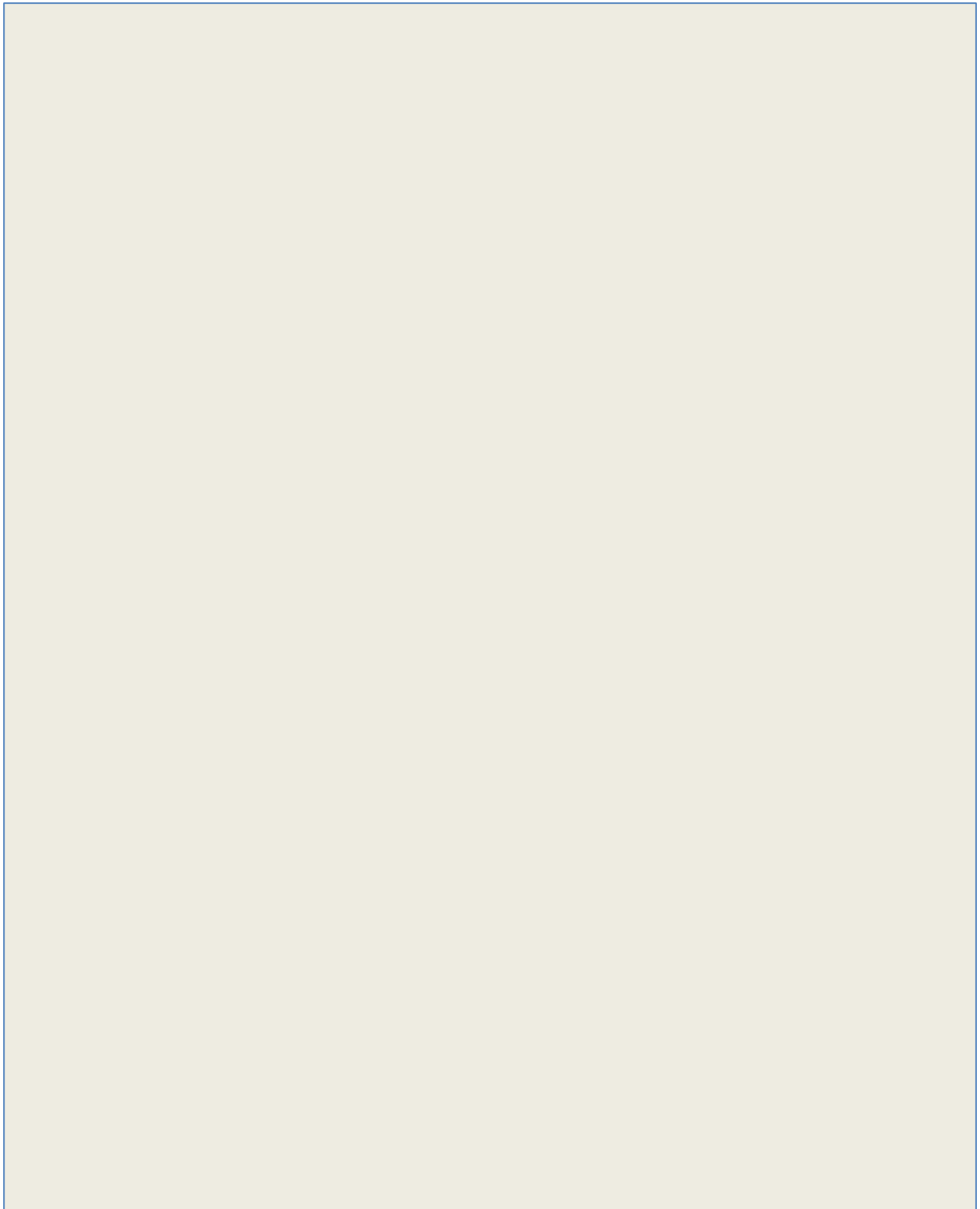
High reproductive performance is an essential requirement to ensure maximum food animal production and satisfactory economic return. The AI promotes genetic and economic gains through the use of superior genetic bulls. However, implementation of AI programs based on estrus detection is hampered mainly by post-partum anestrous and estrus detection failure. The timed artificial insemination (TAI) has been applied routinely in the reproductive programs on farms. TAI protocols are designed to promote control of both luteal and follicular function, permitting the TAI with satisfactory pregnancy per AI. Crossbreeding is the mating of individuals from different lines, breeds or populations with the objectives (a) to utilize the different additive genetic levels between breeds to generate offspring with better economic ability caused by new combinations of additive genetic components and (b) crosses between pure lines / breeds express heterosis. Crossbred cattle are more robust and economically efficient compared with the parental breeds.⁵⁰²

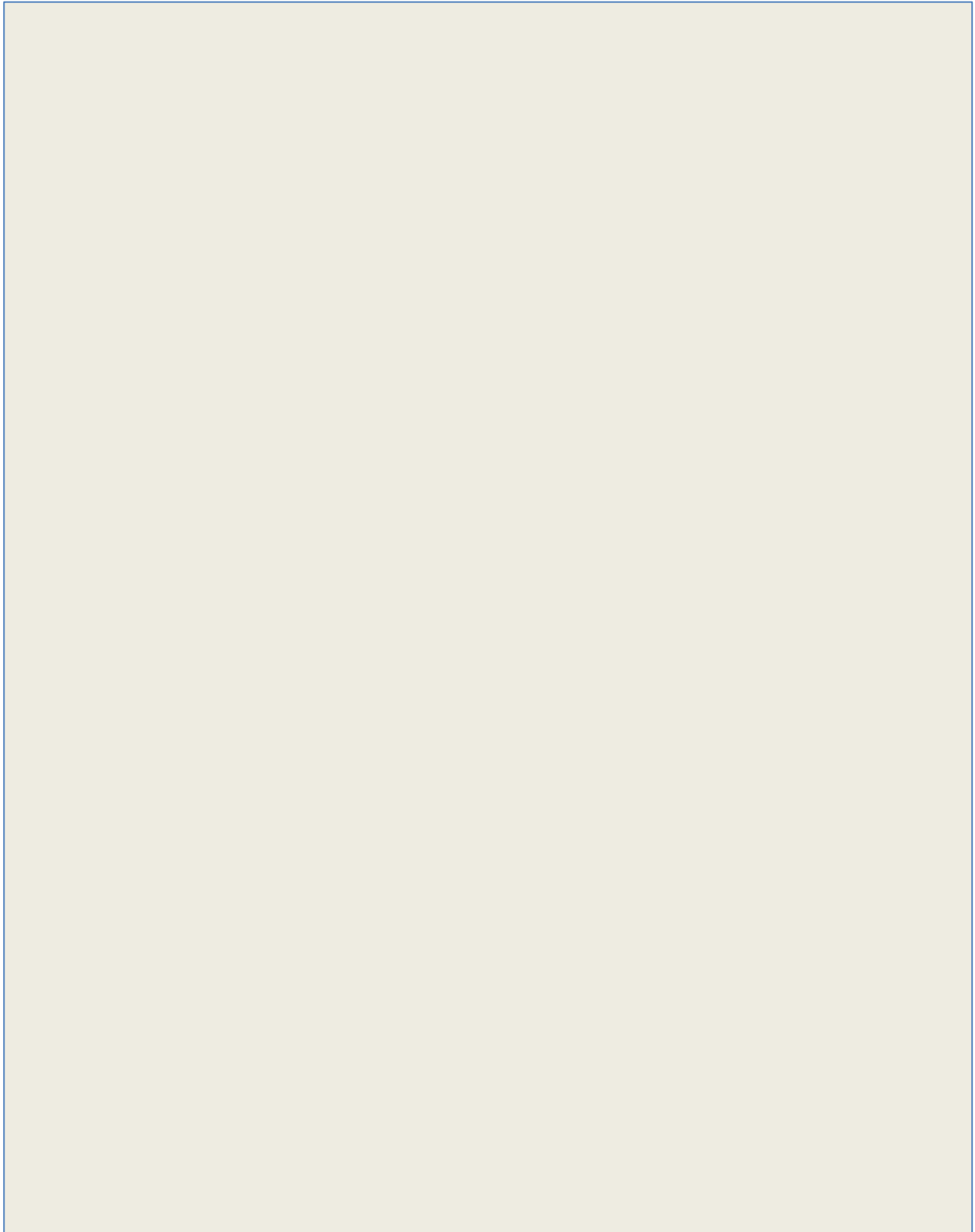
The cattle of the then East Bengal was mainly indigenous type (*Bos indicus*) with low productive potentiality and this situation was somewhat improved by introduction of improved variety of *Bos indicus* Hariana bull from northern India in limited regions by the British Viceroy Lord Airlith Gow in 1936. After independence from British Raj in 1947, second effort was made to upgrade the native cattle by importing Sindhi and Sahiwal bulls from West Pakistan to East Pakistan for natural services.

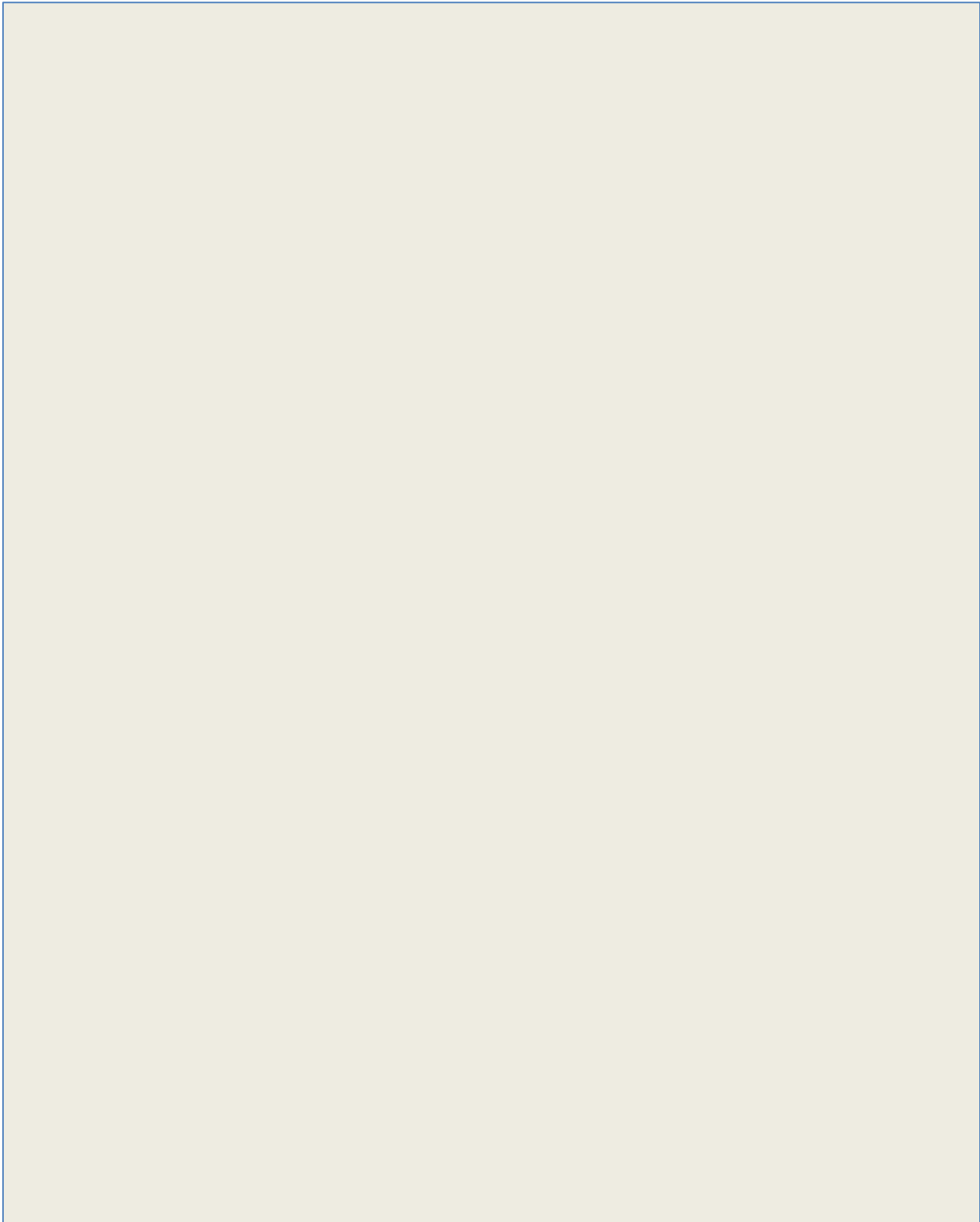
Dairy cattle improvement program in Bangladesh was started in 1958 by DLS with AI program which was strengthened in 1975-76. However, the absence of following the proper process of improvement like registering, recording and others, the government has not achieved any marked over this long period of 55 years.⁵⁰³ The dairy cattle improvement program has been launched with the aims to improve the indigenous cattle through crossbreeding program by using both tropical bulls (Sindhi and Sahiwal) and temperate bulls (Holstein-Friesian and Jersey). Accordingly, in 1973, some Friesian and Jersey bulls were imported from Australia and ultimately crossbreeding program by using artificial insemination program started rapidly in Bangladesh.

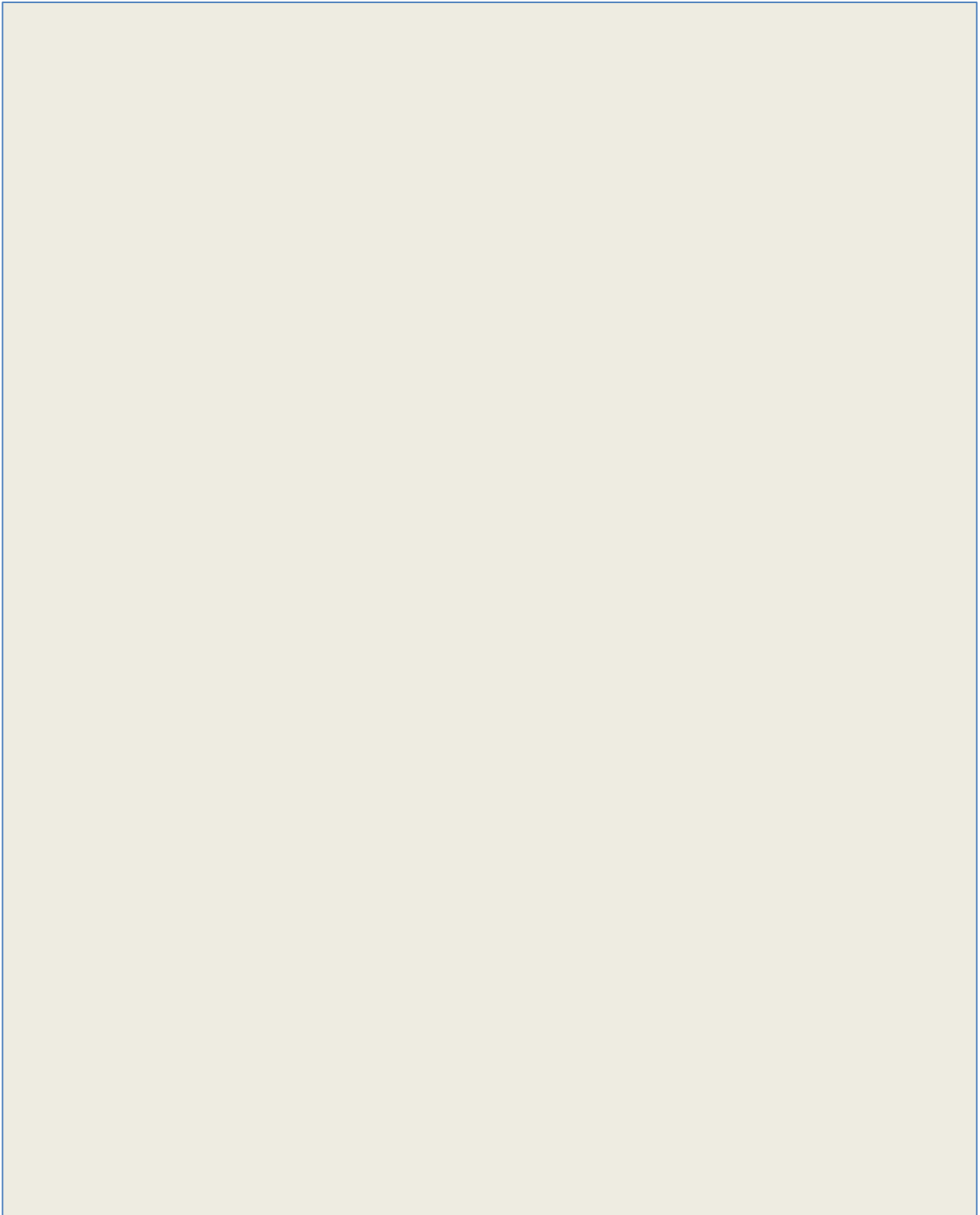
DLS was started AI for dairy cattle improvement in the 1960s, BRAC was started cattle breeding program with AI services using government liquid semen in 1985 in Manikganj district using trained technicians. Up to 1996, BRAC worked in collaboration with DLS for a decade for AI. But this partnership discontinued due to management, non-cooperation and lack of control over AI volunteers by BRAC. BRAC has established its own bull station and started actual frozen semen production and started its AI program in 2000. This NGO have trained 2523 AI technicians and operating AI services in 61 districts (440 upazila). This organization have produced 13,00,000 doses frozen semen (including previous frozen semen stock) and inseminated 13,24,000 cows throughout the country.^{504,505} Currently DLS, BRAC, Cooperative Dairy Production System and other organization have been working in crossbreeding program in Bangladesh. Accordingly, huge number of inland research reports has been published on semen and AI services in cattle in Bangladesh (**Table 13**).











Milk-vita (Bangladesh Milk Producer's Cooperative Union Limited= BMPCUL)

Milk vita, the trade name of BMPCUL started dairy business based on genetic improvement of dairy cattle through AI services of their cooperative farmers in 1972. In addition to semen, Milk-vita has periodically imported Sahiwal bulls from Pakistan (1991) and four Friesian and three Jerseys bulls from Australia (2002). Initially, Milk-vita started to produce and use liquid semen, later they shifted towards producing frozen semen.⁵⁰³

Lal Teer Livestock Limited (LTLL)

The LTLL has started cattle and buffalo improvement program since 2009. They are producing semen from locally produced environmentally supported proven bull at different blood levels crossing with the imported frozen semen of Holstein, Frisian, Jersey and Sahiwal breeds and distributing / marketing it through AI services for increasing milk production throughout the country.⁵⁰³

Pran Dairy

The Pran Dairy has started dairy breed improvement program with frozen semen and AI services imports from World Wide Sire, USA.

Gentech International

The Gentech International has started dairy breed improvement program with frozen semen and AI services imports from World Wide Sire, USA. They have also started to develop AI inseminator to provide training to the local field participants.

BAU AI services

Two departments of the BAU are also involved in AI services to the farmers in and around the university areas. The frozen semen is originated from the government AI Laboratory while liquid seem is produced by their own bull studs.

Central Cattle Breeding Station & Dairy Farm (CCBSDF)

Research on semen production and their uses for AI have been conducted at the CCBS, Savar during 2008-2009 on 145 breeding bulls of various breeds and breed combinations.⁵⁶¹ Approximately 1.7 million doses of semen were produced from these bulls (Table 14).

The AI is the first generation reproductive biotechnology that has made a profound contribution to the genetic improvement as well as recognized breeding tool of the cattle.⁵⁸⁰ The majority (58.0%) of the smallholder farmers have reported to faced medium problems while 39.0% with high and only 3.0% with low problems in adopting AI in their cattle. The inseminator problem and heat stage have been recognized as the most critical problems.⁵⁸⁰ Crossbred cattle contributes about 24.0% of the 6.9% million breedable cows and heifers and HF × L crossbred cow's milk production performance considerably improved over the decades.⁵⁸¹ Approximately 87% smallholder dairy farmers have used AI for breeding cows in Rangpur.⁵⁸² Cows are inseminated 76% by AI and 24% both AI and natural services in Jossore.⁵⁸³

Cattle production, management and dairy products

SN Breed	No. of bulls	Dose of semen (000')	SN Breed of bull	% used in AI
1. Friesian (F)	02	039.6	1. Friesian (F)	54
2. Sahiwal (SI)	10	-	2. Friesian (F) × Sahiwal (SL)	17
3. Local (ND)	08	116.1	3. Sahiwal (SL)	10
4. RCC	02	005.0	4. Friesian (F) × Red Sindhi (RS)	09
5. SL × F	30	-	5. Friesian (F) × Pabna (P)	03
6. L × F	93	1556.9	6. Red Sindhi (RS)	03
7. L × F × F	-	-	7. Red Sindhi (RS) × RCC	02
8. SL × F × F	-	-	8. Friesian (F) × Jersey (JS)	01
-	-	-	9. Red Sindhi (RS) × Sahiwal (SL)	01
Total:	145	1717.6	Total	100

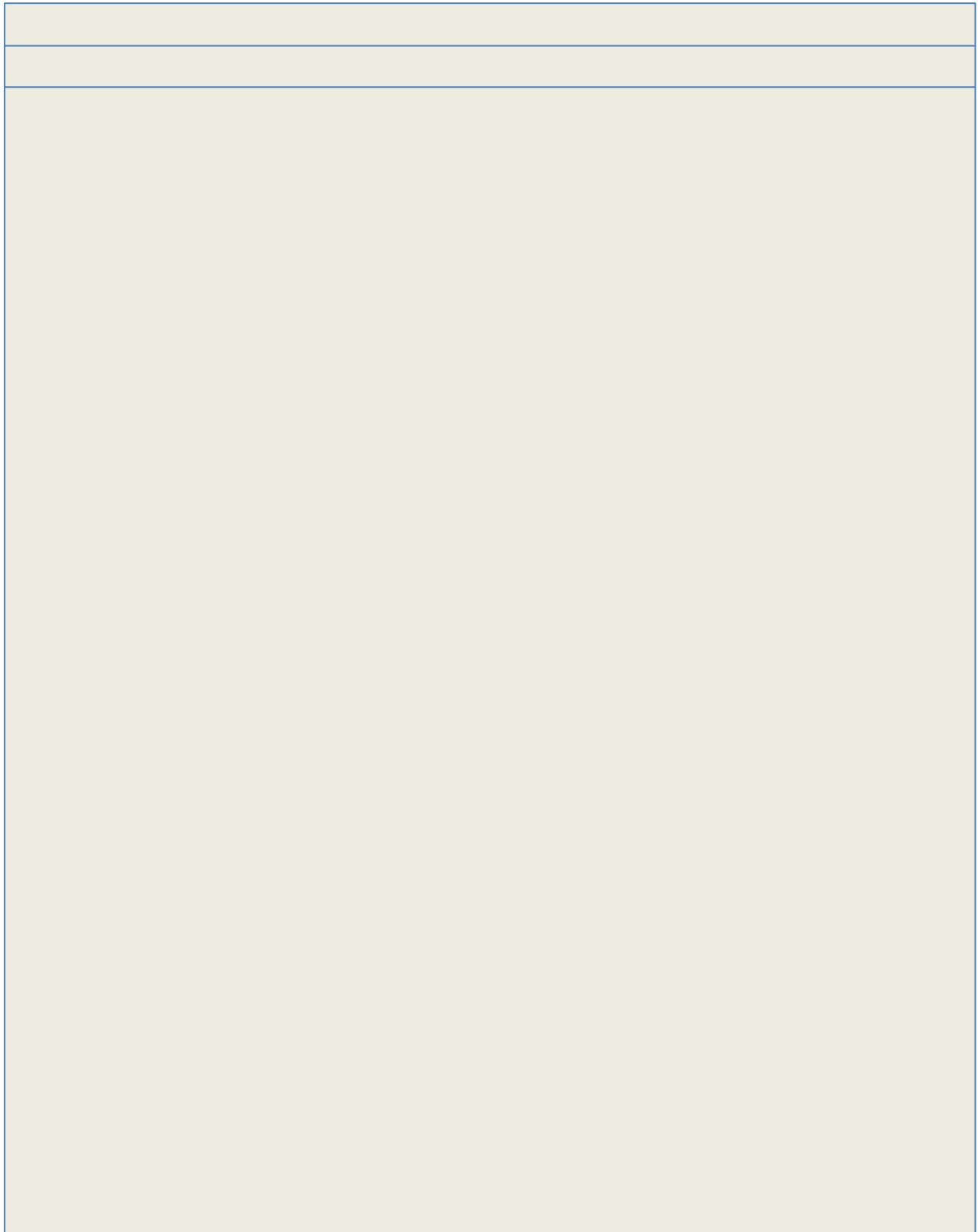
- = Data not available

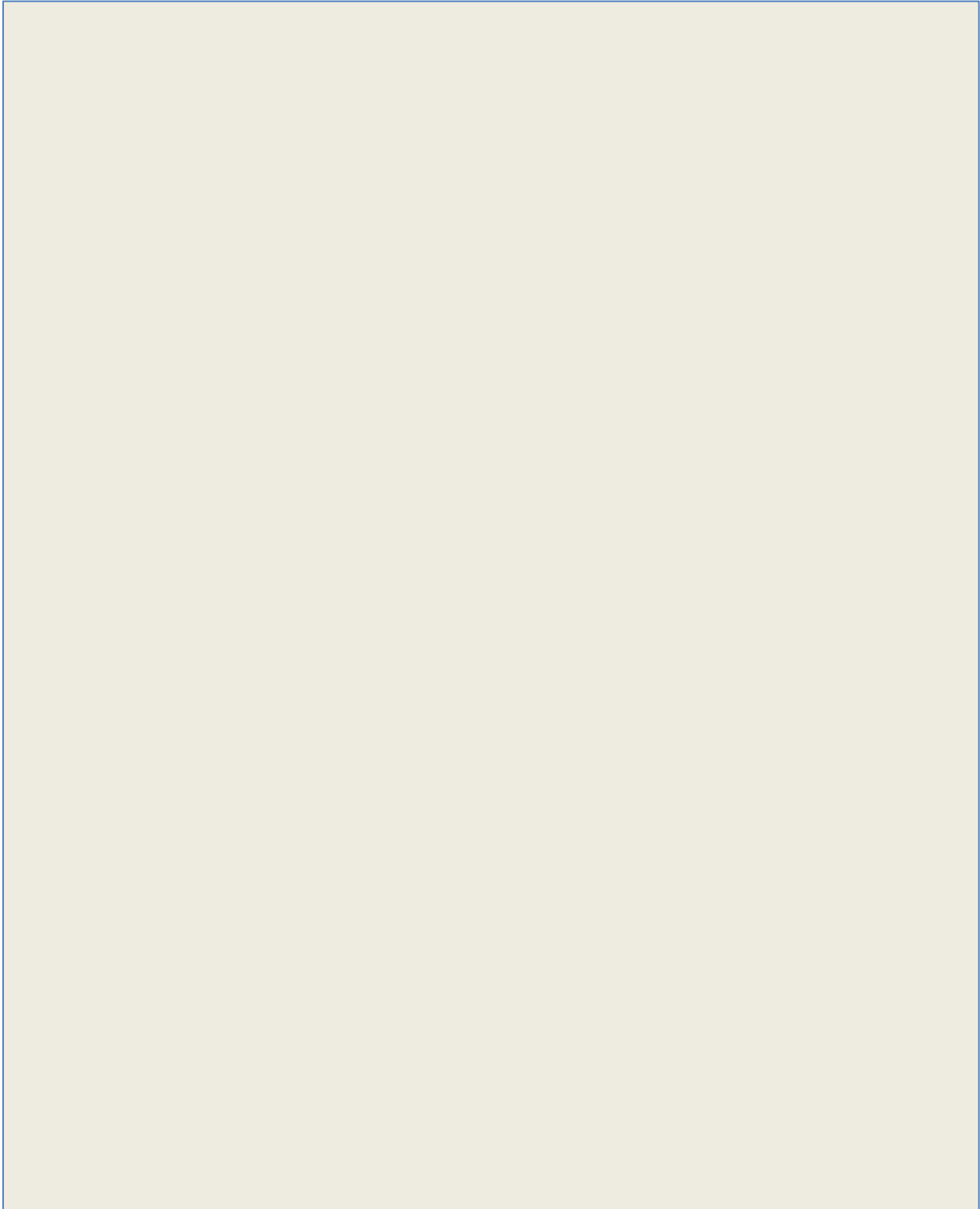
Conception rate (CR) of AI in cattle

The CR plays a major role to achieve a successful reproductive performance of dairy cattle. However, the successful outcome of an AI is a combination of both bulls and cows fertility-linked factors. The AI technique has been used from more than 50 years in Bangladesh and this program is extended every year. The first service CR for particular group can be determined by the number of heifers or cows given first service multiplied by 100. $CR = \frac{\text{No. of pregnant}}{\text{Total No. of cows inseminated}} \times 100$. Pregnancy rate is the percent of cows eligible to be bred that actually get bred that become pregnant multiplied by the CR of those inseminations in any 21-day (average length of a cow's estrus cycle) period of time. Table 15 shows the conception rate under different breeding methods in heifers and cows in Bangladesh. Research findings on the factors associated with the conception rate have been reviewed (Table 16)

SN Breeding methods & results of service	No. of cattle	Conception rate (%) with services					Ref. No.
		1 st service	2 nd service	3 rd service	4 th service	5 th service	
A. Breeding methods							
1. Natural service	237	62.45	06.75	05.91	04.64	79.75	584
2. AI with liquid semen	802	55.86	48.31	41.53	39.62	38.46	584
	323	25.08	18.58	12.69	02.48	58.83	584
3. AI with frozen semen	325	42.15	14.46	05.85	02.46	64.92	584
B. Results of service							
1. Live calves borne	802	410 (51.1)	151 (42.7)	69 (37.7)	39 (36.8)	23 (35.4)	585
2. Abortion/stillbirth	802	038 (8.5)	020 (11.7)	07 (09.2)	03 (07.1)	02 (08.0)	585

Table 15 shows that the CR and calving rate reported highest after first AI services (55.86% and 51.1%) respectively, reduced gradually with the increasing the number of services and lowest after 5th AI 38.46% and 35.4%, respectively.





Effects of the stages of estrus and semen on CR

The effects of the different stages of estrus cycle (Table 17) and semen (Table 18) on the conception rates in cattle is reviewed.

SN Breeding method	AI at different stages of estrus			SN Problems related to CR	Prevalence,%
	Early	Middle	Late estrus		
1. AI with 1 st day LS	61.54b (52)	69.01a (71)	34.88c (43)	1. Errors in estrus detection	29.94
2. AI with 2 nd day LS	60.87b (46)	66.67a (69)	30.95c (42)	2. Delayed insemination	35.03
3. AI with FS	57.61b (92)	72.20a (205)	35.71c (28)	3. Abnormal utero-vaginal secretion	09.98
				4. Cystic ovaries	02.94
				5. Miscellaneous causes	22.11
Estrus period ⁵⁹⁶		Estrus period ⁵⁹⁷		Estrus period ⁵⁸⁶	
1. 09.1-12 hrs	CR 78.06	1. ≤ 12 hours	CR 38.1% (8/21)	1. 07-10 hours	CR 48.32%
2. 12.1-15 hrs	80.36	2. 13-18 hours	53.2 (42/79)	2. 11-14 hours	CR 60.26%
3. 15.1-18 hrs	76.61%	3. 19-24 hours	66.0 (33/50)	3. 15-18 hours	CR 39.42%

Insemination of cows and heifers at mid-cycle (12 to 15 hrs.) had significantly higher CR as compared to early and late cycles (Table 17). Concluded that estrus detection, correct timing of insemination, maintenance of proper cold chain of liquid and frozen semen, proper handling of semen with veterinary control would enable to achieve higher CR.

SN	Sources of semen	No. AI cows	Conception No. (%)	SN	Sources of semen	No. AI cows	Conception No. (%)
1.	DLS	1201	593 (49.62)	2.	Milk-vita	314	124 (39.01)
3.	ACI	392	150 (40.34)	4.	BRAC	600	378 (63.06)
5.	PRAN	405	266 (65.68)		Overall	2912	1511 (51.88)

Embryo transfer (ET) in cows

The production of the first calf by embryo transfer in 1951 in Wisconsin following the surgical transfer of an abattoir-derived day-5 embryo,^{600,601} since then the method has been progressively improved so that it can now be used for commercial ends.⁶⁰² There are two procedures presently available for production of embryos from donor females, (a) superovulation followed by AI and then flushing the uterus to gather embryos and (b) in vitro fertilization (IVF) consists of the recovery of eggs from the ovaries of the females then outside the body unit they are ready for implementation in foster females.⁶⁰³ Although this technology is not commercially available in developing countries including Bangladesh, ET could provide opportunities for the conservation and the development of minor breeds.⁶⁰¹ The achievements of the AI are still not satisfactory in Bangladesh due to mainly unplanned AI practices as well as insufficient extension activities up to the farmer's levels. Moreover, only the AI practices cannot improve the genetic merits of

Bangladesh Milk Producers' Co-operative Union Ltd. (BMPCUL; trade name as Milk-vita), formed in 1977. Currently, approximately 40,000 smallholder dairy farmers have become members of primary dairy cooperatives covering 925 villages in 15 districts including Sirajgonj, Tangail, Manikganj, Takerhat, Baghabarighat, Sree Nagar, Rangpur, Bhairab and Raipur, supplying over two million liters of milk daily. Of the total national consumption of 18 million tons per year of liquid milk, 15 million are produced domestically.⁶¹³

Dairy farming is one of the ancient occupation established in smallholder farmers system in Bangladesh but its development is not at the satisfactory level mainly due to unplanned breeding, shortage of feeds and fodders, management, diseases and marketing of milk.^{582,614-618} The dairy sector is an integral part of farming systems and has created both direct and indirect employment opportunity, improved food security and enhanced supply of quality protein to people's meals, contributing country economic growth and reducing poverty level in rural and urban areas of Bangladesh. Cattle, buffalo and goats are considered dairy animals in Bangladesh. Out of total milk production, about 90% is coming from cattle, 8% from goat and the remaining 2% from buffaloes.⁶¹⁹ There are about 6 million dairy cattle of which about 85 to 90% are indigenous and 10 to 15% are crossbred,⁵⁰³ whereas 3.53 million are milking cows and 2.61 million are dry cows in Bangladesh.⁶²⁰ However, the milk production depends on the genotype, proper feeding, management, breeding, housing and preventive measures against diseases and parasites.

Dairy production system in Bangladesh

Dairy farms having more than 200 lactating cows and land for fodder cultivation are categorized as large dairy farms. Most of the large dairy farms in Bangladesh are two types managed which include Government owned and private sector dairy farms. These dairy farms have mostly crossbred cattle and some extent to some pure breeds cattle. Smallholder dairy farms distributed all over the country. However, the private dairy farms based on location can be categorized into three types, (a) Rural dairies (smallholder farms), (b) Pocket dairies (milk producing areas like Baghabarighat, Munshiganj, Takerhat) and (c) Metro dairies (developed at urban areas). There are four major dairy production systems in Bangladesh based on farm input and output levels. (a) Traditional, (b) Extensive, (c) Intensive and (d) Bathan systems.⁶²¹

(a) The **traditional** system is characterized by small family farms (stallholder farms) in an integrated animal-crop production system with herd size vary from one to six cattle. Traditional smallholder farmers fed their cattle mainly on crop-by-product and residues, natural grasses and graze on communal land and also use shrub and tree leaves without any concentrate.

(b)The **extensive** system is practiced mainly by market-oriented dairy farmers operating on a small, medium and large scale farms. Animals are grazed for part of the day and are stall-fed during the rest. In addition to rice straw and green grasses, also provide some concentrate.

(c)The **intensive** system is characterized by zero grazing, with 2-10 cows, and the application of stall feeding systems using concentrate, rice straw and green fodder.

(d)The **bathan** system is characterized by a group of animals is reared near the banks of river, especially when monsoon disappears and water drains from the arable land, different leguminous fodders like matikalai, khesari kalai and also Jumbo, Napier and German grasses are cultivated and farmers allowed to graze these land during December to May every year.⁶²¹ Approximately 68% of the animals in Pabna and Sirajgonj districts are reared under the bathan system and 32% in the non-bathan system.⁶²²

Research on smallholder rural dairy farms

Due to lack of pasture land and heavy demand of animal sources of protein especially milk, more than 70 to 80% of the cattle population is reared by individual farmers in the rural village management system with low productivity.^{621,623} Smallholder producers dominate in the dairy sector and more than 70% of the dairy farmers are smallholders and produce 70-80% of the country's total milk.⁶²¹ Smallholder dairy farms in rural Bangladesh usually consist of 2 to 45 native lactating cows^{624,625} with an average milk yield of 1.70 liter per cow per day.⁶²⁴ Milk demand measured by per capita consumption is increasing by 4.0% per year which is higher than the growth in milk production (3.6%) and this has led to a continuous widening of the gap between milk supply and demand.⁶²¹ Smallholder dairy farms support the family income, nutrition, women employment and develop a village micro-economy in order to improve rural livelihoods and to alleviate rural poverty.^{259,626,627,628} The Bangladesh Government launched a national program to increase milk production in 1991 by providing subsidies to dairy farmers who were rearing a minimum of five lactating dairy cows, either deshi, crossbred or exotic. This program was quite successful and the milk production greatly increased.⁶¹³ Currently, high milk yielding different crossbred cows are reared under smallholder farming system. Many scientists have performed their research on cattle production and health and also some important review articles have been published of the work of the different scientists.

Breeds and population of dairy cows

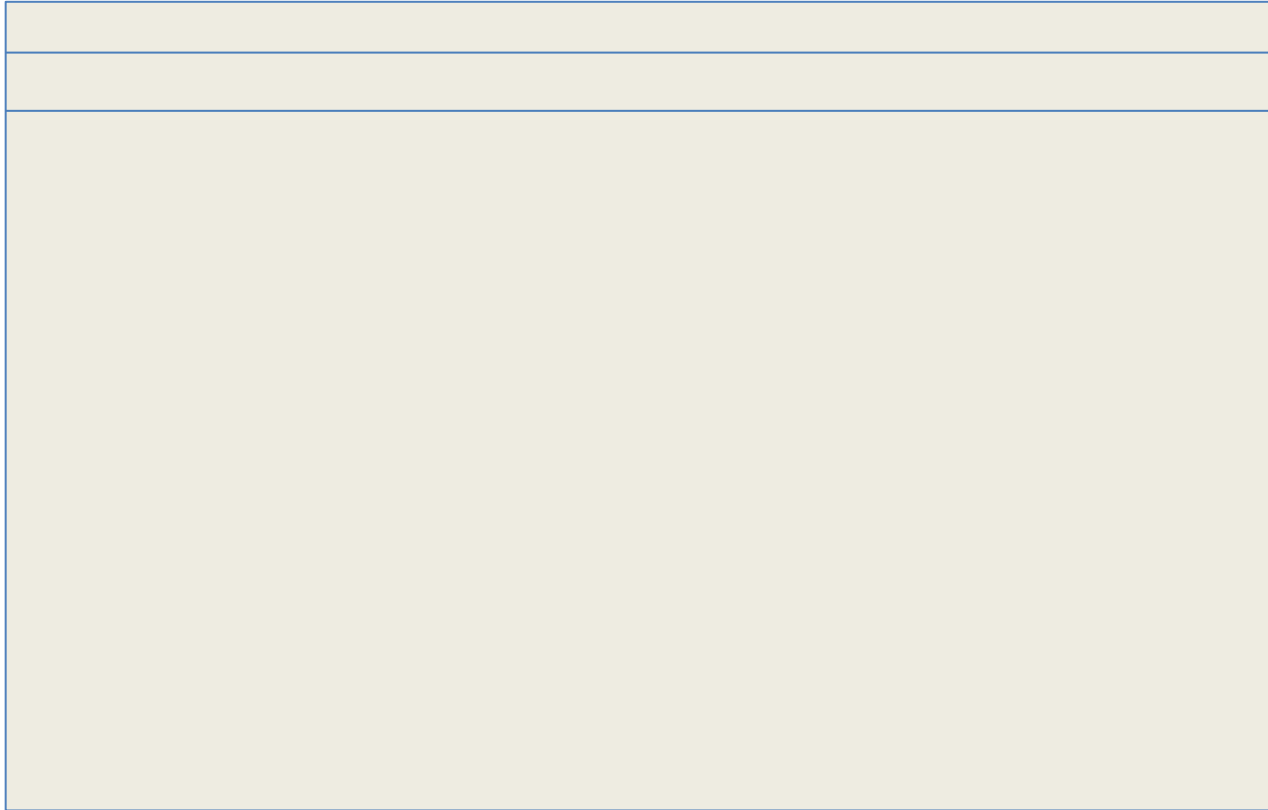
Indigenous cattle consisted of (a) Non-descriptive deshi, (b) RCC, (c) Pabna cattle, (d) North Bengal gray, and (e) Munshigonj white cattle. Cross-bred cattle are the results of crossing between local with different exotic breeds like Holstein, Friesian, Sindhi, Sahiwal, Jersey at different level.^{503,629} Approximately 85% cattle in Bangladesh are indigenous in origin.¹³ Inclusion of quality genes over the past decades of crossbreeding resulted in crossbred cows of about 47% with an average lactation yield of 1838 liter in 266 days, while the similar performance of a local cow is 619 liter in 230 days, respectively. The crossbred cattle population has also increased milk production horizontally at the expense of genetic dilution.⁶³⁰

Smallholder dairy farmers are rearing different cross-bred at rural levels and most commonly 25.0% farmers rearing HF cross, 20.0% Sahiwal cross, 22.0% Sindhi cross and 33.0% indigenous cows in Bogura district in Bangladesh.⁶³¹ Farm owners had 85.4% crossbred (Friesian and Jersey) and 14.6% indigenous cows in Rangpur district.⁵⁸² Some research findings on breeds and population of cattle have been reported (Table 20)

- The small farmers by keeping 8 to 10 crossbred cows could earn a modest living by adopting small dairy farming as a profession⁵⁸²
- Holstein-Friesian crossbred cows were ranked best as dairy cattle.²⁵⁹

A total of 50 smallholder dairy farms have been investigated to study the management system of the farms and an average of 5.12 lactating cross-bred cows with an average milk production 5.78 liter / cow / day have been reported from Jossore.⁶³²

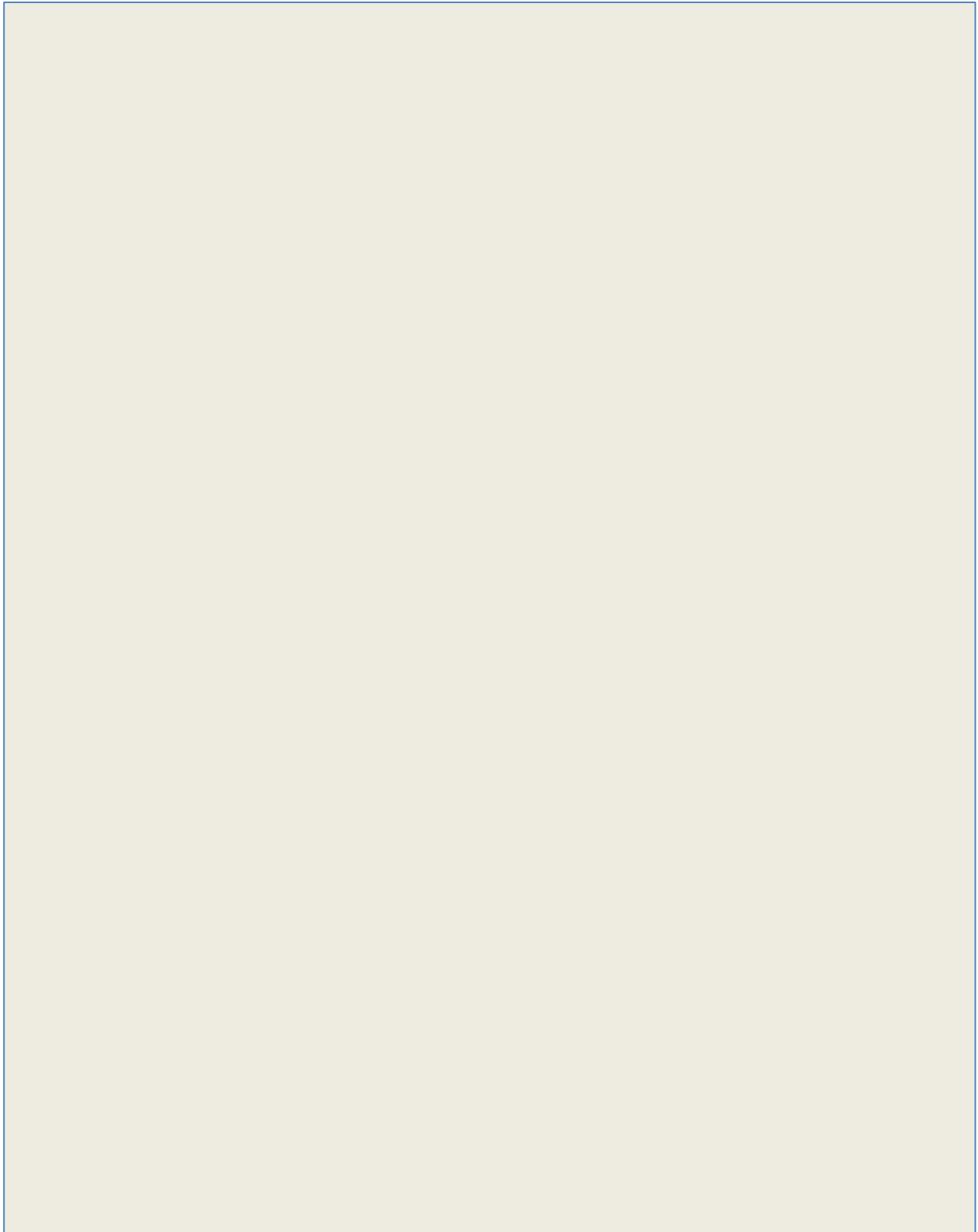
- The results showed that 98% of the dairy cattle are cross-bred (Pabna x HF, SL x Jersey) in Milk-vita area of Sirajgonj and Pabna with highest cross-bred population in the Shahjadpur, which is located close to the Milk-vita center and accordingly used of concentrate and AI better than other areas.⁶²²

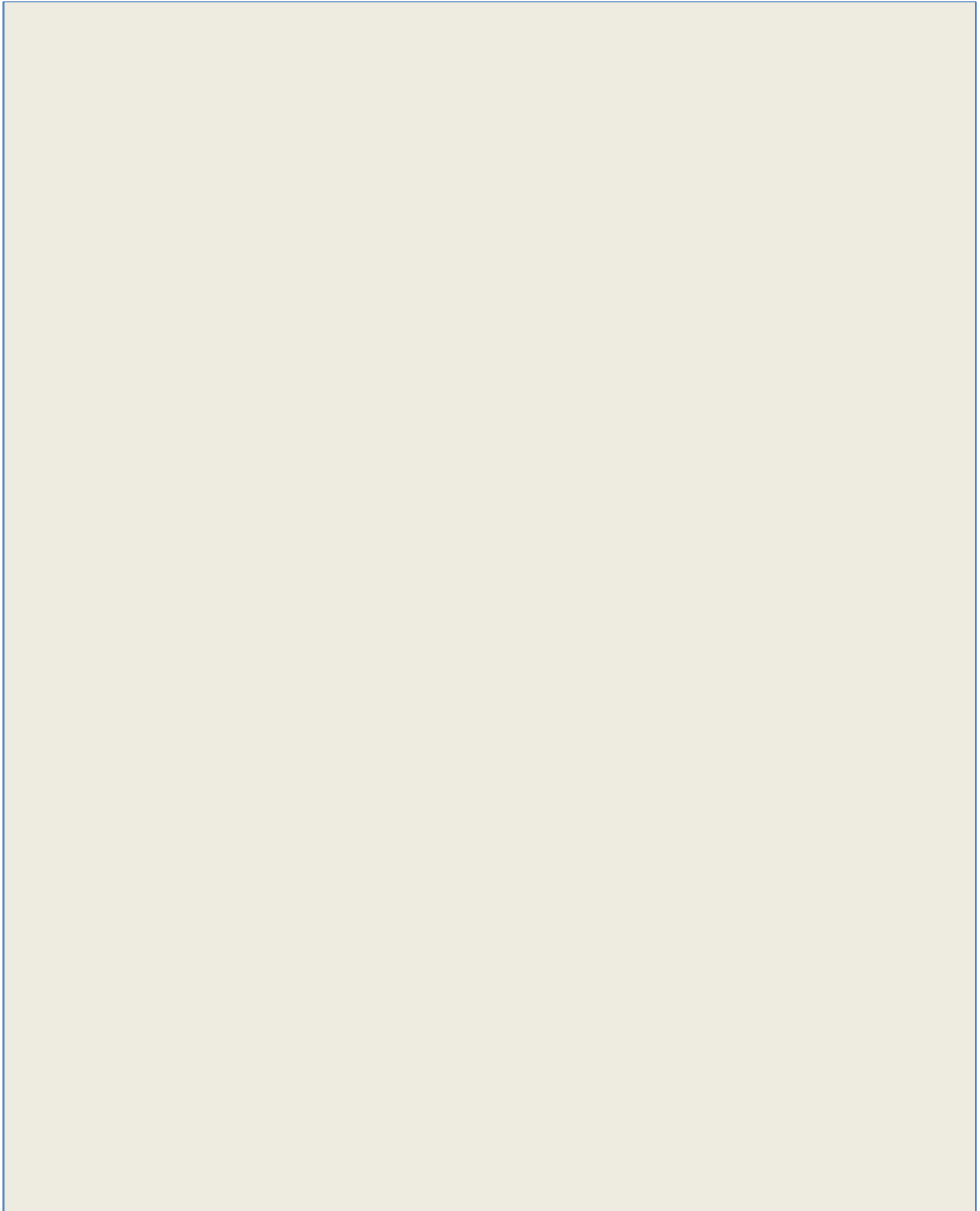


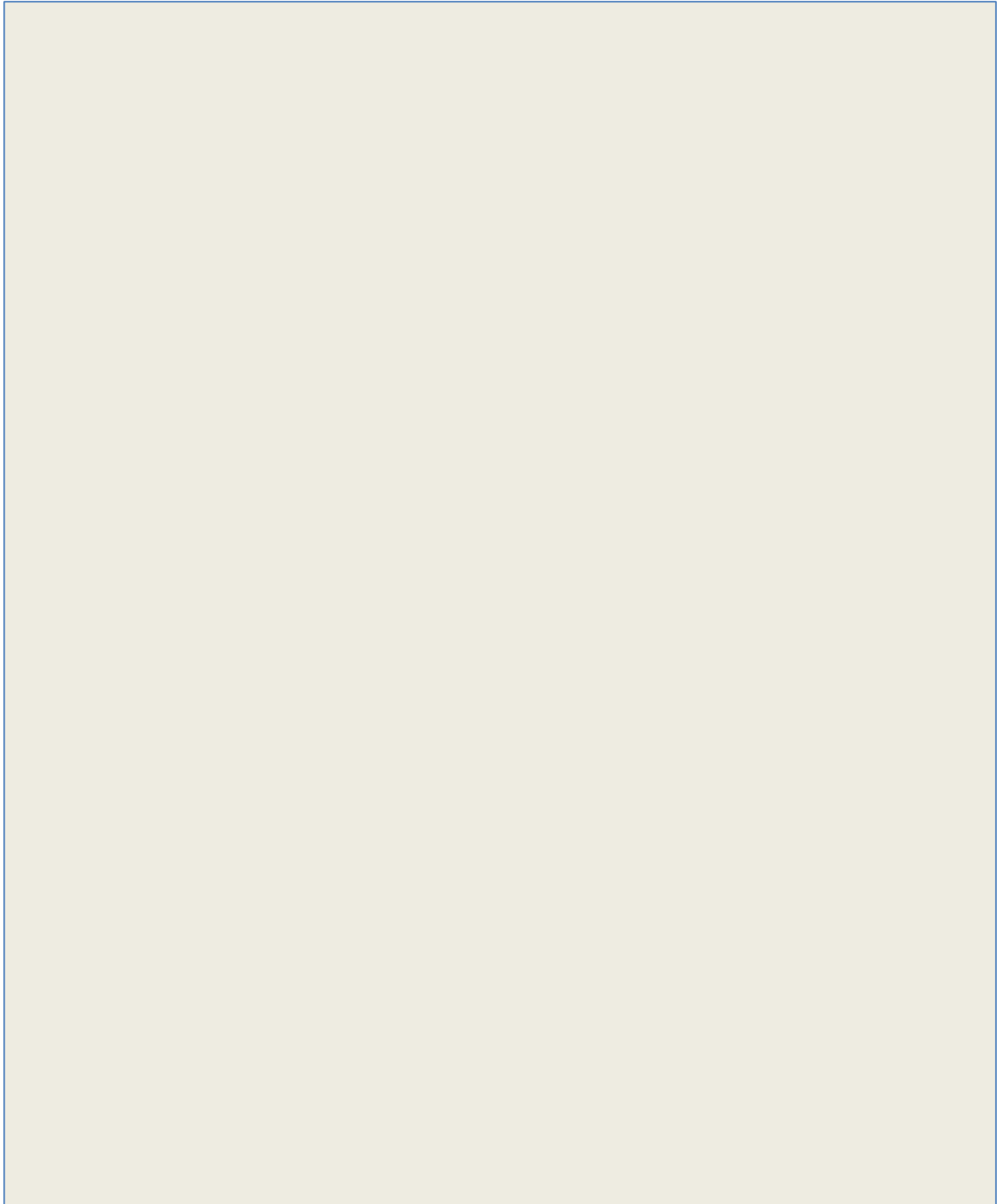
Milk production and processing

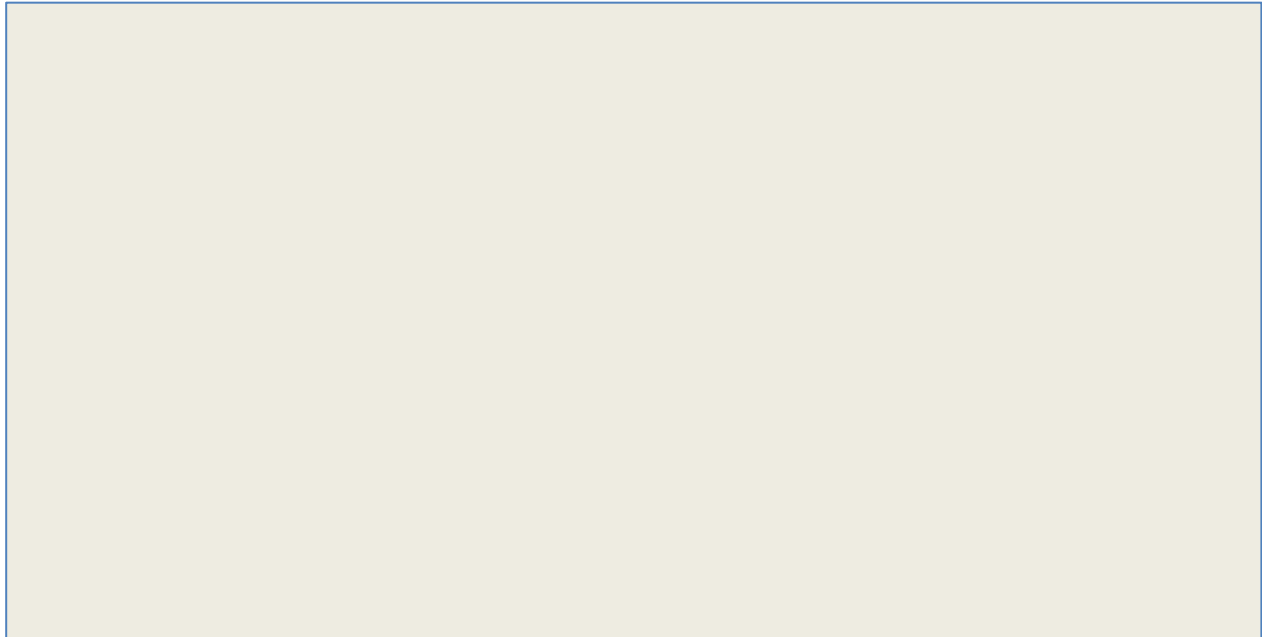
Dairying is considered a major source of nutrition and income, and offers good opportunities for both farm families and non-farm rural and urban employment. Milk demand, measured by per capita consumption, is increasing by 4% per year, which is higher than the growth in milk production (3.6%).⁶²¹ The indigenous cows have been reported to produce 1.9 liter of milk per day against crossbred cows producing 7.8 liters/day.⁶⁴³ The production and rural consumption of milk and milk products have decreased while import and urban consumption have increased. The urban consumption has increased due to increased urban population and faster increased urban income.⁶⁴⁴ The municipality town households consume more milk, sweetmeats and dahi than rural and metropolitan city whereas metropolitan households consume more powder milk, condensed milk, ghee and ice cream.⁶⁴⁵ Institutional support and policies play a major role in narrowing this gap and should therefore be considered in developing strategies for dairy development.⁶⁴⁶ The research findings on milk production status in dairy cattle in Bangladesh have been reviewed (Table 22).

Table 22. Milk production status in dairy cattle in Bangladesh			
Year	Objectives	Major findings	References
1994	To investigate feeding practices and milk yield based on farm size	The highest mean milk yield (liter/day) has been reported in large (2.43 ± 0.87), followed by medium (1.88 ± 1.84), landless (1.10 ± 0.44) and small (0.88 ± 0.13) native cattle dairv farms.	647









Dairy cattle production in Bangladesh is characterized by low productivity levels mainly due to genetic and nutritional constraints. Local cows yield on average 1.5 liter milk per day against 5 to 8 liter in cross-bred cows in Bangladesh.³⁰ The cost of rearing cross-bred cows reported higher than indigenous cows but it is compensated by higher milk yield, hence rearing of cross-bred cow is advisable in study area Sirajgonj district.⁶⁵¹ A local cow is produced an average of 256 ± 2.64 liters of milk per lactation that increase in overall family income at the rural level in Bangladesh.⁶⁸⁸

Milk production (L/d) of local cows has been reported to be significantly higher in Munshiganj (5.72 liter) and Sirajgonj (5.66 liter) followed by Tangail (2.94 liter), Rangpur (2.24 liter) and Madaripur (2.11 liter), these difference of milk production of local cows has been explained mainly due to the availability of fodder and genetic status. The average daily milk production and average lactation period of cross-bred cows have been repowered as 7.86 liter and 269 days, respectively.⁶⁵⁹ Daily milk yield /cow / farm has been reported to be 4.27 and 1.78 liters for crossbred and local cows respectively in Rangpur.⁵⁸²

- The per day milk production has also been reported to be 1.86 liter in local cow whereas 5.94 liter in cross-bred cows and the income level from milk yields of crossbred cows reported as 3.19 times higher than the local cows.⁶⁸⁹
- The highest milk production has been reported during the month of February (10.01%) and lowest during September (6.46%) of Milk-vita societies in Bangladesh.⁶⁶⁸
- An average lactation yield of 1838 liter in 266 days in crossbred cows, while the similar performance of a local cow 619 liter in 230 days has been reported.⁶³⁰
- Approximately 78% smallholder dairy farmers are milked their cows once daily and about 31.0% are used AI for breeding their cows.⁶⁴⁰
- Milking is usually done by male 76%, female 20% and both 4% milkers in Jossore.⁶³²

vita is the largest pioneering dairy cooperative venture in Bangladesh deals with about 350,000 liter / day liquid milk production, collection, processing and marketing with a diversified set of dairy products.⁶⁹⁴ Milk production increases 5.98% per year where demand increases by about 10% due to an increase in purchasing capacity and food habit change of consumers in Bangladesh.⁶⁹⁴

BRAC Dairy

BRAC Dairy was established in 1998. It began as an income-generation sector to create a market for rural dairy farmers and provide them a profit-making platform. Currently, BRAC Dairy collects cows' milk from rural dairy farms to the 101 chilling centers and sells them in nationwide through its internal and external distributors and retail chains under the brand name Aarong Dairy. It has the processing capacity of 170,000 liters of milk per day and holds 20.83-24.00% of the national market share. Currently, this enterprise serves approximately 50,000 dairy farmers in the western region of Bangladesh including (Khulna, Dhaka, Rajshahi and Rangpur) with over 1400 employees working under this umbrella.⁶⁹⁵

Pran Dairy (Pran Dairy Ltd.)

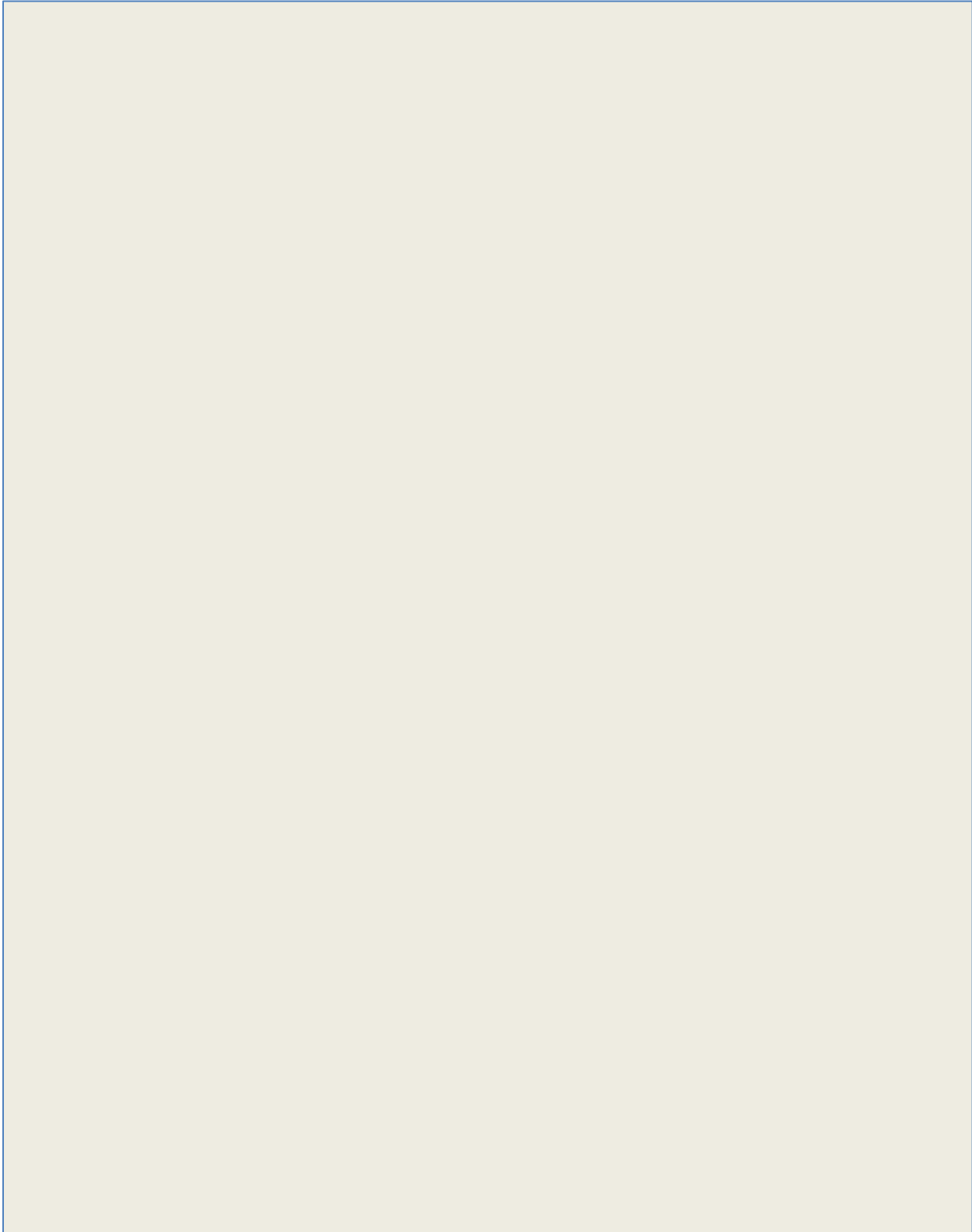
The Pran Dairy has established in 2001 as Pran Dairy, a sister concern of Pran Group which is the 3rd largest dairy milk processor in Bangladesh has the capacity to collect 200,000 liters of milk daily from the existing five dairy hubs. The company has setup 101 milk collection and chilling centers, around 20 centers per hub to collect milk from nearly 12,000 contract farmers having over 50,000 cows.^{696,697}

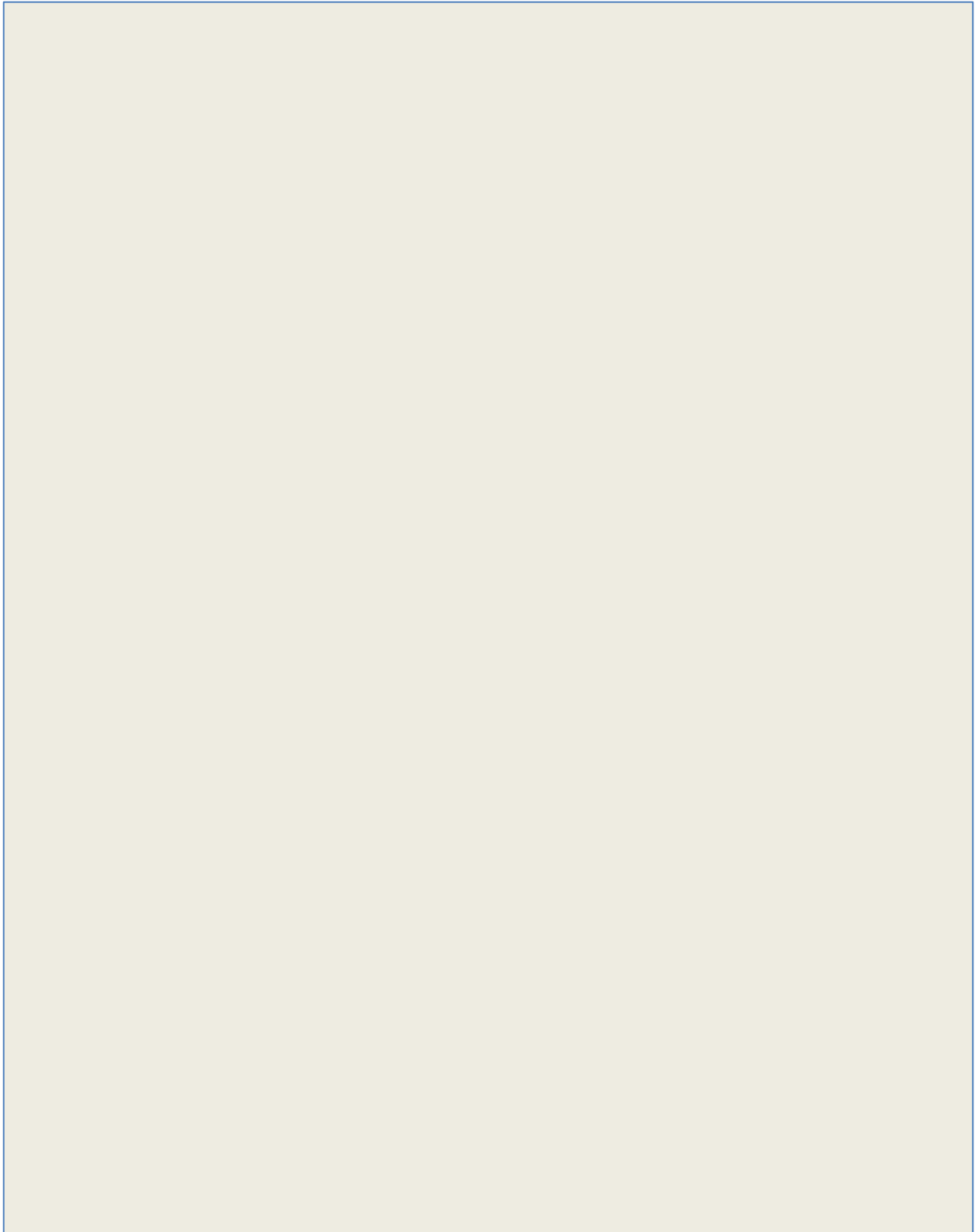
Economics of dairy farming

The rank of the major cost items related to importance of milk production includes the concentrate feeds, green grass and labor cost. The major problems of milk production in the bathan areas are the rain and thunder storm, scorching sunshine and low prices of milk. This study has suggested that if the cattle could be sheltered in sheds and support price of milk be ensured, milk production in the bathan areas would be profitable enterprise.⁶⁹⁸

A dairy farm with 13 to 15 months calving interval, 24 months for age at puberty, 1.33 services per conception and 5.0 kg milk per day per cow have been reported economically profitable.⁶⁹⁹ Research findings on the economics of dairy farming are reviewed (Table 24).

Years	Objectives	Major findings	References
1993	Assess economics of milk production	The economics of milk production in selected areas of Bangladesh has been reported	700
1994	Assess major problems of milk production in bathan areas	Rain and thunder storm, scorching sunshine and low milk price are the major problems. Animal shelter in shed and support milk price have been suggested for profitable bathan enterprise.	698
1994	To compare the cost and return of rearing native & cross-bred cows	The benefit-cost ratio of milk/L has reported higher in cross-bred (1:1.33) than native (1: 1.04) cows. This study has recommended dairying with cross-bred cows for viable enterprise.	701





2019	To assess the socio-economic farm and technological aspects of dairy farms	The price of milk varied from region to region with higher in urban market. Results showed that 62.7%, 52.9% and 51.0% dairy farm families have smartphone, facebook and internet users, respectively. Technological based milk market linkage could be created.	723
2019	Economic analysis of dairy farming	Smallholder farms have owned av. 3.07 lactating cows consisting of 0.37 native and 2.70 crossbred cows. Native cow produces 1.9 & crossbred 6.48 liter/d. Crossbred provided higher economic benefit than native cows.	724

Economic analysis of dairy farms

Table 25 shows the annual production cost of mini dairy farms and **Table 26** shows the overall livelihood status of GO and NGO supported dairy farmers' with self-managed farmers.

C. Annual returns of mini dairy farms	
SN Source	Overall, %
1. Sale of milk	69.43
2. Sale of ploughing	02.26
3. Sale of cow-dung	04.13
4. Sale of cattle	12.60
5. Calves & heifer	11.58
Gross return	100

- Crossbred (2.55) and native (0.65) cows
- Higher milk production in crossbred (5.66L/d) than native (2.23 L/d) cows
- Higher lactation period in crossbred (304 days) than native (210 days) cows.
- Benefit : Cost ratio = 1 : 1.03

• Overall benefit : cost ratio was 1 : 1.03 indicates that mini dairy farming is economically profitable in the rural areas of Bangladesh.

The profitability of 60 Ideal Milk Farm programs financed by Bangladesh Krishi Bank (BKB) in three selected districts (Mymensingh, Dhaka and Narayanganj) have been evaluated that the total cost of dairy decreased with the increase of farm size.⁷⁰⁵ It appears from another study that the BKB loan funded dairy farms are marginally profitable with benefit cost ratio 1.13.⁷⁰⁶ Labor and concentrates constitute the major share in the cost components of maintenance of cows. Productivity and profitability of supported dairy farming was higher than the self-managed due to intervention.⁷¹⁹

The profitability reported greater with cross-bred than with local bred animals (**Table 27**).^{649,662-664,666,670,726,727} So, dairying should be encouraged with cross-bred cows in Bangladesh.⁷⁰¹ Native

Cattle production, management and dairy products

	<p>Conclusions</p> <ul style="list-style-type: none">•The income of the dairy farms have been reported to be increased of Tk.25400.0 due to intervention.•The labor, paddy straw, green grass and concentrate feed cost have been reported to have significant effect on gross returns from milk production for both the supported and self-managed farmers.•There is a scope to improve the overall livelihood status of dairy farmers.

cows produced 0.63, 1.78 and 0.84 liters, whereas cross-bred cows produced 34.42, 10.00 and 4.75 liters per farm for large, medium and small farms, respectively.⁷²⁵ However, the productive and reproductive performance of crossbred cows reported better than local cows.

To identify the development and production pattern of the smallholder dairy farmers of the

Milk-vita society shows that the collection of milk, number of active society and members, number and productivity of lactating cows improve year to year due to increase in extension activities and breeding policies of Milk-vita. But lactating cows per member (2.06) yet not increased indicates that the economic status of farmers remain unchanged.⁶⁵⁵ Economic of dairy farming in Satkhira district has comparatively increased in terms of milk production and cash income in members of field fertility clinics (FFC) than non-member farms.^{716,717}

The impact of the government subsidy on the development of private dairy farms has been evaluated on 200 pre-subsidized and 200 post-subsidized dairy farms in 6 divisions in Bangladesh. Overall milk production, fodder production and labor employment have significantly higher in subsidized than non-subsidized dairy farms in Bangladesh.⁷¹⁴ Most of the dairy farmers believe that dairy farming is a profitable enterprise and can be more profitable if Government gives support on feed cost, marketing, loan and dairy farm management training.

Research on reproductive and productive performance of dairy cattle

The dairy cattle improvement program has been launched to improve native cattle for milk production by incorporation of both tropical (Sahiwal & Sindhi) and temperate (Holstein-Friesian & Jersey) breeds in Bangladesh. The productive and reproductive performances of different local, pure and crossbreds cattle have been partially reviewed in Bangladesh.^{728,729} The reproductive performances of both the indigenous (90%) and crossbred (10%) cattle of Bangladesh have been reported to be poor, required average two services for conception, calving interval between 365 to 536 days and post-partum service period between 103 to 161 days.⁷²⁹ Analysis of reports showed that the Holstein-Friesian crossbred cattle performed comparatively better than others crossbred.⁷²⁸ Supplement of UMMB (@ 250g / head / day) has reported a positive effect on fertility of the local cows under village condition of Bangladesh.³⁹⁷ Recently, the Field Fertility Clinic (FFC) services caused to increase the total milk production, total return and net return per head of cow which indicates the positive impact for dairy development.⁷¹⁷ The influence of season and month on first service conception rate⁷³⁰ and age, parity and farming condition⁷³¹ in cattle have been reported. For accurate analysis of data, the definition of the productive and reproductive indices is required.⁷³²

- Birth weight- Live weight of calves recorded within 24 hours of birth.
- Growth rate- Weight gain per day
- Lactation length- Interval between first and last milking of a cow in the same lactation
- Lactation milk yield- Quantity of milk given by a cow over a lactation period
- Daily milk yield- Lactation milk yield divided by lactation length
- Age at puberty- Age at which heifer allowed for first service
- Weight at puberty- Weight at which heifer allowed for first service
- Age at first calving- Age at which heifer gave first calf.
- Service per conception- Average number of services required for each successful conception
- Post-partum anestrus period- Interval between date of a given calving and the date of first insemination after parturition
- Gestation length- Days between effective inseminations to concerned calving
- Calving interval-Days between two successive calving.

Cattle production, management and dairy products

Reproductive performance of cattle (heifers and cows) is one of the most important factors that influence ranch profitability. Understanding the biological mechanisms associated with getting a cow or heifer bred can be a significant management tool for increasing realized income. The mean values of all the available published articles on productive and reproductive performances of different genotypes of cattle in Bangladesh have been reviewed and it appears that the mean values of these parameters varied greatly (Table 28a-d).

() = No. of reports analyzed - = No available report
 SL= Sahiwal^{518,733-740} RS = Red Shindi^{518,733-738} HF = Holstein-Friesian^{518,737,741,742}
 JS = Jersey⁷³⁸ AFS = Australian-Friesian-Sahiwal^{739,740,743} AFS × PV = Pabna variety⁷⁴⁴

() = No. of reports analyzed - = No available report
 RS × SL^{518,736} HF × L^{18,518,630,635,686,736-740,742,743,745-769} HF × SL^{61,739,740,743,758,770,771}
 HF × RS^{518,736} HF × PV (Pabna variety)^{39,744,771,772} JS × L^{518,686,718,731,736,738,745-750,755-757,763,769,773-775}

() = No. of reports analyzed - = No available report
 SL × L^{34,44,518,630,634,733,736,745-751,755-757,759-761,763,768-770,773-775} RS × L^{44,518,630,733-736,745-753,755,756,759,761,768,769}
 RS × PV⁷³³⁻⁷³⁵ SL × PV^{39,492,771,772,776} RCC^{11,43,44,588,630,636,732-735,737,755-757,777-784}

() = No. of reports analyzed - = No available report PV^{39,44,492,518,630,733,734,771-773,785,786}
 DV (Dhaka variety)^{733,734} MV (Munshiganj variety)⁷⁸⁷ NBG (North Bengal Grey)¹⁴
 DDC (Dinajpur dwarf cattle)¹² NICB (Non-identified crossbred)^{495,582,630,642,763,788-794}
 Local (Indigenous, Native, Zebu, Non-descriptive)^{18,34,36-38,322,485,495,518,582,630,635,642,736-741,746,748,749,751,754,758-761,763-767,774,788,791-803}

Age at puberty in heifers

Puberty is defined in heifers as the time when they first ovulate and show an estrus or heat period. Puberty is a period at which sexually organs functionally developed and animals become able to release the gametes by first ovulation.⁸⁰⁴ Puberty is also defined as when ovulation is accompanied by visual signs of estrus and subsequent normal luteal function.⁸⁰⁵ Although puberty and initiation of normal estrous cycle are complex events that require maturation of the hypothalamic-pituitary-ovarian axis, it has been well documented that nutrition, age and genetics are regulators of age at puberty.⁸⁰⁵ Tables 28a-d show that the mean values of age at puberty in heifers varied from 572.4 days (19.08 months) in Dinajpur dwarf cattle to 1283.78 days (42.79 months) in non-descriptive crossbreds heifers. These mean age at puberty reported in different genotypes of heifers found highest in comparison to the reported standard values. Heifers must reach puberty by 13 to 14 months of age to calve as two years age, however it is influenced by age, weight, hormone, genetic (breed), nutrition and environment of heifers.⁸⁰⁶ New modern hormonal technologies, proper management, housing, feeding system of the heifers can reduce the age of puberty and sexual maturity.⁸⁰⁴

Length of estrous cycle in cows

Estrus in cattle is commonly referred to as heat. The estrous cycle of the cow is the period from one estrus (heat) to the next estrus which is usually averages 21 days with a range of 18 to 24 days. Tables 28a-d show an average length of estrus cycle 20 days in Holstein-Friesian and HF × RS, 21 days in Sahiwal, JS × L, RS × L and Pabna variety, 22 days in Red Sindhi, RS × SL, HF × L crossbred cows.

Duration of estrus in cows

The average duration of standing heat is 15 to 18 hours but heat duration may vary from 8 to 30 hours in cows. Estrus is short in cow, with ovulation occurring 10 to 12 hours after the end of estrus. The best conception rates occur if AI is carried out in the middle to the end of standing estrus i.e. 13 hours before to 8 hours before ovulation, about 30 hours after the onset of estrus. The average values on the duration of estrus in cows reported as 19 hours in Red Sindhi, HF × L, HF × RS, RS × SL, 20 hours in Sahiwal, HF, JS × L, RS × L 21 hours in local cows and 22 hours in Pabna variety (Table 28a-d).

Age at first service in heifers

Tables 26 a-d show that the mean values of the age at first service in heifers of different genotypes reported in Bangladesh varied widely from 659.33 days in HF to 2290 days in local non-descriptive heifers. However, the standard target age for the age at first service has been suggested to 18 months, an age when heifers are expected to reach around 300kg for Holsteins and 275 kg for crossbreds.⁸⁰⁷

Age at first calving in heifers

The world cattle farming practice has adopted first breeding of heifers at 15 to 18 months of age with calving between 24.5 to 27.5 months as a model with optimum economic profit.⁸⁰⁸ Analysis on the published reports on age at first calving in different genotypes shows comparatively lower age at first calving in AFS (792 days) and HF (939.33 days) than other

genotypes especially highest in Pabna variety (2323.9 days) (Table 28a-d). However, 24 months has been reported as optimum age at first calving and reduction of age at first calving to 24 months of age suggested to be an effective management practice.⁸⁰⁹ An optimum range of age at first calving (AFC) on dairy farms appears to be 22 to 25 months inclusive. Lower and higher than this figure can bring lower first lactation 305 days and lifetime milk yields, lower fertility and lower chances of surviving to a second lactation.⁸¹⁰ The cost of raising a heifer to 24 months of age has been reported very high and letting them stay on farm in an unproductive state for more months costs more per animal in addition to reduced milk production.

Gestation period in cows

The length of the gestation period has interested farmers because a knowledge of the time to expect the birth of the calf enables proper preparation like drying off the cow and getting her in the proper physical condition for parturition and subsequent lactation. 'The period of development from the fertilization of the egg by the sperm cell until the birth of the fully developed offspring capable of independent existence outside the body of the mother is known as the period of gestation.'⁸¹¹ Simply, gestation period is the time interval between fertilization of an egg and the birth of the young which begins at fertilization and ends with parturition.⁸¹² Analyzed results reveals that the gestation period varies from 276 days in Jersey breed to 310.2 days (10.34 months) in Manikgonj variety of cows in Bangladesh (Table 28a-d). Gestation length is influenced by many factors like breeds of cows and bull, calf gender, single or multiple birth, the parity of the cow and fetal genotype but the breed of cow has the greatest influence on gestation length.⁸¹³ Increasing cow's age, male fetuses and growing fetus weight have been reported to contribute for prolonged gestation length in cows.⁸¹⁴

Post-partum anestrus period (PPAP)

The PPAP refers to a condition where cows have not been observed or reported in estrus for several weeks after calving, often to the end of the voluntary (elective) waiting period in dairy cattle which is the time from calving to the subsequent estrus and conception.⁸¹⁵ To maintain a 365-day calving interval, cows need to conceive on average by 83 days (60 to 90 days) after calving with gestation length 282 days when the uterus undergoes involution and preparation for the next pregnancy. Comparatively short average PPAP have been reported in Munishigonj variety (70.26 days; single report) and Red Chittagong (89.51days; 11 reports) cows than other genotypes of cattle with especially highest PPAP in JS × Local crossbred (291.61 days) cows (Table 28a-d). The causes of the post-partum anestrus in cattle are often multifactorial but can be broadly categorized into physiological, nutritional, managerial, environmental and pathological whereas suckling and nutrition (negative energy balance) are considered the most important.^{815,816}

Calving interval

Dairy cattle production is characterized by cycles of calving, lactation including gestation and a dry period followed by the next calving. The term 'calving interval' refers to the period from one calving to the next calving from the same cow. The optimum calving interval seems to be somewhere between 12 and 14 months. There is general agreement that 12 months represents a

short calving interval based on pregnancy period of 280 days and a non-pregnancy period of 85 days. Comparatively highest calving interval have been reported in HF × SL (518.09 days) and RS × PV (571.81 days) crossbred cows than other genotypes especially found lowest in MV (399 days) in Bangladesh (Table 28a-d). However, the breed means for first calving interval across time ranged from 390 days for Jerseys to 407 days for Brown Swiss.⁸¹⁷

Dry period in cows

The dry period is the period before calving that cows are not milked which is traditionally 6 to 8 weeks. The main functions of the dry period are to treat the cow with antibiotics in case of persistent sub-clinical mastitis, to allow the cow a rest period before birth of the next calf and to minimize milk yield in the next lactation. The udder of dairy cow requires a non-lactating or rest period, prior to calving in order to regenerate their mammary gland and optimize milk production in the subsequent lactation. This phase of the lactation cycle is commonly referred to as the dry period. Analysis of the findings on dry period in the different genotypes of cows reveals lowest length of dry period in MV (72.6 days) and JS × L (79.83 days) crossbred cows in comparison to other genotypes (Table 28a-d). The dry period of the dairy cows lactation cycle ranges from 45 to 60 days in length.⁸¹⁸ Numerous studies demonstrated that a 60-day dry period is optimum and a dry period less than 40-day reduces milk yield in the subsequent lactation.⁸¹⁹ The cow and her udder are prepared for the next lactation during dry period, hence any abnormalities during the dry period will have a negative effect on the cow's health and milk production after calving. However, the dry period of 40 to 80 dry days provided maximum performance in Holstein cows.⁸¹⁹

Number of services per conception (NSPC)

The NSPC is frequently used as an indicator of fertility and the optimum value is considered to range between 1.6 and 1.8 and NSPC around 2 is still acceptable.⁸²⁰ Out of the 24 genotypes of cattle investigated for the NSPC reveals that except two genotypes JS (2.01) and non-descriptive crossbred (2.13) all the 22 genotypes required less than 2.0 NSPC (Table 28a-d). Responsible factors for NSPC are the quality and quantity of semen, accuracy of heat detection, time of insemination and skill of the inseminator, level of fertility, season of the year and environment factors. Factors like cattle breed, lactation number, AI number and sire breed are the most important factors to get maximum conception rate of the cows.⁸²¹

Lactation length (LL) and lactation milk yield (LMY)

The standard LL of 305 days has been selected because this is approximately the normal lactation length of cows calving at interval of 12 months. However, in tropical regions, restricting the lactation records to 305 day would have less effective, as few cow's milk more than 305 days.⁸²² Analysis of findings on LL and LMY of the different genotypes of cows reveals that the average highest LL of 359.33 days in HF cows with highest LMY of 3399.28 liters and lowest LL found in NBG cows (218.58 days), whereas the average lowest LMY reported in SL × L crossbred (158.73 liters) cows (Table 28a-d). When the results on LL and LMY analyzed based on the crossbred between Pabna varieties with different exotic genotypes found highest LMY in AFS × PV (2223.76 liter) in 305.18 LL (Table 28a-d). These findings

are in conformity with individual report of highest LMY reported in AFS × PV (1632 liters) in 282.80 days LL in comparison to PV (1503 liters), HF × PV (1619 liters), JS × PV (1517 liters) and SL × PV (1548) cows.⁸²³

Daily milk yield in different genotypes of cows

Tables 28a-d show that the comparatively highest average daily milk yield by HF (8.81 L/d) followed by AFS (5.8 L/d), SL (4.1 L/d) and RS (3.83 L/d) of the exotic breeds of cows. These analyzed findings are also in support the individual report of the CCBSDF where 11.57 liter/day milk yield reported in HF cow followed by AFS (4.68 liter/day).⁸²⁴ The HF crossbred with PV produced highest daily average milk yield (9.11 L/d) in comparison to HF × SL (8.47 L/d), HF × L (6.66 L/d) and HF × RS (4.42 L/d) whereas the non-descriptive crossbred produced milk 6.27 L/day (Table 26d). Among the local varieties of cows, highest average daily milk yield reported in MV (6.8 L/d) variety in comparison to other local varieties (Tables 28a-d). Comparatively highest daily milk yield has been reported in H × L (3.29 L/d) than JS × L (3.08L/d), SL × L (2.84 L/d), SD × L (2.99 L/d) and RCC (2.46 L/d).⁷⁵⁶

Seasonal influence on the occurrence of estrus in cows

Table 29 shows that the estrus occurs throughout the year in all the seasons but higher in rainy season in comparison to other seasons in the Rajshahi Government Dairy Farm whereas it occurs at the similar percentage in the BLRI Cattle Breed-1, Savar. The seasonal variation on the occurrence of estrus with higher in summer than in winter which positively correlated with environmental temperature and insulation duration whereas negatively correlated with rainfall in Holstein cows have been reported elsewhere.⁸²⁵

Table 29. Seasonal influence on the occurrence of estrus and conception in indigenous cows maintained under farming conditions					
SN Season	Rajshahi Government Dairy Farm (Study period 1986-1987) ⁸²⁶			BLRI Cattle Breed-1 (BCB-1)2 (Study period 1992-2006) ⁴⁸⁵	
	No. of cows	Estrus No. (%)	Conceived No. (%)	SN Season (month)	Estrus cows No. (%)
1. Winter (Dec-Feb)	71	42 (59.15)	20 (47.62)	1. Winter (Oct-Jan)	384 (27.39)
2. Summer (March-May)	62	37 (59.68)	19 (51.35)	2. Summer (Feb-May)	517 (36.88)
3. Rainy (June-August)	35	23 (65.71)	13 (56.52)	3. Rainy (June-Sept)	501 (35.73)
4. Autumn (Sept-Nov)	26	09 (34.62)	06 (66.67)	-	-
Overall	194	111(57.22)	58 (52.25)	Overall	1402

The influence of parities on productive and reproductive performance of native cows under farm condition have been reported.⁸²⁷ There are some differences on daily milk yield, lactation length, birth weight of calves, post-partum anestrus period and gestation length but no differences on the calving interval and number of services per conception have been reported in native cows.⁸²⁷

Genotype (breeds) has a significant effect on biological efficiencies of dairy cows.^{475,828} Performance of the Holstein Friesian breed and its crosses with local cows especially PV and

MV has been reported highest productive performance among all the investigated genetic groups in Bangladesh. Among the cross-bred, the F2 and subsequent generations have reported inferior than the F1.⁷³⁷ However, the pure exotic breeds especially HF has been reported not suitable in tropical environment in Bangladesh and moreover it requires low temperature, better feeding and management and less resistant to diseases and parasites. Accordingly cross-bred (HP × L) cows have been suggested to rear under Bangladesh environmental conditions.^{829,830}

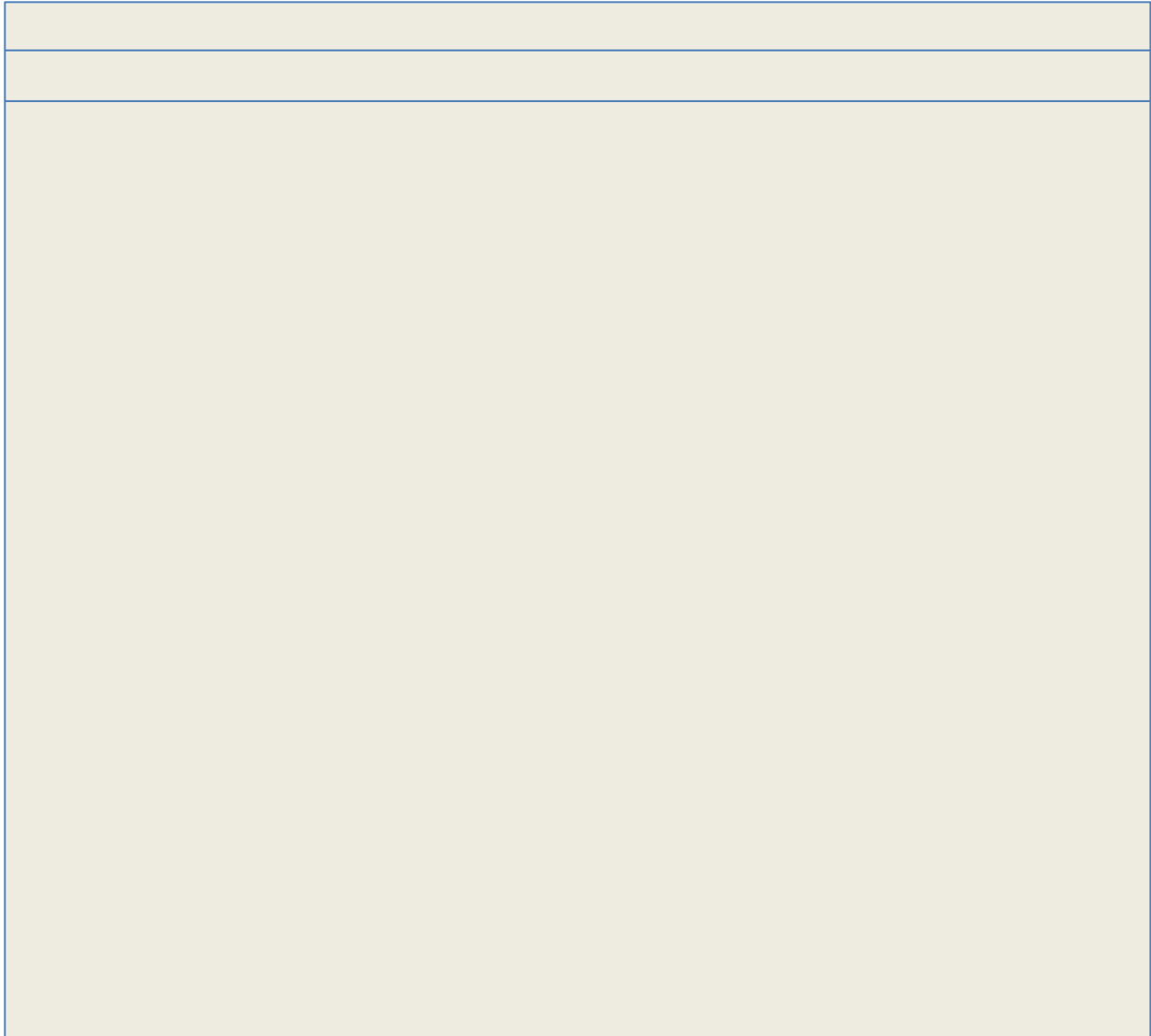
Estrus and pregnancy diagnosis in dairy cattle

The AI is the most viable option to produce pregnancies in dairy cows but implementation of a successful AI program on dairy cattle requires accurate and efficient detection of estrus. Several significant physiological changes have been reported to occur during the peri-estrous period that enables detection of estrual behavior and other correlated traits in cows. Some of these changes include physical activity, vaginal cytology and pH, electrical resistance of vaginal mucus and genital tissues, body temperatures, pulse and heart rates, blood flow, rumination time, pheromones, blood metabolites and hormones, milk yield and feed intake.^{831,832} Cows are monitored traditionally for visual signs of estrus such as 'standing to be mounted' by a herd mate but it is difficult to monitor several times in a day and identify when to inseminate.

Methods of estrus detection that are widely used on farms do not have good rates because the physiological and behavioral changes of the animals as well as the period of the duration of estrus cycle are being expressed in low intensity and short duration and even they are very variable and difficult to measure. Accordingly, the use of electronic methods have been suggested to improve estrus detection.⁸³³

Return to estrus from 18 to 24 days after AI is often considered by dairy farmers the easiest and least costly method for determining non-pregnancy in dairy cattle early post breeding. Estrus detection efficiency is estimated to be less than 50% dairy herds which is likely a result of the short duration of estrus behavior reported for lactating cows housed in concrete flooring in common housing system. Estrus cycle duration varies widely among lactating dairy cows from the standard 21-day interval and averaged around 24 days with a high degree of variability among animals inseminated lactating dairy cows.

Pregnancy examinations are primarily used to identify pregnancy and non-pregnancy status of inseminated or mated females cattle, so that non-pregnant cows can be managed and reinseminated to reduce inter-insemination and calving intervals. Additional benefits are the detection of uterine or ovarian abnormalities, diagnosis of twins and others.⁸³¹ Rectal palpation, ultrasonic diagnosis, progesterone diagnosis, early pregnancy factor diagnosis, diagnosis using pregnancy-associated glycoproteins, diagnosis using activity and temperature have been described.⁸³¹ Early pregnancy diagnosis is crucial to shortening the calving interval through enabling the farmers to identify open animals so as to treat and /or rebreed them at the earliest opportunity. However, several methods of pregnancy diagnosis are being practiced in bovine species, yet none qualifies as the ideal pregnancy diagnosis methods due to the inherent limitations of sensitivity, accuracy, specificity, speed and ease of performing the test. **Table 30** shows the summary on the research findings on the estrus and pregnancy diagnosis in cattle of Bangladesh.



Research on commercial dairy farms

The productive and reproductive performances of both the smallholder and commercial dairy farms have been analyzed (Tables 28a-d) and evaluated.⁸⁴¹⁻⁸⁴³ Analysis of data of 25 commercial dairy farms in the districts of Dhaka and Gazipur suggested that the dairy farmers have ample opportunities to increase output by using more of concentrate feed and labor inputs.^{788,842} A survey of 30 commercial dairy farms in CTG showed that 57% farm owners belong to business class and the remaining 43% to different categories. Of the business categories, 53% considered dairying as a side-business whereas 47% considered it as a main business enterprise.⁷⁸⁸

Constraints of dairy farms

Dairy farming both private and commercial have been reported to be an important and have the potential to poverty alleviation, food security, improved family nutrition, income and

feeding technology, proper hygienic and sanitation program, proper treatment, sound breeding policy should be taken and more participation in management practices are necessary for increasing milk production as well as establishing dairy enterprises.⁶⁴⁰

Research findings on milk and milk products

Billions of people consume milk and milk products every day in the world. Milk is a composite physiological fluid of most complete food and dairy products are considered to be the most nutritious foods of all. Children and adolescents should be encouraged to consume milk and milk products because calcium of milk is required for bone development and maintenance.

Dairy industry in Bangladesh has been transforming from traditional substance to more market-oriented and enterprise-driven approach in the milk production system which would open the opportunity for dairy farmers to exploit the rising demand of milk and milk products at national level.⁸⁴⁹ Bangladesh has milk production of 9.92 million tons in 2018¹⁷ whereas the Integrated Dairy Research Network (IDRN) estimated for 2018 as 7.98 million tons.⁸⁵⁰ The milk availability per capita is reported as 165.07 ml/day/head against the minimum requirement of 250 ml/day/head.¹⁷ The self-sufficiency according to DLS is 64% while the same is 53% according to IDRN.⁸⁵⁰ Only 9.0% of the total milk production is delivered to the processors and the remaining 91% is traded as informally.⁸⁵⁰ The maximum milk production in 2030 will be 13.6 and 18.1 million ton as forecasted by the IDRN and DLS, respectively. Both data sources might be overestimated for the milk production which can be tested by taking backward validation and use appropriate methods and models for forward estimation which in turn will help for increasing the precision of the data.⁸⁵¹

Milk production trend of Milk-vita through the year,⁶⁶⁰ lactation curves of different cattle breeds⁸²³ and lactation and stage difference in milk yield⁸⁵² have been reported from Bangladesh.

Seasonal influence has been recognized as one of the factor on milk production and milk fat content in dairy animals in Bangladesh. Higher milk production has been reported during January (40.94%) and February (41.13%) and lower for July (20.47%), August (17.84%), September (18.59%) and October (18.87%) in Baghabarighat milk shed area,⁸⁵³ whereas highest milk production has been reported in the month of June and lowest in January, August, September and December in the Sree-Nagar Milk Shed area and these differences have been explained to be associated with the availability of forage.⁸⁵⁴ The first month of lactation reported as best milk producing period among the five months and the management system had positive association with milk composition of local Pabna cows.⁴²

Composition of milk

The physiochemical properties of different packaged fluid milk,⁸⁵⁵ effect of feeds on the composition of milk,⁸⁵⁶ compositional profile of milk⁸⁵⁷ and physical, chemical and microbiological quality of cattle and buffalo milk⁸⁵⁸ have been reported from Bangladesh. Milk composition is subjected to change in response of genetics, breeding, feeding, number and stage of lactation and health status of the lactating animals.⁸⁵⁹ Significantly higher fat, protein and total solids in milk of RCC have been reported in comparison with the milk of cross-bred (HF cross, Jersey cross & Sahiwal cross) cows,⁸⁶⁰ even milk of RCC showed best data both from nutritional and technological aspects.⁸⁵⁹

metabolites (α -keto glutaric, orotic, succinic and formic acid) in milk of Holstein cross cows, three in milk of RC cows (α -keto glutaric, succinic and uric acid) and two (citric and α -keto glutaric acid) in milk of indigenous cows have been reported.⁸⁶³ All the animals species and breeds showed considerable variation regarding the major components in milk. RCC and Deshi cow's milk are more favorable because of their higher true protein, casein, lactose, and total mineral content. The indigenous cattle milk is more or less similar to RCC milk regarding all most all the milk components.

Evaluation of the quality of raw milk

Milk is one of the most complete nutritious foods for humans considered to be the 'ideal food' because it is rich in nutrients essential for growth and maintenance of a healthy life of all ages especially more importance for the infants. Due to presence of most of the nutrients for health in milk, it acts as an ideal growth medium for bacterial pathogens that cause spoilage of milk. The evaluation of the quality of milk mostly includes somatic cell count (SCC), micro-biological count (MC) and chemical composition mainly protein and fat contents. Milk from a healthy udder may be sterile or contains very low level of bacteria, usually 10^2 to 10^3 cfu/ml of milk but the addition of microbes due to contamination during milking process and growth will reduce the time required for milk to spoil. The udder and teat (udder interior & teat exterior), environment and the milking and milk handling equipment are the three main sources of microbes of contamination of raw milk. Most of the raw milk samples have been reported to be contaminated with bacteria associated with human health risk in Bangladesh.⁸⁶⁴⁻⁸⁶⁶ Antibiotic resistance bacteria isolated (*Staphylococcus aureus*, *Escherichia coli*) from raw milk samples have been reported from Bangladesh.⁸⁶⁷ The main sources of microbial contamination of raw milk are the infected udder and teat canal, surface of the teat skin, surrounding air, housing conditions, water supply, milker's hands and hygiene and equipment hygiene. The milking hygiene has been reported to have a significant effect on initial bacterial count of milk and washing and disinfection of udder and milker's hands, and sanitary rinse of milking pails just before milking with calcium hypochloride solution (200 ppm Cl) significantly improved initial bacterial quality of milk.⁸⁶⁸ Accordingly, the commercial and hygienic quality of raw milk determination is required prior to reception of raw milk for further processing.⁸⁶⁹ Comparison of milk constituents between market raw milk and milk from dairy farm (Table 33) and between local market raw milk and Milk-vita milk samples (Table 34) have been evaluated.

The quality of milk supplied by vendors in Mymensingh town reported inferior in comparison to milk produced in BAUDF.⁸⁷⁰ Market milk samples had significantly higher % of water than the BAUDF milk samples, but total solid, solid-not-fat, fat, lactose and protein had also significantly lower in market milk than BAUDF milk samples.⁸⁷¹ The physical properties and chemical composition of milk supplied to the BAU campus from BAUDF reported to be superior to other suppliers in relation to the quality.⁸⁷² Raw milk samples of BAUDF found superior than the village sources of milk which may be due to maintaining better hygienic condition.⁸⁷³

Significantly lower all milk constituents of local market samples indicates that this market milk may be adulterated by adding water in it.⁸⁷⁴ Milk collected from Baghabarighat dairy plant has reported to be superior than milk collected from other plants of Milk-vita.⁸⁷⁷ The total solids, fat and protein contents of all the samples reported within the normal range except the milk fat

Cattle production, management and dairy products

SH = Students' Halls (BAU) R = Reference - = Data not available ? = Samples numbers not available
 *Four villages milk samples (Boira, Shuriakhali, Churkhali & Paglabazar)

MG = Manikgonj MY = Mymensingh MCC = Manikgonj Chilling Center TCC= Tangail Chilling center
 TPP = Takerhat Pasteurization Plant BDP = Baghabarighat Dairy Plant Ref-4! = Mean values of 5 centers
 *Average values of three market samples

content collected from Shombhuganj bazaar (32.66g/kg) and Mymensingh Sador bazaar (30.66g/kg) which showed less than normal level (35.0g/kg).⁸⁷⁵ Moderate level of TVC and TCC in raw milk collected from local market may be due to poor hygienic milking, improper cleaning of dairy utensils and unhygienic handling during marketing of raw milk.⁸⁷⁶ The qualitative and

quantitative aspects of dairy milk collected at morning and evening have been reported to be varied with that the evening milk contained higher amount of fat (4.58 vs. 5.41 %), SNF (7.75 vs. 7.81 %) and TS (12.33 vs. 13.23) but yields have reported higher at morning (52.77%) than evening (47.24%) milking except fat content.⁸⁵³

Evaluation of the quality of pasteurized milk

Pasteurized milk is a dairy milk that is heated to a specific temperature and held at that temperature for a specific duration in order to kill the harmful bacteria that makes milk safe to drink before it is packaged and shipped to grocery stores. Pasteurized milk is produced by heating milk for a minimum time of 15 second at a temperature of 72 °C or 30 minutes at a temperature of 63 °C. The post-pasteurization contamination (PPC) of pasteurized fluid milk have been reported with bacteria that are able to grow at 6 °C. Several gram-negative bacteria when introduced as PPC can grow rapidly at refrigeration temperatures around 6 °C and spoilage that can be detected sensorially within 7 to 10 days of processing.⁸⁷⁹ In Bangladesh, contradictory reports on the contamination of post-pasteurization of milk have been published, in which both the commercial pasteurized and UHT milk have been considered safe for human consumption within the mentioned expiry date⁸⁸⁰ whereas high count of bacteria in both the raw and pasteurized milk^{881,882} and the TVC varied from 35500 to 1150400 in the different commercial brands of pasteurized milk have been reported.⁸⁸³ Low levels of fat, SNF and specific gravity in the different brands of pasteurized milk samples indicates water adulteration in pasteurized milk in Bangladesh. High bacterial count including the coliforms in pasteurized milk samples may cause significant public health hazard.⁸⁸³ Table 35 shows comparison of chemical composition between raw milk and pasteurized milk and Table 36 shows the evaluation of liquid pasteurized milk marketed packaged cow milk.

SNConstituents	Raw milk samples (n = 42)			Pasteurized milk samples (n = 42)		
	BAUDF	BAUSV	MDF (K)	Milk-vita	CCBS&DF	TDL
1. Milk fat (g/kg)	37.2	46.2	39.86	24.5	26.07	24.7
2. TS (g/kg)	126.29	143.20	124.41	109.11	109.59	109.14
3. Acidity (%)	0.14	0.17	0.14	0.15	0.14	0.15

BAUDF = BAU Dairy Farm BAUSA = BAU surrounding area MDF (K) = Mini Dairy Farm (Kewatkali)
TDL = Tulip Dairy Ltd.

The quality of milk marketed by Milk vita has been reported superior to other milk, whereas Aarong ranked second. Jahan was inferior quality in comparison to other packaged fluid milk.⁸⁸⁵ Table 36 shows that the Milk vita brand pasteurized milk maintained standard levels for chemical and bacteriological quality as per BSTI standard.⁸⁸⁶ Milk brand names used in abbreviated forms but not mentioned and reported that the different brands of Bangladeshi pasteurized milk did not maintain the standard and acceptable quality.⁸⁸³

* × 10⁴ Farm F= Farm Fresh RDM = RD Milk - = Data not available

Ultra-high temperature (UHT) milk

There are a wide variety of microbes have been reported to be contaminated the raw milk and milk products. Raw milk can be a source of many harmful pathogens, causing a number of diseases like brucellosis, campylobacteriosis, Q fever, salmonellosis, listeriosis, tuberculosis and others. To overcome this milk borne disease problem, milk is subjected to heat treatment of various intensities like pasteurization, sterilization and ultra-high temperature (UHT). The UHT processing of milk involves heating milk in a continuous process to high temperature of 135 to 150 °C (138 °C) for a few seconds (1-8 seconds) destroys all microbes present in milk as well as inactivates all the enzymes, cooling rapidly and aseptically packaging of milk in sterile containers, thus gives the milk a better shelf-life and commercially stable. The shelf life of UHT treated milk and dairy products at ambient temperature storage is 3 to 9 months.⁸⁸⁷ Very limited works on the quality of existing UHT treated milk available in the local market have been conducted in Bangladesh (Table 37).

Table 37 shows that the Starship UHT chocolate milk better and more acceptable milk followed by Milkman.⁸⁸⁸ Overall acceptability UHT milk supplied by Aarong reported better, followed by Farm Fresh. However, none of the samples meet the standards of whole milk in terms of total solids, solid-not-fat and fat contents. Therefore, it is recommended that the manufacturers should standardize the raw milk during processing.⁸⁸⁹

The UHT milk of Farm Fresh have been reported to be superior than Pran Dairy and Aarong Dairy because it contained higher Total solids (119.23 g / kg), fat (34.97 g / kg), lactose (43.23 g / kg) and ash (7.0g / kg).⁸⁸⁹ The quality of UHT and pasteurized milk have been reported to be excellent with the respect of parameter studied.⁸⁹⁰

The chemical quality of raw milk collected from different sources reported superior to pasteurized milk. All the raw milk samples fulfills the normal chemical composition of milk but fat and total solids content of pasteurized milk samples reported below the normal range which implies that some portion of fat has been withdrawn from the pasteurized milk. It appears that

the quality of pasteurized milk available in local markets is poor and consumers are not getting high quality milk.

Bacteriological and chemical evaluation of powder milk

The physical, chemical and bacteriological assessment of market dry milk have been evaluated in Bangladesh.⁸⁹¹⁻⁸⁹⁴ The TVC of powder milk varied from 200,000 to 4,30,000 /g of powder milk have been reported.⁸⁹² No significant variation of microbial population among the different brands of infant milk food but the sanitary quality of the commercial infant milk food samples reported lower than the suggested standards.⁸⁹⁵ Out of 12 full cream powder milk samples tested, of which 11 (91.67%) contaminated with *E. coli* and 6 (50.00%) contaminated with *Staphylococcus aureus* in Bangladesh.⁸⁹⁶ However, no bacterial contamination has been reported in different commercial brands of powder milk that good sanitary measures have been adopted during processing and storage of milk.⁸⁹⁷

Table 38 shows a significant variation of bacterial population among the different brands of dry milk and the lower sanitary quality of the market dry milk samples suggests standard of International Commission in Microbiological Specification for Food (ICMSF). It appears that the considerably lower quality of the commercial sweetened condensed milk samples as per recommended standards of the ICMSF. Significant variations ($p < 0.01$) in TVC have been reported among different brands of powder milk samples.

Preservation and adulteration of milk

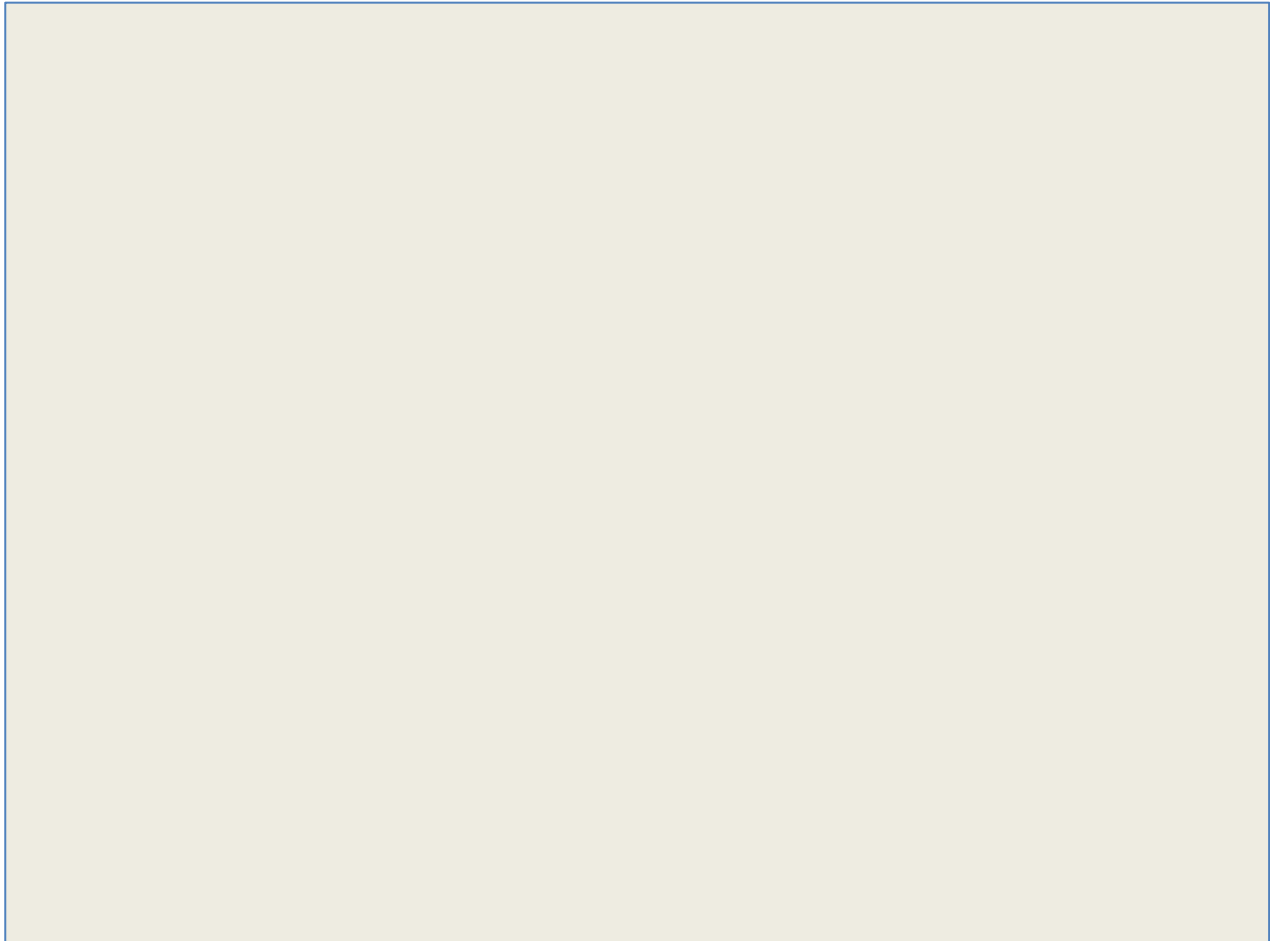
The storage of raw milk are usually performed in refrigerator, adding plant leaves, adding chemicals, heat treated (boiling, pasteurization, UHT) for preservation. The limited production of milk leads the dairy personnel to adulterate milk with unhealthy liquor and other solid substances. The way of adulteration is occurred by unhygienic milking, inappropriate transport

TVC = Total viable count SC = Staphylococcus count TCC= Total coliform count DMC = Direct Microscopic count
 Y & M = Yeast and Mold != logarithms and in average g% = g/100g - = Data not available

system, germ favored storage and milk collector itself which creates milk contaminated.⁹⁰¹ The addition of water to increase volume of milk, thickening agents like starch, flour, skimmed milk powder, whey powder or other ingredients to counter the dilution and extend the solids content of the milk, vegetable oil, sugar cane or urea to compensate the fat, carbohydrate or protein content of diluted milk. Some chemicals like hydrogen peroxide, carbonates, bicarbonates, antibiotics, caustic soda and even the most lethal chemical formalin to increase the storage period of milk, ice to enhance the shelf life of milk, detergents to enhance the cosmetic nature of milk which diminishes foamy appearance and whitening of milk or calcium thioglycolate / potassium thioglycolate / calcium salts of thioglycolic acid and urea for whitening of milk and giving it a genuine look.⁹⁰² The quality of farm produced milk and rural milk have been reported to be deteriorated by middlemen due to adulteration with water which have been reported to be 68.0% and 54.0% of the milk samples of vendor supplied rural and vendor supplied farm milk and also added formalin preservatives respectively.⁹⁰³ However, milk adulteration is a global concern and developing countries including Bangladesh are at higher risk associated with it due to lack of monitoring and policies that has been overlooked that can pose serious health hazard leading to fatal diseases.

Milk is being very easily adulterated throughout the world because demand and supply gap, perishable nature of milk, low purchasing capacity of customer and lack of suitable detection tests.⁹⁰⁴ Adulterants in milk mainly include addition of vegetable protein, milk from different species, addition of whey and watering which are known as economically motivated adulteration which do not pose any serious health risk.⁹⁰⁵ Adulterants in milk that having adverse health effects are urea, formalin, detergents, ammonium sulfate, boric acid, caustic soda, benzoic acid, salicylic acid, hydrogen peroxide, sugar and melamine. Cane sugar, starch, sulfate salts, urea and common salts are added to increase solid-not-fat (SNF). Melamine is added to increase protein content falsely.⁹⁰⁶ Ammonium sulfate is added to increase the lactometer reading by maintaining

the density of diluted milk. Formalin, salicylic acid, benzoic acid and hydrogen peroxide act as preservatives and increase the shelf life of the milk.⁹⁰⁷ Vegetable oil is added to increase non-milk fat in milk. Detergents are added to emulsify and dissolve the oil in water giving a frothy solution which is the desired characteristics of milk.⁹⁰⁸ **Table 39** shows the summery of the research findings on preservatives and adulterants added to milk and milk products in Bangladesh.

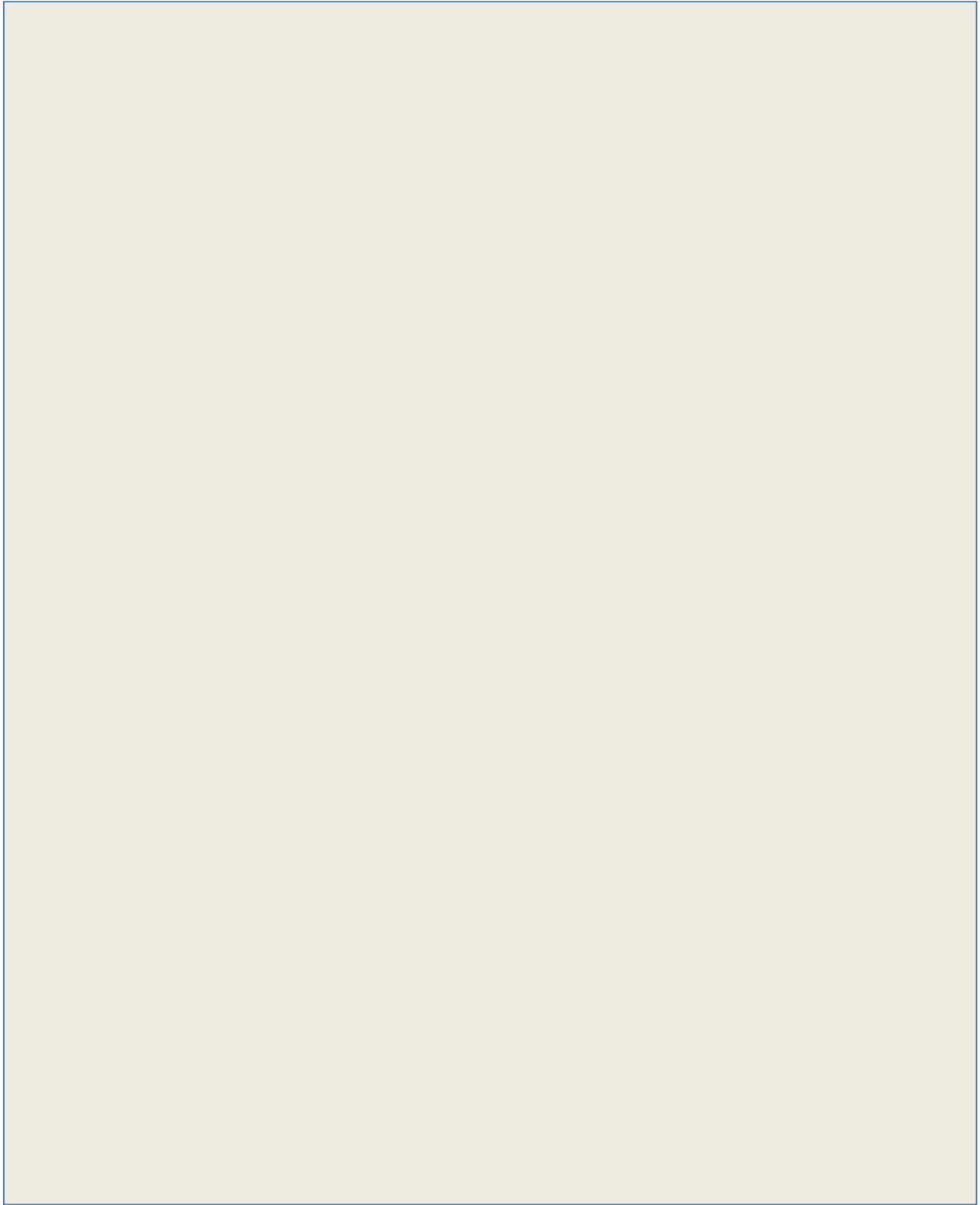


It appears from Table 39 that NaHCO_3 is the effective chemical for neutralizing the acids produced by acid producing bacteria and can be used as a short term preservation of milk under rural condition in Bangladesh where scientific cooling or pasteurization facilities are not available.

Some of the milk adulterants may produce severe public health disorders of which melamine can induce renal failure and death in infants.⁹³² Both the peroxides and detergents in milk can cause gastro-enteritis. Excessive starch in the milk can cause diarrhea due to effects of undigested starch in colon and accumulated starch in the body may be fatal for diabetic patients.⁹⁰⁸ Urea in the milk overburdens the kidneys as it have to filter out more urea content from the body.⁹³³

Preparation of milk products

Milk is an essential basal constituent of a wide range of milk products worldwide which include liquid milk, fermented milk, cheeses, butter and ghee, condensed milk, evaporated milk, dry milk or milk powder, cream, ice cream, whey products, yogurt, curd and casein. Manufacture of table cream from reconstituted milk,⁹³⁴ low fat-milk in the household by gravity method,⁹³⁵ manufacture of peda from sweetened condensed milk,⁹³⁶ use of vegetable oil in manufacture of Khulna cheese from powdered milk,⁹³⁷ comparison of quality of khejur gur sandesh with sandesh of different sweetmeat shops⁹³⁸ and different varieties of sweets which are



19. Ingrain vough	Compare the quality between lab made and collected from market of Dinajpur district	Organoleptic, chemical analysis and bacteriological status of lab made and collected from three sweetmeat shop have been evaluated. Lab made Indrani vough has been reported as best in relation to bacteriological status but Sananda sweetmeat shop's product reported superior than other two sweetmeat shop products. Preparation method has been described.	959
20. Chamcham	Compare the chamcham prepared with cow milk, buffalo milk & mixed milk	Examination of the quality of chamcham showed that chamcham prepared from buffalo milk reported superior to that of cow milk chamcham and 50% cow milk and 50% buffalo milk chamcham. Method of chamcham preparation has been described.	960

Rossomali

Rossomali is a royal sweet often served in weddings and eaten on special occasions. The dessert is called rossomali in Bengali language, ras malai in Hindi language and rasa malei in Odia language. It is believed to have originated somewhere in Eastern Indian sub-continent, presumably in Bangladesh, Indian state of Odisha and West Bengal region. (en.wikipedia.org/wiki/Ras_malai). It is a soft white round patties immersed in creamy, milky syrup flavored with cardamom, pistaias and saffron.

Method of Rossomalai preparation⁹⁵⁵⁻⁹⁵⁷

- Approximately 3.0 liters of raw milk should be collected, of which about 1.80 liter milk should be boiled in a stainless pan for five minutes for preparation of chhana and remaining 1.20 liter milk should be used for malai preparation.
- The boiled milk (1.80 liter) should be cooled to 80 °C. Then the coagulant, sour whey (360 ml with 1.22% acidity) water should be added to the cooled milk for over 30 seconds allowing precipitating the milk curd (called chhana) until chhana separates.
- Whey is then removed from chhana through filtering cheese-cloth / muslin cloth and water is expelled out leaving chhana inside the cloth.
- Then 1.0% (w/w) flour is added to the chhana and it is then grinded and kneaded to prepare chhana balls (small balls of 0.5-0.75 cm size) with a smooth surface without any visible sign of cracks.
- Concentrated sugar syrup (sugar : water = 1.5 :1) is then prepared and the solution is then heated to boiling. The small ball-shaped chhana put gently in the boiling sugar syrup and cooking for 20-30 minutes. Care should be taken that the balls never over crowded the pan and there is enough space for moving them freely. After swelling the colors of the balls are slightly darken, then the cooking should be finished.
- Then sweet balls should be cooked at room temperature and filtered from sugar syrup. At that time sweet balls became large size due to osmosis activity and weight increased more than three times (1-1.25 cm).
- The 1.20 liter of whole milk, 40 g sugar and 3 to 4 pieces of cardamom should be mixed in a pan and heated until the volume is reduced by 50%. When milk turned light brown color then malai is formed.
- Balls of chhana are then cooked in hot malai for 3 to 5 minutes, cooling to room temperature (about 25 °C) for 5-6 hours and it becomes ready for human consumption.

Rosogolla

The dessert is known as Rasagola in Odia and Rosogolla or Roshogolla in Bengali. Rasgulla is derived from the words 'ras' (juice) and 'gulla' (ball). Rosogolla is a sweet syrup cheese ball most popular in the regions of South Asia, manufactured from chhana which is obtained by heat and acid coagulation of milk.⁹⁴⁹ It is one of the most delicious and nutritious among all sweetmeats due to its fairly high protein, fat, mineral especially Ca and P and also fat soluble vitamin A and D.⁹⁶¹

Method of Rosogolla preparation⁹⁴⁷⁻⁹⁵⁰

The pre-requisite for producing excellent quality rosogolla is the availability of high-quality chhana together with the binding material, kneading and concentration of sugar syrup, cooking and soaking time. The correct concentrations of cooking sugar syrup is required for the body and textural properties of rosogolla and its inappropriate concentration leads to cracked, flattened or even brushed rosogolla. Cooking is the process in which a soft and smooth body of chhana balls converts to a fluffy and fibrous network that provides spongy texture typical to rosogolla.

Materials

Cow milk 3.0 liter with 4.0% fat, food grade citric acid, soft wheat flour (ACI Pure), cane sugar and cardamom

Methods

Chhana preparation

- Fresh cow milk (3.0 liter) should be heated to boiling (95 °C) in a stainless steel pan for 10 minutes and then cool down up to 70-80 °C.
- The coagulants (fermented whey pH 4.2 or 1% citric acid) are then added at a temperature of 70 °C along with gentle stirring and the casein is then allowed to precipitate.
- The lumps (known as chhana) are then allowed to stay for half an hour for complete coagulation of chhana, as well as to cool down to room temperature (25-37 °C).
- Chhana is then separated from whey by filtering through a muslin cloth for 2 to 3 hours for the visible cessation of drainage of whey.
- When the loosely bound whey is completely drained out, the muslin cloth is tied together then the coagulum is hanging for about one and half an hour to complete drainage of whey.

Preparation of sugar syrup

The cooking and soaking sugar syrup @ 60 and 40⁰ Brix concentrations have been reported to be most suitable for rosogolla making using admixture of 5% (w/w) wheat flour.⁹⁴⁹

Rosogolla preparation

- The chhana should be mixed with wheat flour (5.0% w/w) and kneaded properly to make uniform and smooth dough.
- The chhana dough is then divided into small pieces of about 10g and rolled between the palms to obtain smooth balls without cracks.
- Cooking (@ 60) and soaking (@ 40) sugar syrup are prepared separately by dissolving the requisite amount of sugar in portable water. Heavy sugar syrup containing 5% sugar (sugar : water = 1 : 1) has also suggested. A 1.5 liter sugar solution is used for cooking and 1.0 liter for soaking.
- Sugar solutions are then clarified by adding some quantity of raw milk during boiling and filtered through a muslin cloth.

- The Chhana balls are then gently dropped into the boiling syrup contained in Karahi.
- After a few seconds, the foam is formed which covered the floating balls.
- The mild temperature is regulated as the balls are constantly covered with foam.
- Some quantity of water is then sprinkled during the continued boiling of sugar syrup to maintain the sugar syrup concentration.
- It is carefully watched that balls are not over crowded in the karahi and there is enough space for moving freely, especially when they swelled.
- The heat is controlled so that the balls are constantly covered with foam.
- After a regular interval, cool water is sprinkled for keeping the sugar syrup at a controlled density.
- Complete cooking of chhana balls is accompanied 20 to 30 minutes.
- The balls are swollen to about double the original size.
- Finally, the balls are transferred to the clarified hot sugar syrup having 40% (sugar : water= 1 : 2) strength for soaking and 2 to 3 cardamom pieces are added to the sugar syrup and then cooled down to room temperature or below for 4 hours and ready for human consumption

Balish misti / Balish Rossogolla

Balish misti is one type of rossogulla famous sweet of Netrokona district. This misti is pillow-shaped and looks like a pillow as kheer is coated on the top of the sweet that is why it is called balish misti.

Method of preparation⁹⁴⁸

- Approximately 3.0 liters cow milk is boiled in a stainless steel pan for 10 minutes and then is cooled at 70 °C.
- About 600 ml whey water is added in the 3 liters of the boiled milk at a temperature of 70 °C.
- Lumps of casein are formed as soon as the whey is added to the boiled milk, which is generally known as chhana.
- The contents are allowed to cool down at room temperature (about 25 °C) for 30 minutes and then the coagulum is transferred to a muslin cloth.
- When the loosely bound whey is completely drained out, the muslin cloth is tied together then the coagulum is hanging for about one and half an hour to complete drainage of whey.
- The coagulum is then carefully removed and weighed.
- The ingredients composition of Rassogolla preparation include chhana 590g + flour 75g, chhana 610g + flour 80g and chhana 595g + flour 75g can be used.
- Chhana and flour are weighed separately, mixed and kneaded.
- Then the kneaded mash should be converted into an oval shape with proper consistency to avoid the crack on the surface.
- About 3kg of sugar is dissolved in 2.5 liters of water in an iron pan and the solution is boiled.
- After some times of boiling the scum is labeled out for obtaining clean syrup.
- The syrup is kept in a suitable sized pan with a depth of 20 cm.
- The chhana of desired size (Balish) is made by hand.
- When all the Balish Rossogolla is made they are put gently in the boiling sugar syrup for cooking.

- Care should be taken that the newly prepared Rassogolla (Balish) are not over crowded in the pan and there is enough space for moving freely especially when they are swelled.
- The heat is so controlled that the rossogolla are constantly covered with foam.
- To control the density of the sugar syrup throughout the cooking period water is sprinkled at a regular interval.
- In 10-15 minutes Rossogolla are swelled and after 10 minutes of swelling the color of the Rossogolla become light are dark.
- Then the Rossogolla are allowed to stay for sometimes to become cool.
- After 3 hours Rossogolla are suitable for consumption.

Indrani vough

Indrani vough is a famous sweet of the district of Dinajpur. Description of this sweet is not available in the webpage and so far only one article has been published.⁹⁵⁹

Preparation of Indrani vough⁹⁵⁹

- Approximately 3 liters raw whole milk, 200g sugar, 20g flour and 240 ml sour whey are required for the preparation of Indrani vough.
- At first 1.70 liter cow milk should be heated to boil for five minutes into two separate iron pans. The milk should be cooled to 80 °C after boiling and sour whey should be added until chhana separates.
- The contents should be allowed to cool down at room temperature (25 °C), after 30 minutes the coagulum should be transferred to a muslin cloth and the cloth should be hung for about one hour for complete drainage of whey.
- Approximately 60g of chhana is usually obtained from 1.7 liter of fresh cow milk should be broken and kneaded with flour (5.5% by the weight of chhana) in order to obtain the desired body and texture.
- Rossogolla (disc shaped) should be made without the signs of cracks.
- Concentrated sugar syrup (sugar : water = 1.5 : 1) should be made and heated to boiling.
- Just after boiling the scum should be labeled out to obtain clear syrup.
- Then Rassogolla of chhana should be cooked in the boiling syrup for 8 to 10 minutes.
- For the preparation of malai 1.30 liter cow milk should be heated in a pan until 50% volume is reduced. The rossogolla is cooked in hot malai for 3 to 5 minutes.
- Then the Indrani vough is prepared and it is allowed to stay for sometimes to become cool.
- After 5 to 6 hours Indrani vough would be ready for consumption.

Cham cham

Chom chom, cham cham or chum chum is a traditional Bengali sweet, popular throughout the Indian sub-continent. This sweet comes in a variety of colors, mainly white, light pink, light yellow. The history of Porabari cham cham, an oval-shaped brownish variety of chom chom from Porabari in Tangail district in Bangladesh.

Requirements⁹⁶⁰

- Approximately 3.0 liter raw whole milk, sugar 2 kg to prepare sugar syrup, flour 40g (1.0% of weight chhana and sour whey 500 ml are required to make 1.5 kg Cham cham.

- Out of the three liters milk, two liter milk is used for chhana preparation and one liter milk is used to Mawa preparation.

Preparation of Chhana

- Two liters of milk should be heated to boiling at 90 °C in stainless steel pan.
- The milk should be cooled to 80 °C after boiling and adding sour whey water at 70 °C and the lumps of casein formed are allowed to stay for few minutes for complete of chhana. The contents should be allowed to cool down at room temperature (25-29 °C).
- After 30 minutes the chhana and whey mix should be transferred to a piece of muslin cloth.
- When whey will be completely drained out, the chhana should be hung for about one hour for complete drainage of whey. Then the Chhana should be carefully removed from the muslin cloth and weighed.

Preparation of Cham cham

- The mass of Chhana is then broken (grinding) and kneaded with wheat flour (1% of the volume of chhana) in order to obtain the desired body and texture.
- Small balls should be made without cracks.
- Concentrated sugar syrup (sugar : water = 1.5 : 1) should be made and heated to boiling.
- Just after boiling the scum is ladled out to obtain a clear syrup.
- Then the balls of Chhana are cooked in the boiling sugar syrup for 40 to 45 minutes, then cooled to room temperature.

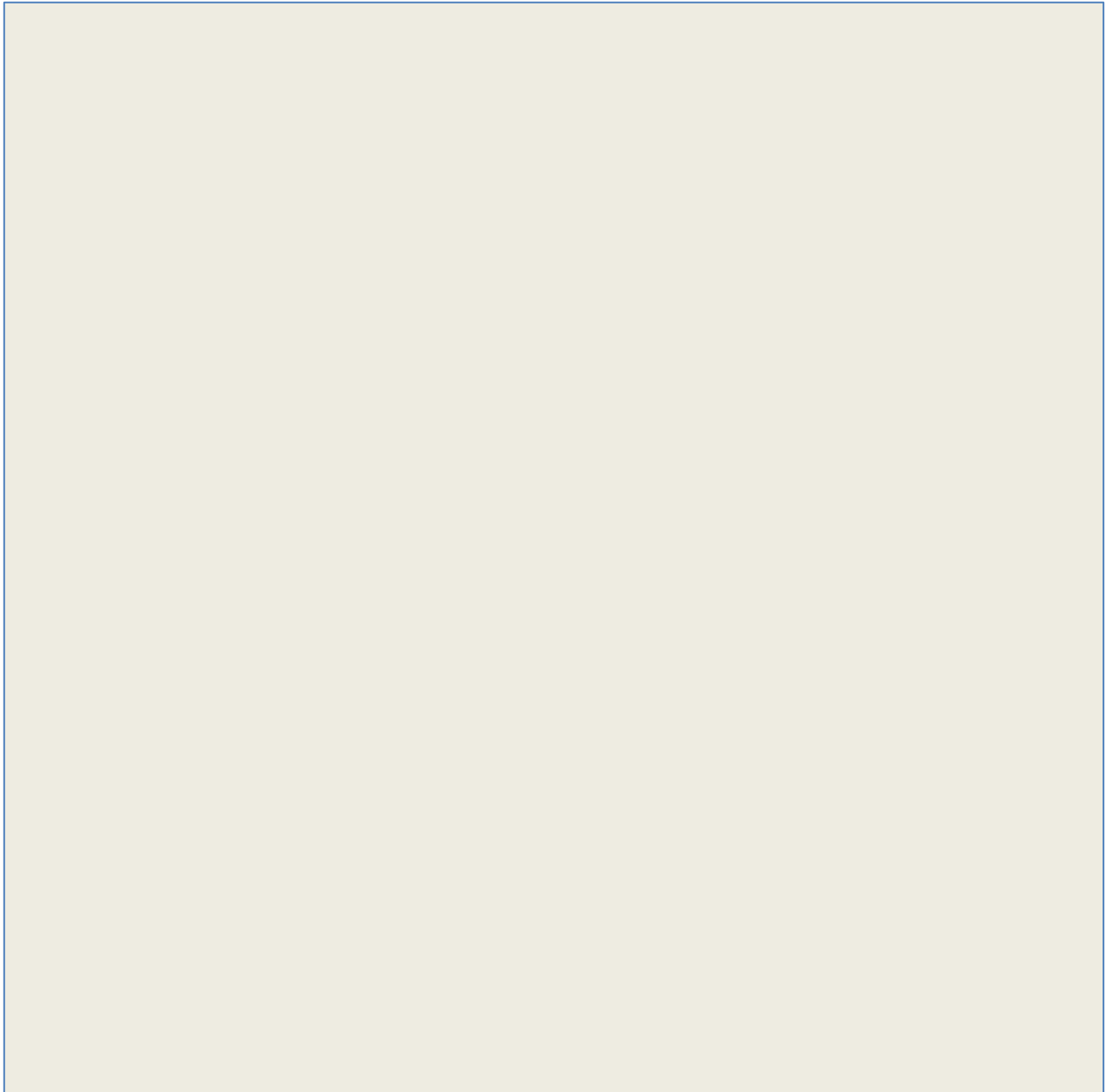
Preparation of Mawa

- Rest one liter milk should be boiled to dry for the preparation of mawa.
- Raw chamcham should be separated from sugar syrup, arranged on trays and mawa is then spread on the balls to garnish the chamcham.

Cheese

Cheese is a dairy product which is derived from milk and produced in wide ranges of flavors, textures and forms by coagulation of the milk protein casein. It comprises proteins and fat from milk, and milk is usually acidified and adding the enzymes of rennet (or bacterial enzymes with similar activity causes the milk proteins (casein) to coagulate. The solids (curd) are separated from the liquid (whey) and pressed into final form (Wikipedia). **Table 41** shows the research findings on cheese published from Bangladesh.

Table 41. Research findings on cheese preparation and its quality evaluation			
Year	Constitutes	Results	Reference
1970	Dhaka cheese	Reported that about 1.2 million lbs of Dhaka cheeses are being supplied to Dhaka city from Austogram of Mymensingh district. Family profession has changed due to inadequate and high price of milk supply	962
1971	Cheese preparation method has been described	The commercial 'lactic' culture and Hensen's commercial rennet have been used for preparation of cheese. The cheese preparation method has been described.	963



Cheese making procedure of Austogram

- Cheese is prepared by producing curd from milk by adding crude rennet extract.
- This is obtained from the fourth stomach (abomasum) of cows and goats.
- The abomasum obtained from slaughter houses is washed and dried with sodium chloride and is kept till it is used.
- Before cheese making, this is soaked in water for at least 12 hours. This is locally known as ‘maoa.’
- The raw milk is set with maoa and the coagulation takes place within an hour.

- The curd is broken by hand or a bamboo knife and settled for a few minutes, then packed in a basket. The whey is pressed out by hand.
- For proper size and shape turning is made at certain intervals.
- When the curd is sufficiently dry after 24 hours, it is salted with sodium chloride.
- The salt is plugged into three centrally bored holes.
- The cheese is then ready for sale.

Analysis of cheese

- Five cheese samples of these manufacturers were collected and analyzed.
- These cheeses were found to contain 39.5% fat, 5.12% salt and 60.7% total solids.
- The TVC was 400,000,000 / g after incubating for 120 hours at 20 °C in plate count agar.
- The gram positive cocci constituted the predominant flora microorganisms

Methods of collection of rennet

- The abomasum of suckling slaughtered calves of different ages should be collected.
- The stomachs should be cleaned by rinsing in cold water and the adhering fats are needed to be removed mechanically.
- The mucous membrane of each stomach should be separated and cut into pieces of convenient size and then should be weighed in grams.
- The fresh cut pieces of each stomach should be added to 500 ml of 10% sodium chloride containing 6% boric acid as preservative and then macerated for 3 days in the refrigerator.
- After 3 days of maceration the samples should be filtered and the filtrates are collected and the keep in the refrigerator until the activity tests are made.
- The extraction should be repeated twice with the same sample of stomachs and filtrate should be collected after 3 days and 5 days respectively.
- All the successive collection of filtrate from each stomach should be pooled together and quantities obtained should be noted and store in the refrigerator.
- Six samples of rennet extracts obtained from different calves are tested first to find the desired concentration for suitable coagulation in milk.
- Each sample of rennet extract should be diluted with distilled water into 1:10, 1:20 and 1: 30 ratio.
- One ml portion of each dilution should be added to 10 ml portion of whole milk and then need to be incubated at 30.5 °C for half a minute and two minutes respectively in thermostatically controlled water bath.
- On the basis of rennet test for strength of rennet, the strongest rennet coagulates milk rapidly within one minute.
- Coagulation of milk in one minute is considered better for proper clotting of milk.

Some observation

- Milk samples which coagulated in 1 minute are considered to be the desirable strength for the coagulation of milk.
- If rennet extracts obtained from calves of early ages, i.e. 14 to 20 days or less are suitable for the quick clotting of milk.
- If the rennet extract is transferred from the sunlight to low temperature and keep there for a while, the activity of rennet extract might be regained.

- The cheese manufactured by using rennet extract prepared from the fourth stomach of calves of 14 to 25 days showed no flavor deteriorations but the cheese made from rennet extract of calves of 150 to 200 days gave a little bitter taste.
- Bitter taste in finished cheese indicates that the rennet extract obtained from the calves of 125 to 200 days, might contain more pepsin, good for the coagulation of milk.
- It appears that the quality of cheese depends on the nature of rennet extract used for preparation of cheese.

Preparation of cheeses⁹⁶⁷

- The cheeses are prepared by coagulating milk using lactic, citric and tartaric acid.
- Each 1.5 kg of milk is placed in three vats separately.
- The milk is heated to 85 °C and 2g coagulants per kg of milk are added.
- The milk stood for 40-45 minutes.
- When coagulation is completed the curd is cut into several pieces with a knife and left to settle for 25-30 minutes.
- The whey is separated by fine muslin and the resulting curd is put into a wooden box with addition of 1% salt. Then, it is kept in refrigerator for further study.

Preparation of cheese⁹⁶³

- Freshly drawn milk is supplied from BAUDF with acidity ranged from 0.16 to 0.18%
- The milk is then placed in two vats each containing 20 lb of milk for making two different blocks of cheese.
- The milk is heated by hot water supplied from a hot water tank.
- At 30-31 °C 'lactic starter' is added @ 4-5 oz for each 20 lb milk.
- The acidity is increased by 0.01-0.02% usually within 40-50 min.
- Hansen's commercial rennet is added for coagulation.
- The milk is coagulated within 40-45 minutes and it is cut with a knife or broken by hands into smaller particles.
- The salt is added @ 3 oz / 20 lb of milk in two methods.
- In one bucket salting is done by sprinkling as the curds are hooped in a basket.
- In another, salt is plugged through centrally bored holes after 24 hours of hooping.

Preparation of cheese⁹⁷⁰

- Rennet and starter culture are collected from Classic Dairy Foods, beg Housing, Khagdohar, Mymensingh
- The milk is heated at 80 °C for 30 minutes and then cooled for about 45 minutes to 38-40 °C and a culture of thermophilic bacteria (5%) is then added.
- After 30 minutes, calcium chloride (CaCl₂) dissolved in water is slowly added at 0.5g/2.5 L of milk and after 15 minutes rennet dissolved in water is slowly added at 0.5 ml/2.5 L of milk.
- While adding CaCl₂ and rennet, milk is agitated by curd rake and ripened for about 40 to 50 minutes for curd formation.
- When curd formation is completed it is cut into cubes by curd cutter and the temperature is raised to 45 °C, while stirring gently.

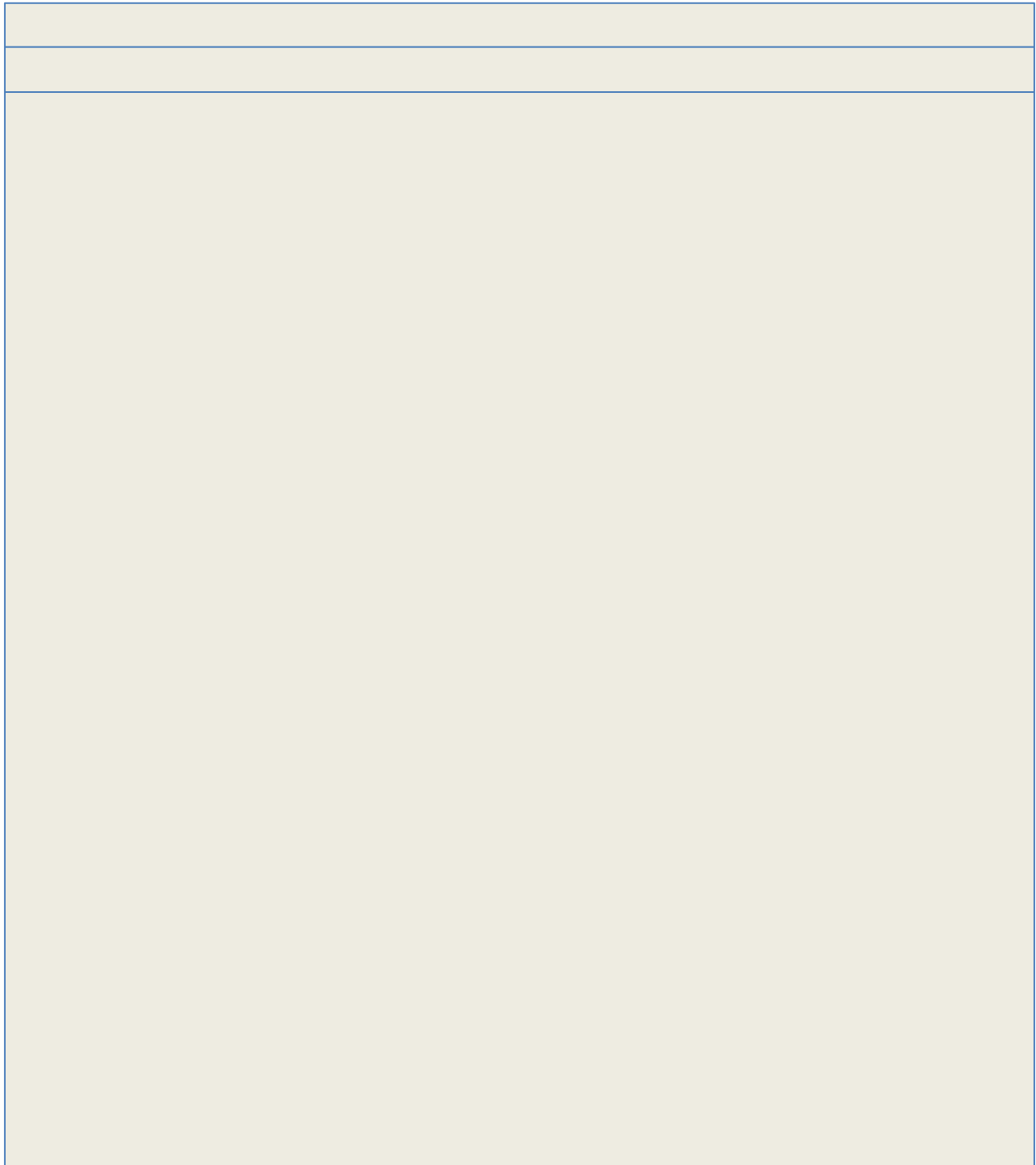
- After 15 minutes the whey is removed from the curd using cheese cloth and put into a wooden cheese dice.
- The cheese is kept for 12 hours or one night in refrigerator and taken out and dipped into 25% salt solution for 30 to 40 minutes.
- The cheese is wiped with soft cloth and packed tightly with transparent polyethylene.
- Cheese thus prepared is defined as Mozzarella cheese and is stored in deep freeze.

Procedure of cheese preparation

- 2.5 liter milk is boiled at 81 °C and after cooling at 40 °C 0.03% calcium chloride is added and allowed to stand for 10 minutes.
- Then bacterial culture [generally 1% starter culture (sour dahi)] is added to the milk sample.
- After addition of starter culture, the milk sample mixed thoroughly.
- Ripening is taken for one hour at 40 °C.
- Lactic acid bacteria are responsible for turning lactose into lactic acid, thereby reducing the pH of the solution. When the pH is lowered, the protein is more easily precipitated.
- This is the vital for the production of cheese curds.
- At that time the milk is allowed to ripen for one hour up to reaches appropriate pH level.
- After the addition of starter culture 5,6 7,8 drops papaya latex (papain) and 0.28g rennet is added for coagulation of milk.
- After collection of fresh papaya from the garden washed with alcohol and punched with syringe and latex is collected drop by drop.
- The papaya latex served to coagulate the milk protein and formed curds.
- Required quantity of papaya latex (papain) is added to the sample by thoroughly mixing and allowed to stand for 3-4 hours to complete coagulation.
- The coagulated curd is cutted into small pieces like ¼ to 5/8 inch cubes using stainless steel wire knife for removing whey water from the curd and gaining appropriate pH.
- The curd is cooked at 46 °C for 20 minutes with stirred constantly.
- When most of the whey is drained out from the coagulated curd it is collected.
- When all of the curd is milled about 1% (by weight) salt is added.
- Then the curd is hooped and pressed into a stainless steel dices to form cheese block by forcing pressure.
- After collection of cheese it is kept in refrigerator for further use.
- It may be concluded that cheese from buffalo milk with 6 drops papaya latex (papain) had highest acceptability for preparation of desired quality cheese.

Ice cream

Ice cream is a frozen dairy food with mixture of milk, cream or butterfat, sugar and flavoring ingredients that has been frozen into a soft, creamy delight using special techniques. Hundreds of flavors have been devised, but most popular being vanilla, chocolate and strawberry.⁹⁷³ Table 42 shows the research findings on ice cream in Bangladesh.



Procedure of ice-cream preparation

Method-A⁹⁷³

- $\frac{3}{4}$ cup white sugar, 1 cup heavy whipping cream, $2\frac{1}{4}$ cups milk and 2 teaspoons vanilla extract
- Stir sugar, cream and milk into a saucepan over low heat until sugar is dissolved.

- Heat just until mix is hot and a small ring of foam appears around the edge
- Transfer cream mixture to a pourable container such as a large measuring cup. Stir in vanilla extract and chill mix thoroughly, at least 2 hours (overnight is best).
- Pour cold ice cream mix into an ice maker, turn on the machine and churn according to manufacturer’s directions, 20 to 25 minutes.
- When ice cream is softy frozen, serve immediately or place a piece of plastic wrap directly on the cream and place in freezer to ripen 2 to 3 hours.

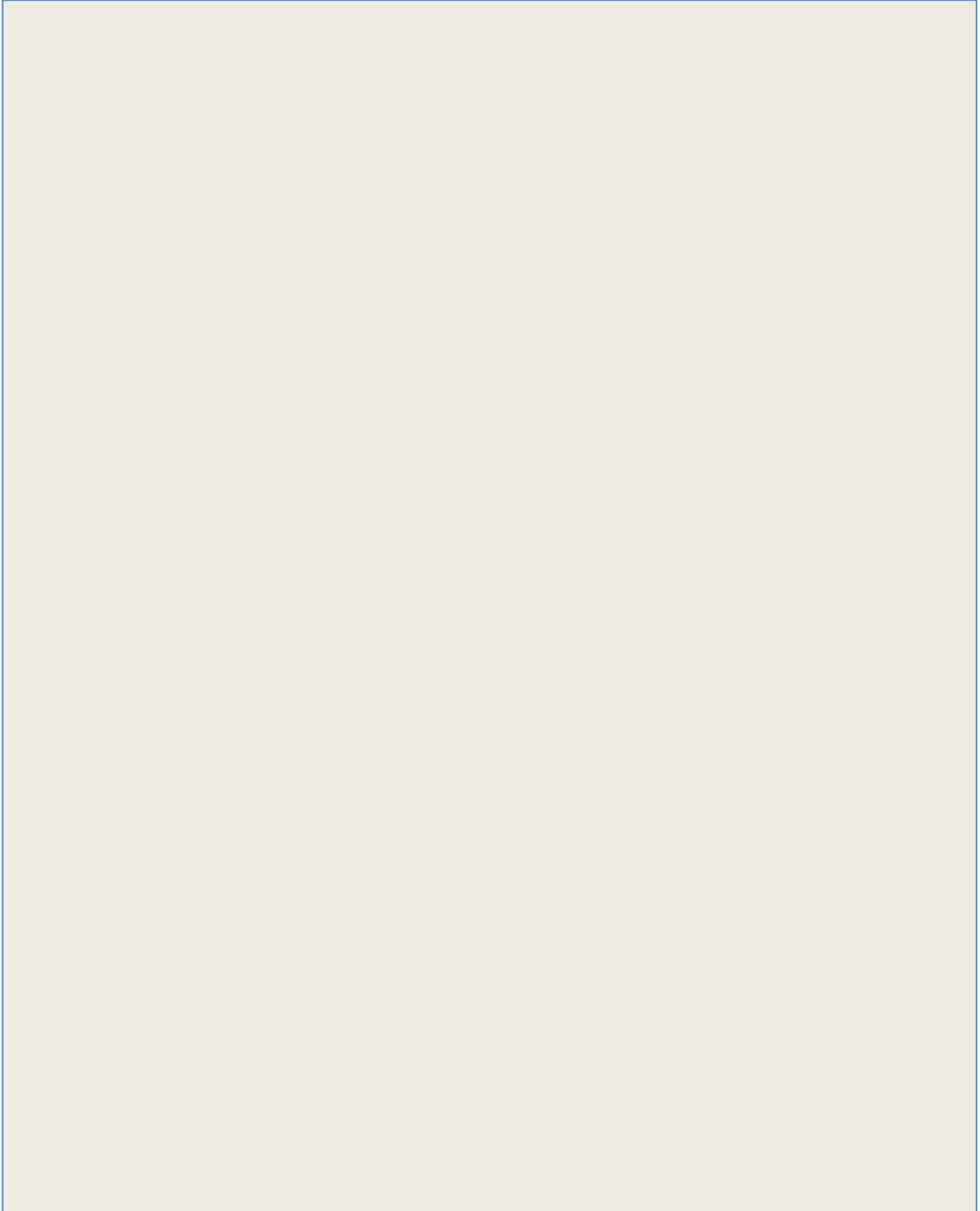
Method-B⁹⁷⁹

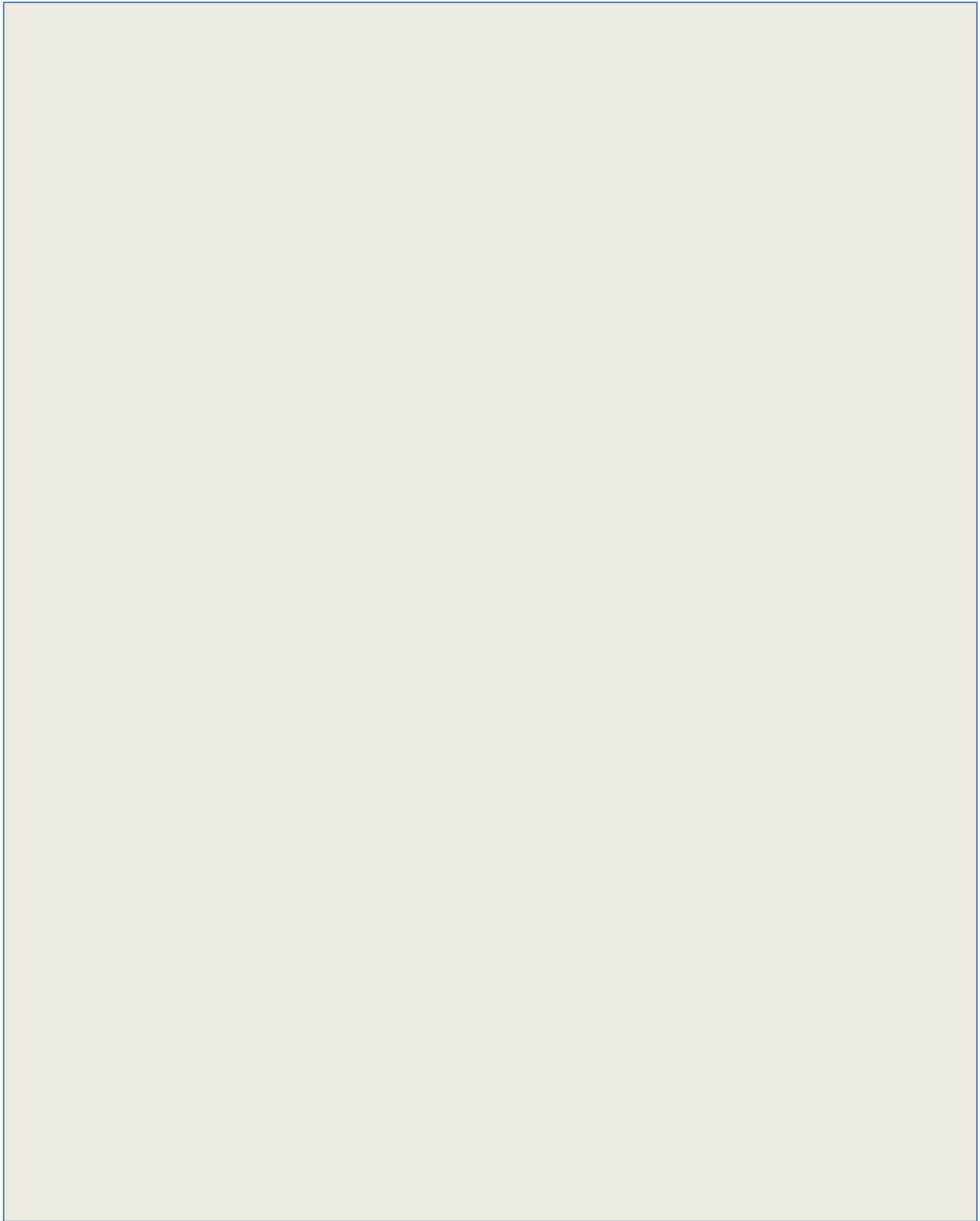
- Whole milk or skim milk, sugar (14%) and ice cream powder (2%) were mixed in a saucepan and heated up to boiling along with continuous string.
- The saucepan is taken out from the heater and allowed to cool down to room temperature.
- The mix is kept in the refrigerator at 4 °C for 24 hours.
- The cool mix is subjected to over-running for 45 minutes.
- After over-running the sample is poured in small cups and was transferred into deep freeze at - 20 °C for hardening.

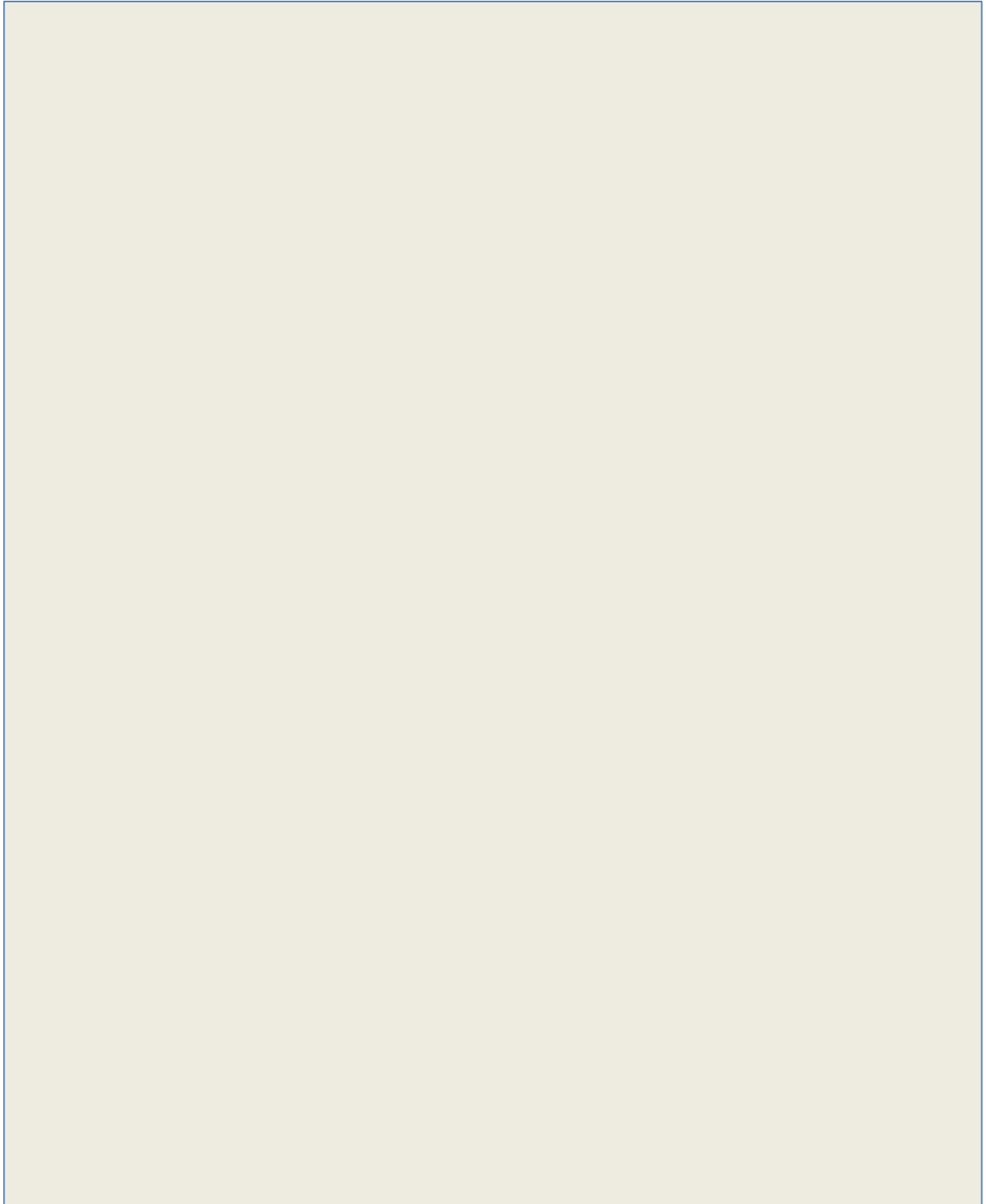
Dahi (Yoghurt)

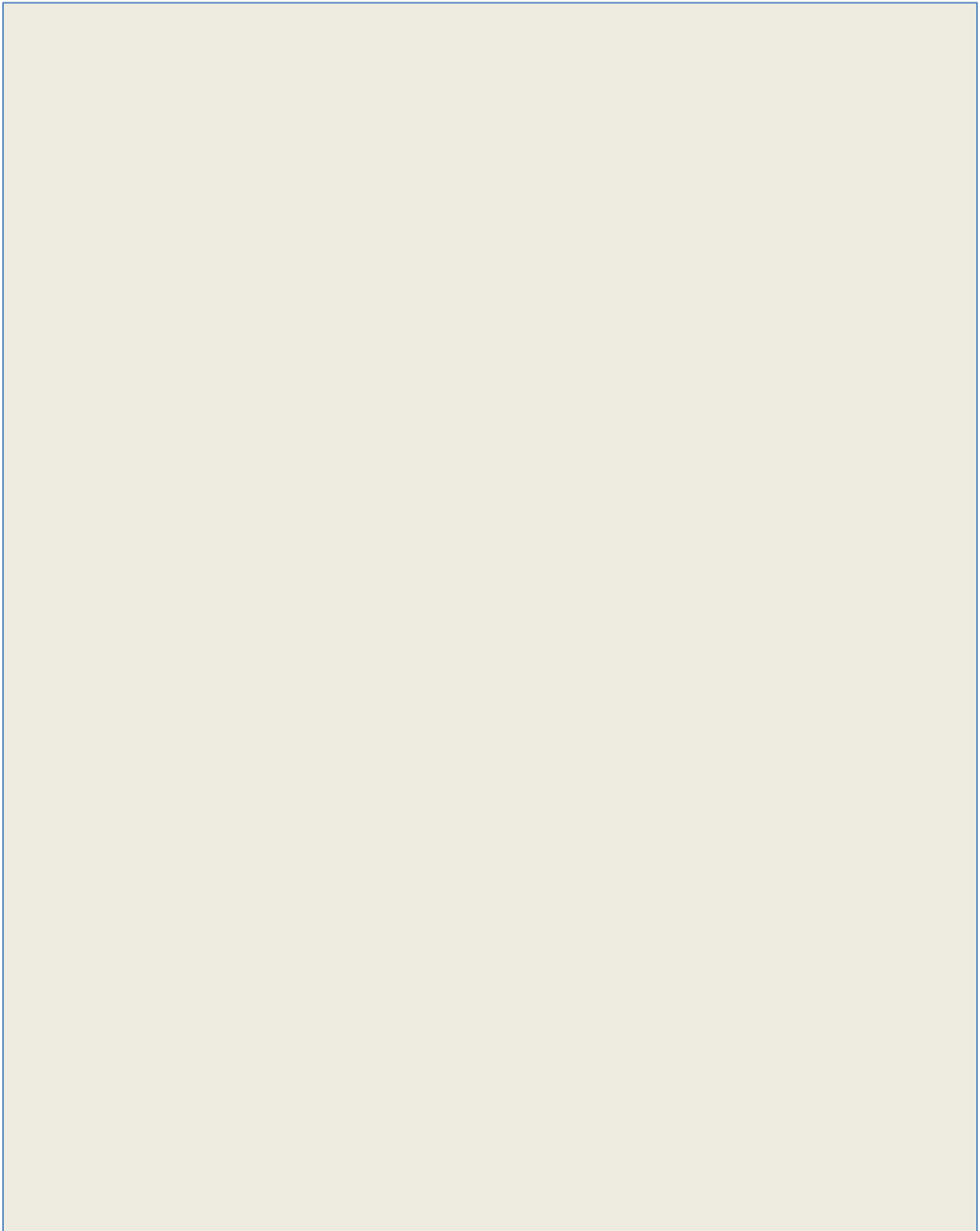
Dahi is considered the oldest fermented milk product of Indian sub-continent and may be considered the western equivalent to yoghurt. Curd and dahi mean one and the same thing in the Indian sub-continent and both are made from milk and are fermented by adding healthy bacteria to the milk. Curd is prepared after curdling warm milk using some amount of curd or dahi. Dahi does not include milk coagulated by the addition of acids or milk enzymes. Traditionally, dahi is prepared by natural culturing of boiled and subsequently cooled milk resulting in variability in its quality due to undefined starter cultures and uncontrolled fermentation.⁹⁸³ Yoghurt is a fermented milk product prepared by addition of both *Streptococcus thermophiles* and *Lactobacillus bulgaris* as the starter culture because of their symbiotic relationship.⁹⁸⁴ The function of the starter cultures is to ferment lactose (milk) sugar to produce lactic acid. The increase in lactic acid decreases pH and causes the milk to clot or form the soft gel that is characteristic of yoghurt. The fermentation of lactose also produces the flavor compounds that are characteristic of yoghurt. Functional properties of traditional dahi could be enhanced either by modification of basic milk, exopolysaccharide producing starter cultures, introduction of probiotic cultures and inclusion of diverse food additives like fruit juices, herbs and spices. Table 43 shows the preparation and evaluation of dahi which are locally produced in Bangladesh.

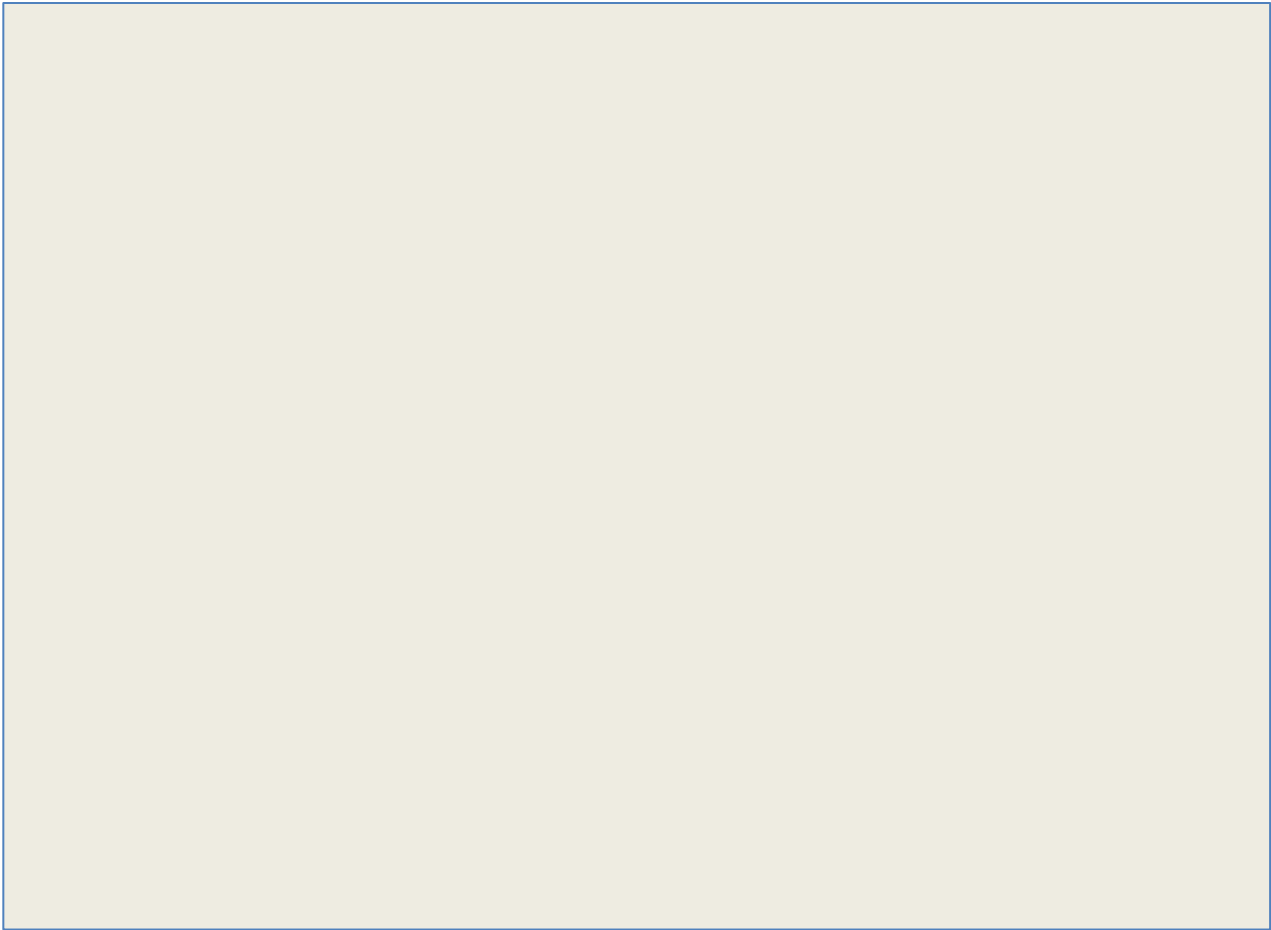
Table 43. Preparation and evaluation of yoghurt marketed in Bangladesh			
Year	Research objectives	Summary of research results	References
1972	Bacteriological quality of dahi tested from five sweetmeat shop of Mymensingh town	These dahi has been reported to be contained wide varieties of bacteria with no uniformity. Higher proportion of lactobacilli has produced dahi which criticized for high acid taste and lacking desirable flavor. A ratio of two or more streptococci to one lactobacillus would give better results	985











Procedure of dahi preparation⁹⁹⁰

- Buffalo and cow milk are mixed and boiled for 5 to 10 minutes in order to destroy the viable organisms that present in milk and reduced up to 10-15% of volume of milk.
- Sugar is then added to the milk @ 125 g / l of milk.
- The boiled milk is then cooled to body temperature (36.4 °C) and inoculated with desirable proportion (2-3%) of starter culture which can be used local market dahi.
- Culture is mixed thoroughly and after mixing it is sampled in plastic cups and keeps in the incubator having the temp (35-36 °C) until the complete coagulation (8 to 12 hours).
- After complete coagulation the dahi samples are stored at refrigerator until further use.

Method of preparation of fruit dahi⁹⁹⁴

- Whole milk is heated to boiling for about 20-30 minutes, non-fat milk powder is mixed with the whole milk in desired proportions (3%) before heating.
- The milk is stirred with spoon.
- Sugar is added to the milk @ 8.0% based on total amount of milk.
- After completion of heating milk is divided into five equal parts.
- Four different types of fruit juice namely mango, date palm, banana and apple juice is added to four cups except control (plain dahi).

- Fruit juice is added @ 10% based on total milk in the cups.
- The cups are incubated with culture.
- Heated milk is cooled to about 40 °C and inoculated with desirable proportion of cultures (2%).
- The samples are incubated at 37 °C until the complete coagulation of fruit's milk mixture.
- After 8-12 hours the complete coagulated fruit-milk mixture called fruit dahi are stored at refrigeration temperature.

Preparation of banana juice and different types of dahi⁹⁹⁶

- Mature ripe banana skin should be separated with the help of clean hand, the seed and black spotted are removed from banana fruit pulp.
- Then the banana pulp is blended and after completion of blending, the juice is filtered using clean cloth and then it is stored in the refrigerator until use.
- Whole milk is boiled in a pan for about 30-40 minutes to reduce 20-25% of its original volume.
 - Sugar is added to the milk @ 10% during boiling.
- During heating milk is stirred thoroughly with the help of a stirrer.
- After desired heating, milk pan is taken out from the heater and allowed to cool.
- Banana juice is taken out from the refrigerator and kept in the room temperature for thawing.
- When the temperature of milk became about 40 °C then the milk is divided into four equal portions.
- Banana juice is then added into each portion of milk as: A: 10%, B: 20% and C : 30% and D: Plain (control). Different level of banana juice could be used successfully to prepare fruit dahi but also makes the product cheaper in comparison with plain (control) dahi.

Preparation of dahi⁹⁹⁷

- Whole milk collected for the preparation of dahi is heated to boil consistently until it reduced to 20-25% of the volume of milk.
- At the boiling of milk, sugar is added @ 8% of the total volume of milk.
- During heating, milk is stirred thoroughly with the help of stirrer,
- After desired heating, milk pan is taken out from the heater and allowed to cool down to near 42 °C and inoculated with 2% starter culture.
- After inoculation, warm milk of 42 °C is poured into several clean plastic cups that are boiled previously for maintaining their hygienic quality and kept undisturbed at an incubation temperature of 37 °C until coagulation.
- After complete coagulation (3.5-4 hours), the dahi samples are taken out of the incubator and stored in a refrigerator at about 5 °C for analytical purpose.
- All dahi used in this trial are prepared following the above way.
- Powdered milk is added with the skim milk before heating of milk.
- Similarly, vegetable oil i.e. soybean oil is mixed to the skim milk during heating of skim milk. Before adding, soybean oil is heated for neutralizing its odd flavor.

Methods of preparation of mango juice-soy milk dahi¹⁰¹⁷

Soy milk from soybean powder

- 1.0 kg whole soybean seed free from immature field damage and black spot are grinded in a soy flour mill.

- 125g powder is dissolved with 1 liter of water by stirring.
- The soy milk is strained through a fine cloth to separate the residue.
- Soy milk is then boiled at 100 °C for 10-15 minutes with constant stirring.

Preparation of mango juice

- The mango fruit is washed by distilled water, skin is separated, seeds are removed and the fruit pulp is blended.
- After blending the juice is filtered by clean cloth and stored at refrigeration temperature (4 °C) until preparation of dahi.

Procedure of preparation of date palm brown sugar added dahi¹⁰²⁰

- 2.5 liter of whole cow milk is boiled in an open pan called karahi for about 25 minutes in order to reduce the volume by 20%.
- The milk is then divided into 4 equal portions, 0.5 liter each.
- Date palm brown sugar is weighed at different levels 10%, 12% and 14% (weight/volume) of milk i.e. 50g (A), 60g (B), 70g (C) for each of 0.5 liter portion of milk.
- A standard 12% (60g for D) cane sugar as control.
- Date palm brown and cane sugar are added to each portion of hot > 90 °C milk and mixed well with a stirrer.
- The portions of milk are then cooled to 40 °C and 2% mixed starter culture is added to each portion.
- The portions are transferred into 100 ml cups and are incubated at 37 °C in an incubator for 5-6 hours.
- After coagulation, all the samples are put in a refrigerator at about 4 °C until tested.

Procedure of preparation of mango flavored dahi¹⁰²¹

- The collected whole milk is skimmed by an electric cream separator.
- Mango, sugar and starter culture are collected from local market.
- Ripened mangoes (*Mangifera indica*) are washed with clean water and skin is separated with the help of knife aseptically.
- The seeds are removed and mango pulps are blended.
- After blending, the juice was filtered with clean cloth (hot water washed).
- These kept in plastic containers and stored at freezing temperature (-20 °C) until preparation of dahi.
- Skim milk is heated to reduce about ¼ the of its original volume and sugar is added @12% during boiling. During heating, milk is stirred continuously with the help of a stirrer.
- After desired heating, milk pan is taken out from the heater and allowed to cool.
- When the temperature is about 40 °C, then milk is divided into four equal portions namely A, B, C and D and different types of dahi is prepared from each portion.
- Sample A served as control with mango juice and 5, 10, and 15% mango juice is added in group B, C and D respectively.
- Milk is inoculated with 2% starter culture and then distributed into plastic cups.
- The samples are incubated at 42 °C until the complete coagulation of dahi (7-8 hours).
- The dahi samples are stored at about 4 °C at refrigerator until judging.

Preparation of coconut milk dahi¹⁰²²

- The edible portion (cellular endosperm) of coconut is shredded carefully to avoid the waste material.
- Two cups of warm water (250 ml) for every cup of coconut are used to prepare coconut milk.
- The coconut and water are blended with high pressure until the mixture is as smooth as possible.
- When the blending is completed then the coconut milk is filtered by a clean muslin cloth (hot water washed) and kept it in a beaker.
- When skimmed milk powder is dissolved with water then it may be defined as reconstituted skim milk.
- Skimmed milk powder is added @ 9g/100 ml (w/v) of warm water to prepare reconstituted skim milk.

Research on beef cattle production

There are more than 250 beef cattle breeds in the world and 60% of them are found in the USA.¹⁰⁴¹ Currently, beef cattle production business are as popular as dairy production business. Some breeds have been around for centuries, while other have been developed in the last couple of decades by mixing older breeds like American Brahman.¹⁰⁴² The beef cattle breeds of greatest prominence today originated in Britain (Herefords, Angus, beef Shorthorns and Galloways), USA (Black Angus, Beef Master & others), India (Brahman), France (Charolais, Limousin, Normandy), Switzerland (Simmental), South Africa (Afrikaner) and other countries.¹⁰⁴² There is no any recognized beef breeds in Bangladesh, however, the male uncastrated native and cross-breed cattle are mainly used as a beef cattle.^{435,1043} Recently, American Brahman semen has been imported to develop beef cattle in Bangladesh. The American Brahman is a result of 266 and 22 females imported from India to USA between 1854 and 1926. Since then breed has been selectively bred for meat production, making it the ideal breed for meat production.¹³ In comparison to other breeds the American Brahman is able to utilize low quality feed, withstand a wide range of temperatures and consistently maintain a higher feed to weight ratio than most other contemporaries. Overall this makes the breed ideal for meat production in Bangladesh when crossbred with local cattle.¹⁰⁴⁴⁻¹⁰⁴⁶

Native and crossbred uncastrated cattle of two to three years of age are mostly preferred by the butchers for their business whereas rearing of cattle are mainly based on rice straw with inadequate capital, training, feed stuff and fodder crops and marketing facilities.¹⁰⁴⁷ Recently Brahman beef cattle breed has introduced in research in Bangladesh and it has observed that 50% Brahman cross calves well performed live weight of 229.62kg at 12 months of age in comparison with 25% crosses with local cattle.¹⁰⁴⁴ The hearth girth (HG) around the chest and in combination of HG and body length (BL) can be used efficiently to predict live body weight in Brahman crossbred cattle.¹⁰⁴⁸

The per capita intake of meat is only 8.6 kg in humans Bangladesh against 42.1 kg for world and 32.2 kg of developing countries. Therefore, there is a need to develop market beef cattle of average >150 kg carcass weight by 24 months with an average FCR of < 6.5 under the farm feeding and management condition. An experiment has been conducted with imported frozen semen of beef breeds of Brahman, Simmental, Charolais and Limousin in native breeding cows,

2017	To compare the live weight of different crossbred beef calves at birth and at 12 months of age	The birth and 12-m age live weight have been reported with Charolais cross (27.5 & 279.9 kg), Brahman (24.1kg & -), Simmental (21.9 & 297.3 kg), Limousin (19.8kg & 270.2kg) and Local (18.4kg & 194.7kg).	1049
2020	To evaluate the effect of sire and environment on growth performance of grade-2 Brahman calves	The sire and environment have reported to have significant effect on above growth traits at different ages of Brahman progeny which indicates that best sires in best environment can produce superior progeny.	1045
2020	Factors related to growth performance of Brahman graded calves	Improved feeding had positive impact on growth performance of Brahman growing bull calves. Growth performance had positively strong phenotypic correlation different growth traits and factors	1046

The higher birth weight, yearly weight and average daily gain of Brahman crossbred calves have been reported than that of indigenous and other crossbred calves.⁵⁶⁴ It appears that these selected graded Brahman breeding bulls may generate a good opportunity to improve local cattle for beef purposes.

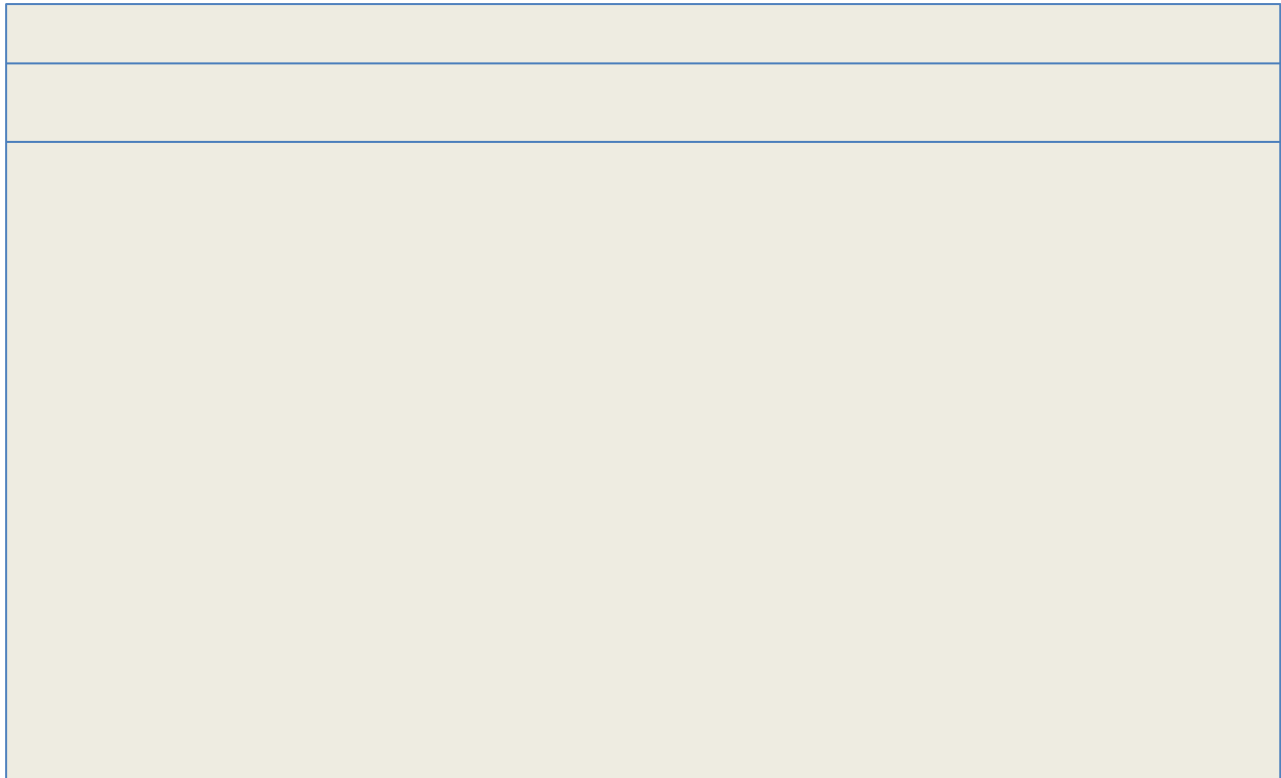
Care of the calf at birth

When calving time approaches, the cow should be watched closely for any complications. The newborn calf should begin to breathe shortly after the umbilical cord detached from dam. Mucus around the nostrils should be removed. Do not pound on the calf's chest or lift it by the rear legs since this can do more harm than good. Shortly after birth, the navel cord should be dipped with a 7% tincture of iodine solution. The cow should be allowed to lick the calf after delivery. In cold weather or if the cow does not lick the calf, the calf should be dried with clean cloths. This practice not only dries the calf but stimulates the calf's blood circulation. Generally dairy calves are removed from their dam shortly after the dam has licked the calf clean, usually with one hour (<http://www.ca.uky.edu>).

Birth weight and growth of calves

Growth is defined as the mass increase in animal live weight and divided into two periods as pre-natal and post-natal growth. Both the pre-and post-natal growth are in equally significant but the breeders generally deal with post-natal growth of animals. Birth weight is an early and easy indicator of pre-natal growth, which is commonly used as an early selection criteria in cattle breeding. **Table 45** shows the analyzed mean values of birth weight of calves reported in different breeds and varieties of cattle.

The birth weight of calves is of critical importance to the dairy and beef cattle industry. Calves that are too small at birth may lack vigor, tolerance to cold-stress, resistance to pathogens or the ability to overcome parturition stresses during adaptation to extra-uterine life. Calves that are too large at birth may cause varying degrees dystocia, leading to increased birth asphyxia, metabolic and respiratory acidosis, depressed immunoglobulin in absorption and increased susceptibility to diseases.¹⁰⁶¹



A = 42,43,58,635,732,735,756-758,777-779,782,783,967,1058	E = 735,745,747,756-758,761,770	
B = 635,739,745,747,754,756-758,761,766,1059,1060	F = 735,747,756,761	
C = 739,757,758,770	G = 492, 735,785	
D = 745,747,754,756,757,758	H = 32,635,739,754,757,758,761,766,778	
? = Not mentioned in the article	AFS = Australian-Friesian-Sahiwal	BC = Brahman cross
SH = Smallholder	RCC= Red Chittagong cattle	() = No. of observation
MV = Munshiganj variety	NBG = North Bengal Grey cattle	DDC = Dinajpur Dwarf cattle
RS = Red Sindhi	- = Data not available	

Male calves, on average tend to be larger and higher birth weight than female calves (Table 45) because bovine males are larger than females and because male calves are often carried a few days longer than female calves of similar genetics, if a cow goes past her due date, she is likely to have a bull calves. If she calves a few days earlier, the calf is often a female calf.¹⁰⁶² However, the birth weight can be affected by changing the rate of fetal growth or by changing length of gestation. Some breeds and family lines within breeds tend to have gestation lengths slightly shorter or longer than the average 283 days. Low birth weight cattle often have shorter-than-average gestation, and high birth weight cattle tend to have longer than average gestation. The fetus is growing fastest in the final stages, so several more days' gestation creates a larger calf. Study showed that each extra day of gestation amount to at least one pound more in the size or weight of the calf.¹⁰⁶²

Environmental factors affecting growth rate include nutrition of the dam and environmental temperature. Overfeeding cows in late gestation increases risk for dystocia because of increased calf size and fat accumulation in the birth canal. Underfeeding to reduce birth weight is counter

productive, however, because of increased weakness and metabolic disease in underfed cows. The cow has poorer colostrum and won't pass adequate immunity to the newborn calf and this weak calf that is slower to get up, slower to suckle, and when it finally does suckle, it gets inadequate colostrum. No significant influence of season on birth weight of calves has been observed with these limited reports (Table 45). Calves born during rainy season reported approximately 10% heavier at birth than those born during the dry season elsewhere. It appears that the breed, gender and season of calving interaction have significant influence on birth weight of calves.

The RCC is a valuable indigenous cattle genetic resource of Bangladesh with many attributes better than other available indigenous types and varieties.⁴⁶ Table 45 shows that highest number of research reports (>16) on birth weight of RCC calves in comparison to other genotypes have been published from Bangladesh. The moderately high heritability of growth of RCC suggests that RCC selected for growth up to 24 months of age would show a quick response.¹⁰⁵⁸ An increasing trend in body weight from birth to 30 months of age with highest body weight gained at 30 months of age and then afterwards showed a gradual declining trend but no difference effects of management system (farm & field) on growth performance.⁴⁶ Although body weight and growth of RCC calves are very slow compared to crossbreds but comparatively higher other native cattle.¹⁰⁶³

Calf management

Heifers are the future of the dairy herd and deserve to have the best management that incorporates all the latest research and management advice. Raising heifer calves is the second largest annual expense, approximately 20% of a dairy business's production cost after feed. Heifers produce no income until they reach first lactation and no benefit until the second lactation. In the return, they will reply the investment through higher milk production and a longer productive life.¹⁰⁶⁴ Management of calves should be a good start with the first step in producing healthy, well grown replacement animals that are ready to enter the milking herd at 22 to 24 months of age. Starting calves off well is essential to minimizing death loss and improving health outcomes. Even when a calf survives a disease, negative economic impacts may occur, and it may never reach her full genetic potential.¹⁰⁶⁵ Calves treated with antibiotics have been shown to produce less milk in their first lactation than calves that receive no treatment with antibiotic.¹⁰⁶⁵ This suggests to encourage farmers to look more to disease prevention than treatment of heifer calves. There are three targets to raise the desired number of healthy, fertile and productive heifers which include: (a) Keeping calf morbidity and mortality to a low level, (b) Maintaining good calf growth and (c) Maintaining good calf health. The goal of calf nutrition is to promote healthy, efficient and rapid growth through milk and to enhance rumen growth and function by initiating calf starter intake.

Colostrum management

Newborn calves have no innate immunity with immature immune system and depends on colostrum from its dam to initially acquire immunity through absorption of antibodies (IgG) which takes more than six months to fully mature immune system. The milk from the first milking following delivery is called true colostrum. After the first milking and for the next two and a half days, the cow's milk is called transition milk. True colostrum contains twice as much

dry matter and total solids, 2-3 times as many minerals and five times as much protein as whole milk (Table 46).¹⁰⁶⁶ Colostrum also contains various hormones and growth factors that are necessary for growth and development of the digestive tract. Colostrum is lower in lactose, thus decreasing the incidence of diarrhea.

SN Constituents (%)	Milking after calving				SN Constituents (%)	Milking after calving			
	Colostrum 1 st	Transition milk 2 nd	3 rd	Whole milk		Colostrum 1 st	Transition milk 2 nd	3 rd	Whole milk
1. Total solids	23.9	17.9	14.1	12.9	2. Fat	06.7	05.4	03.9	04.0
3. Protein	14.0	08.4	05.1	03.1	4. Lactose	02.7	03.9	04.4	05.0
5. Minerals	01.1	01.0	00.8	00.7	6. Calcium	00.26	00.15	00.15	00.13
7. IgG (mg/ml)	32.0	25.0	15.0	00.6	8. Vita-A (µg/dl)	295.0	190.0	113.0	34.0

Colostrum of the right quality and quantity given to the newborn calf at the right time which is the cornerstone of success for calf survival in any herd. It contains important nutrients like vitamins, minerals, energy and proteins, besides antibodies (IgG) and many other important substances. Colostrum is also called maternal derived antibodies (MDA) which are essential to protect the newborn for at least the first 2 to 4 months of life. There are five golden rules of colostrum feeding which include (a) Quickness (< 2 hours), (b) Quantity (10-15% BW), (c) Quality (> 50g IgG/L), (d) Frequency (multiple) and (e) Cleanliness.¹⁰⁶⁷

(a) Quick feeding of colostrum

The calf should get colostrum as quickly as possible after birth, because the ability of the intestine to absorb colostral Ab (IgG) into the blood is most efficient during the first 4-6 hours of life. At about 12 hours after birth the absorption of IgG is reduced by 50% and after 24 hours the calf can hardly absorb any IgG at all. Milk the cows as soon as possible after calving to assure adequate delivery of abs to the calf. If the cow is milked in late after delivery for the first time, abs content of colostrum will decrease by dilution.

(b) Quantity of colostrum

Colostrum is the key to calf survival and newborn calves must receive at least 3.0 to 4.0 liters (10-15% of the body weight) of colostrum within 2 hours of birth and 2-3 liters within six hours after birth depending on the live weight of calves. Protein, fat and sugars from colostrum help to increase the calf's metabolism and heat production. Moreover, colostrum intake facilitates the first feces (meconium). The colostral abs (IgG) are absorbed within 24 hours in bovine which help to protect the calf against infection for 3 to 4 weeks. The calf requires first 4 to 6 weeks times to develop own protective mechanism.

(c) Quality of colostrum

Only feed colostrum with at least 50g/liter of antibody (IgG) by testing with a Brix refractometer or colostrometer. Colostrum with < 50g/L IgG will not provide an adequate protection to the newborn calf. Colostrum should be given to the calf directly after milking the cow for the first

time. Fresh excess colostrum can be stored within one hour of collection in the refrigerator for up to 24 hours and in the freezer (-20 °C) for one year. Frozen colostrum should be thawed slowly in a hot water bath at a temperature of 50 °C. Colostrum should not be fed to calf from dam affected with mastitis, Johne's disease and Bovine virus diarrhea and other diseases.

(d) Frequency of colostrum feeding

The calf should receive multiple colostrum feedings by bottle during the first day of life. Teat feeding with a nipple bottle is best. Use a stomach tube if a calf is unable to bottle or is too weak to consume the full amount of colostrum

(e) Cleanliness

Strict hygiene standards for cleaning and sanitation should be maintained when milking a fresh cow. The udder as well as the milkers should be thoroughly cleaned. Unhygienically collected colostrum can be contaminated and feeding of such colostrum may cause gastro-intestinal infection of newborn calf that may interfere absorption of colostral IgG in the intestine and even may cause enteritis. There is a need to test colostrum for bacteriological count to identify if improvements of colostrum hygiene are needed during collection and storage. Blood IgG antibody levels of calves should be checked to detect that the colostrum has been successfully absorbed to the calf.

Growth rate especially measure live weight at birth and then regularly should be monitored. Colostrum contains growth factors, hormones and other biologically active factors which positively impact the development of the digestive tract. Calves which do not intake and absorb adequate colostrum (IgG antibodies) have lower weight gain, increased risk for disease and death and decreased milk production during their first lactation.

Feeding of milk and milk replacer

The first 3 to 4 months of calf's life is a critical period and the feeding program at this time is important for rapid growth and development of baby calves and reducing death losses. Feeding of whole milk is expensive and milk replacers have been developed to reduce the amount of whole milk used raising calves. Traditionally, whole milk should be fed to calves at 10% of body weight that may be translated into feeding two liters of milk twice daily. Feeding of this two liter of milk does not provide sufficient energy to growing calves. Accordingly, feeding of 15% of calf body weight in whole milk or suitable milk replacer has been suggested. It is a legal requirement to feed calves under 28 days old at least two liquid milk feeds per day. The feeding of correct energy and volume of milk include improved health, growth rates, feed efficiency and lifetime milk performance. The waste milk including antibiotic treated milk, mastitic or high somatic cell count should not be fed to calves. Feeding of these types of waste milk can increase the risk of disease transmission and antibiotic resistance in the calf. The energy requirement of calves less than 3 weeks of age should be met through milk feeding and over 3 weeks of age through a combination of milk, calf starter and forage feeding. Calf should be fed milk at a temperature of 37-39 °C to ensure coagulation in the abomasum. To achieve this, milk should be heated to 40 °C which can also be applied to colostrum and transition milk. Pasteurized milk can also be fed to calf with no antibiotic residues.

Calf milk replacers (CMR)

A good quality CMR should be similar in chemical composition to whole milk. A good quality CMR will contain only milk derived protein (MDP) sources. It should contain the nutrients that calves can digest and in the right proportions. The CMR is generally formulated from by-products of dairy processing, together with animal fats plus added vitamins and minerals. Whole milk powder consists of mainly of 36-40% lactose, 30-40% fat and 28-32% milk protein of DM basis. The by-product of butter making is skim milk which consists mainly of lactose and all the milk proteins but it has only half the energy value of whole milk. Whey, the by-product of cheese making, consists only of lactose, albumin and globulin and is even lower in nutritive value.

The CMR should contain 20 to 27% crude protein and 16 to 20% fat to achieve optimum growth rate (> 900g/day) in early life. Protein sources can be either milk or plant or vegetable proteins. However, the MDP are important for the first 2 to 3 weeks of calf's life because calves aged up to 3 weeks can only digest MDP efficiently. The MDP sources include skim milk powder, whey powder and butter milk powder. Fiber is an indicator of protein quality and protein with less than 0.15% fiber contain milk or egg, whereas fiber levels over 0.20% indicate inclusion of plant proteins. All milk protein include dried whey protein concentrate, dried whey, dried whey product, skim milk, casein and sodium or calcium caseniate whereas alternative plant protein include soy protein isolate, protein modified soy flour, soy protein concentrate, soy flour, animal plasma, wheat gluten and pea protein. Digestibility and subsequent calf growth and feed efficiency are lower with vegetable proteins than with MDP. Soy protein products can contain a variety of anti-nutritional factors that further decrease the digestibility of growing calves.

The CMR should contain 10 to 25% crude fat with 18-20% fat content ideal. Review of research reports show that there is no benefit to feeding CMR with higher than 18% fat content. Calves less than two weeks old cannot digest non-milk fats as well as milk fats. Higher fat CMR may suppress concentrate intake, so may not be suited to systems requiring early weaning. Fat sources should be highly digestible Protein sources are generally classified as either all milk or a portion coming from alternative proteins and preserved with an anti-oxidant. Fats commonly used include tallow, lard, palm and coconut oil. Tallow- a by-product of abattoir, is the most common fat to include because vegetable oils which contain high level of polyunsaturated fats, can cause scouring in calves. Tallow is preferred because it has a similar fatty acid composition to milk fat and is comparatively cheap. Coconut and palm oil have a similar digestibility to milk fat (about 96%).

Ash, vitamins and minerals in CMR should be added as per nutritional requirement and the ash content should not be higher than 8.0% with target ash content of 6.5 to 7.5%. The mineral and vitamins requirement of calves include as calcium 1.0%, phosphorus 0.7%, vitamin A 9,000 iu/kg, vitamin D₃ 600 iu/kg and vitamin E 50 iu/kg.

Calves may be started on a CMR when 2 to 4 days old, but the shift gradually from raw milk to CMR. Abrupt changes will increase the likelihood of nutritional scours and stress. Commercial CMR can be supplied as per direction of the manufacturer's recommendation. When the commercial CMR fed properly, high quality milk replacers will allow calf growth and performance equal or even greater than that attainable with whole milk. The preparation of CMR must be done with care, respecting concentration, water quality, hygiene of mixing and serving

equipment and mixing temperature. A typical milk replacer contains 70-80% milk solids, 17-20% animal and vegetable fats (e.g. tallow), 2% lecithin, traces of minerals (copper, zinc, manganese, cobalt, iron and iodine) and vitamins (A, D, B₁₂, K and E) with added antibiotics or antibacterial drugs.¹⁰⁶⁸ However, adding of antibiotic is discouraged in modernly managed calf rearing.¹⁰⁶⁶

Advantages of CMR

- Advantages include ease of use, biosecurity and economic benefits
- Significantly improve the marketability and profitability of milk
- Grow more healthy calves and significantly reduces risk of disease e.g. Johne's disease, Bovine virus diarrhea and the cost of drugs and veterinary services
- Consistency of products when mixed correctly- less risk of digestive upsets and scours

Disadvantages of CMR

- Lower energy due to fat content compared to take over milk
- Products with plant-based proteins have a lower digestibility in calves less than 3 weeks of age.

Calf starter (Starter concentrate)

The newborn calf has a small undeveloped rumen and it does not contribute to digestion. The purpose of calf starter is to transition the calf from the milk-feeding period to the dry-feeding period. The intake of concentrate and water provide the rumen microbes with the nutrients they need to grow and multiply. Calf starter should be offered to calves starting at 3 days of age. After three weeks of eating starter concentrate, the rumen will have enough microbes to ferment the feed to supply the calf with energy.

Calf starter should be offered from day one and can be provided as a pellet or coarse feed and should be highly palatable to encourage early intake. The particle size of the starter concentrate should be 3 cm pellets and should be larger than 1.19 mm in diameter to avoid ruminal parakeratosis and bloat. It should not be powdery or dusty as this will reduce intake. Calf starter should provide around 18% crude protein to aid microbial growth and promote intake (Table 47). Calves eat only small amounts in the first two weeks but intake begins to increase measurably around 14 days of age.

Forage feed

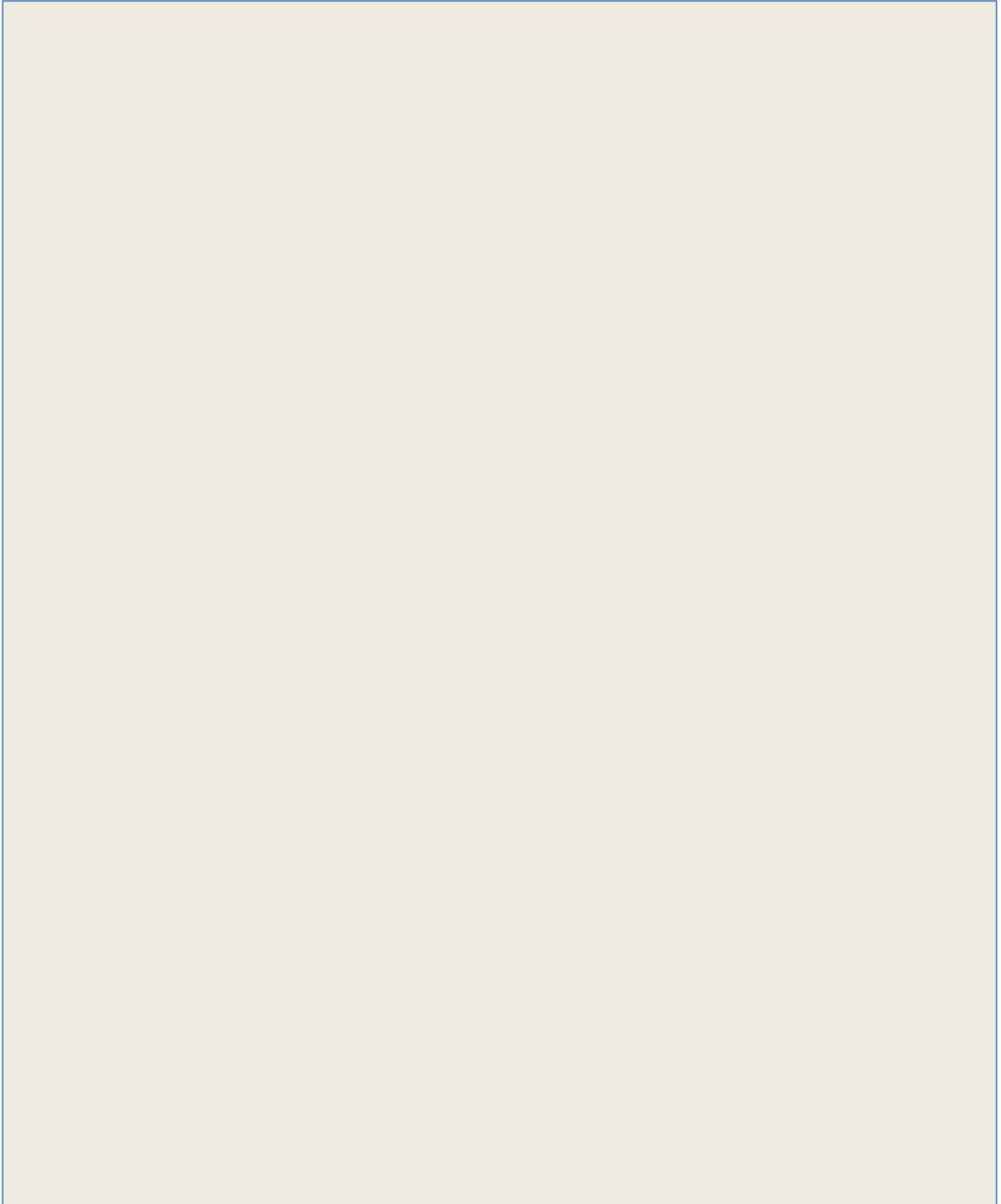
Forages are good source of fiber which promotes the growth of the muscular layer of the rumen and helps maintain the health of the rumen lining. In addition to calf starter, good quality forage should be offered as early as day three. Feed racks and buckets should be located at a height that is suitable for calves and positioned so as to reduce possibility of soiling.

Water supply

Water accounts for 70-75% of a calf body weight and calves will perform best with fresh drinking water available to them from birth. Drinking water is required to support the rumen microbial population and promote good rumen development and function. Fresh water should be provided in addition to milk or milk replacer. Calves will drink 1.0 liter of water per day during the first week of life, increasing to nearly three times by 3-4 weeks of age. Providing drinking water in addition to milk replacer can increase growth by 38% and calf starter intake by 31%. Providing lukewarm water (16-18 °C) during cold weather may stimulate starter intake.

Table 47. Recommended nutrient composition for calf starter ¹⁰⁶⁶					
SN Nutrient	Amount	SN Nutrient	Amount	SN Nutrient	Amount
01. Crude protein, %	16-20	02. Calcium, %	0.7	03. Phosphorus, %	0.45
04. Potassium, %	0.65	05. Copper, ppm	10	06. Zinc (ppm)	40
07. Manganese, ppm	40	08. Cobalt, ppm	0.1	09. Selenium, ppm	0.3
10. Vit. A, iu/lb DM)	1818	11. Vit. D, iu/lb DM	270	12. Vitamin E iu/lb DM)	12

The newborn calf has rudimentary stomach and during the first weeks of life is considered a monogastric animals. The neonatal calf must receive the correct diet based not only in its nutritional requirement but also in what is required for rumen development and transition to a functional ruminant. **Table 48** shows the summary of the different experiments which have been conducted on milk replacers and calf starter with native and cross-bred calves for a period of 90 days.



2011	Effect of feeding shoti based calf milk replacer	A trial research has been conducted under both on-station on-farm condition for the development of cost effective shoti based milk replacer	1082
2020	To evaluate plant sources to develop CMR based growth performance	The shoti and soybean based CMR have been reported to be maintained growth of calves compared to wheat based CMR and milk fed calves.	1083

Plagiarism 1072 & 1073

Composition of calf milk replacer with locally available ingredients

The primary nutrients in milk replacer are protein, fat, carbohydrates, vitamins and minerals. **Table 49** shows the composition of CMR with locally available ingredients. It appears from **Table 47** that shoti and soybean based CMR better compare to wheat based CMR and even milk fed calves. Authors have suggested to use this CMR in the smallholder farms as well as commercial dairy farms and even suggested to utilize this formula for commercial production. However, the plant protein sources are highly discouraged to use for the preparation of CMR as these are associated with digestive disturbances within 3 weeks of age of calves.¹⁰⁶⁶

T1 = Wheat based (n = 6)			T2 = Shoti based (n = 6)			T3 = Soybean based (n = 6)		
SN	Ingredient	%	SN	Ingredient	%	SN	Ingredient	%
1.	Wheat flour	29.0	1.	Shoti powder	39.0	1.	Soy powder	08.0
2.	Soymeal	47.0	2.	Soymeal	50.0	2.	Soymeal	43.0
3.	Rice flour	13.0	3.	Soybean oil	09.0	3.	Rice flour	38.0
4.	Soybean oil	09.0	4.	DCP	01.0	4.	Soybean oil	09.0
5.	DCP	01.0	5.	Common salt	00.5	5.	DCP	01.0
6.	Common salt	00.5	6.	Vita-Min-premix	00.5	6.	Common salt	00.5
7.	Vita-Min-premix	00.5	-	-	-	7.	Vita-Min-premix	00.5
•	Total cost Tk / kg	52.69	•	Total cost Tk./kg	94.45	•	Total cost Tk./kg	51.11
•	Diarrhea	14.0	•	Diarrhea	12.0	•	Diarrhea	08.0

T = Treatment group DCP = Dicalcium phosphate

The overall calf rearing scenario in Bangladesh is still remain in traditional practice in which more than 95% of dairy smallholder farmers overlook the scientific technology on calf management. Moreover, the smallholder and even commercial dairy farmers are permitted to rear their calves by the cows. Calves reared with their dam start grazing and ruminating at approximately three weeks of age and regularly graze with adult cattle at 4 to 6 months of age. These calves are mainly suffering from malnutrition followed by late rumen development, late maturity, late in estrus, decrease conception rate and low milk production that results in economic loss to the farmers. Commercial CMR has been manufactured and marketed in developed nations and even most of the developing countries but it has not yet been developed in Bangladesh.

Navel disinfection

The umbilical cord of a newborn calf is a potential source of infection. During pregnancy, its main purpose is to attach the unborn calf to the dam to provide nutrients. Many blood vessels lead directly from the navel to a calf's organs. If bacteria enter, they have easy access to vital parts of the calf's body. Consequently, as soon as possible after birth, the navel should be dipped in a 7.0% iodine-based solution after proper removal of debris or straw on the navel cord, if any. If more than 5.0% of calves develop navel infections, the calving pen and calf facility may need some deep cleaning and navel disinfection may need to occur more quickly after birth. The navel should be examined regularly for about a week after birth. It should be dry, soft and not painful.

Public health and environment of livestock rearing

Livestock keeping at urbanized areas is increasing folds in rate now-a-days in Bangladesh. Urban livestock rearing practices has been reported to be associated with public health and environmental issues.¹⁰⁸⁶

Culling of dairy cattle

Culling cattle is very important in any cattle operation because a producer gets rid of those animals that are inferior to the genetic qualities of the herd, those that are no longer productive and those that have no value being in the cow herd any more.¹⁰⁸⁷

There are too many definitions have been used for the culling of dairy cattle. Some of them are: The culling is the removal of a live cow from the farm for immediate slaughter and sale is the movement to another farm for future dairy purposes and assumed to exclude temporary ownership by traders who subsequently send animals for slaughter and mortality is the death of an animal on the farm whether euthanized or unassisted. Culling is the act of identifying and removing a cow from a herd and assuming a constant or expanding herd size, replacing the cow with another cow, often a first-lactation heifer.¹⁰⁸⁸ Culling is the departure of cows from the herd due to sale, slaughter or death which has been classified as voluntary or involuntary.¹⁰⁸⁹ Culling (exiting) is the departure of cows from the herd because of sale, slaughter, salvage or death.¹⁰⁹⁰ In most cases the cow that exits is replaced, thus replacement has been a useful synonym for the event. The term 'cull' refers to all cows that leave the dairy regardless of their destination or condition at departure. Some may object to including cows that are sold for dairy purposes as part of a general cull category, as the word 'cull' generally means to separate off for undesirable reasons. Cows removed from the herd is based on the destination of the cows after removal and these can be placed into three groups: (a) Dairy sale- sale in the context of culling means that the cow is sold alive to another dairy with the expressed goal of continuing to provide income, such as producing milk, calves, (b) Slaughter-Salvage- means that the cow left the dairy alive to be slaughtered for human consumption and (c) Death (died, dead)- means that the cow died on the dairy.¹⁰⁹⁰

Cows that involuntary culling implies that cows are culled due to disease, injury, infertility or death whereas the voluntary culling implies low yield or cows surplus to herd requirement when animals are healthy and farmer has complete freedom of choice over which cows are removed from the herd. Culling has also been classified based on reasons as either biological or economic. Biological (forced) culls are those cows for which no possible productive feature exists, like

permanently sterile, irreparably injured, positive for tuberculosis and brucellosis, whereas economic mean that cow is removed because a replacement is expected to produce greater profit.¹⁰⁹¹

Reproduction (e.g., failure to conceive) has been recognized as the primary cause of culling, secondly production and thirdly mastitis in USA.¹⁰⁹² Highest culling has been reported caused by infertility, followed by mastitis in Iran.¹⁰⁹¹ Review of available inland literature reveals that only two articles on culling dairy cattle have been published based on breeds of cattle¹⁰⁹³ and age of cows¹⁰⁹⁴ from BAU Dairy Farm of Bangladesh (Table 51 & 52).

A total of 238 animals have been culled, with annual culled rate 10.50, 7.98, 13.03, 7.56 and 60.92% in Pabna, Sahiwal, Sindhi, Red Chittagong and cross-bred cows respectively. Among all the breeds the highest percentages of culling rates reported in cross bred-cows (Table 51). The highest culling rate recorded in Pabna variety probably due to short lactation period and long calving interval. Red Chittagong cattle showed the second highest percentages in disposal for low production (22.2%). Highest culled rate caused by death due to parasitic diseases have been reported in crossbred (22.0%) in comparison to other breeds (Table 51). Mastitis has been highest in Sahiwal as the first cause for disposal of the animals. Tables 51 and 52 show highest culled rate of dairy cows due to parasitosis (22.0%), followed by pneumonia (13.10%), reproductive disorders (15.2%) and low milk production (8.3%). Table 52 shows that the highest culled rate has been reported in old aged cattle in comparison to other age groups. Dairy farmers should be encouraged to record and monitor disease events and reproductive performance and use these information as the basis for management efforts aimed at reducing the need to replace cows.¹⁰⁹⁰

Manure management and biogas production

Some definition and terminologies related to manure which include: **manure**- broadly refers to dung of farm animals and poultry, either sole or added with urine, waste water, feed waste, litter / bedding materials, **animal slurry** is the manure of feces, urine, waste water and sometimes feed residues and bedding materials, which contain variable moisture contents 90 to 95%, **bio-slurry** is the semisolid by-products from biogas plant after anaerobic digestion of manure, **composting** is a manure treatment system which can be used to produce a stabilized product that is free from odor, harmful coliforms and fly problems, and **biogas** which is produced through anaerobic digestion of biological materials including livestock manure. Farm animals annually produce about 151.3 million tons of fresh manure, of which 3.08 tons/ year is produced under Milk-vita areas and other commercial farms in Bangladesh. Traditional management system of manure is considered as waste that pollutes air, water and soil that poses a threat to public health. The cattle manure is usually managed as (a) solid storage (56.2%), (b) liquid slurry (1.65%), (c) burned fuel (37.3%) and (d) anaerobic digester (4.80%) in Bangladesh.¹⁰⁹⁵

Livestock manure pollutes environment through emitting greenhouse gases (GHGs) estimated to be 9.5% of the total of livestock origin.¹⁰⁹⁶ It has been reported that 56.2 to 57.0% manure of large ruminants is kept in solid storage, 37.3 to 43.0% as burned fuel, 4.8% is used in anaerobic digestion and 1.65% is lost as liquid slurry.¹⁰⁹⁷ The total annual methane emission from manure is estimated to be 176.75 Gg and emission from cattle manure 87.85% in Bangladesh.¹⁰⁹⁷ The

cattle dung, poultry litter and town cattle market straw have been reported to produce biogas yields of 0.034, 0.030 and 0.142 m³ / kg with methane concentrations of 60%, 62% and 74% respectively.¹⁰⁹⁸

Bangladesh remains far behind its neighbor countries in developing biogas as an alternative to conventional fuel. India has established 4.0 million biogas plants, 8.0 million in China and 80,000 in Nepal whereas it is only 10,000 in Bangladesh.¹⁰⁹⁹ Cattle dung available from 22 million large ruminants is nearly 0.22 million tons. One tone dung can produce 37 m³ of biogas. Available cattle dung can produce 2.97 × 10⁹ m³ of gas which is equivalent to 1.52 × 10⁶ ton kerosene or 3.04 × 10⁶ tons of coal.¹¹⁰⁰

The dung is mixed with water in equal ratio and stored in a tank. After 10 to 12 days biogas is produced in the plant which is supplied to the ovens through plastic pipes.¹⁰⁹⁹ Biogas is a combustible gas produced by anaerobic digestion (AD) and fermentation of organic materials by the action of methanogenic bacteria in a wet process: the dung is mixed with water and left to ferment in an enclosed vessel. The resultant gas which is emitted is mainly composed of methane (60-70%) and carbon dioxide (30 to 40%)- a very similar composition to piped gas in towns, which is derived from fossil fuels. Methane based gas produces more heat than kerosene, fuel wood, charcoal and dung-cake.¹¹⁰¹

Limited inland research reports on biogas production and management system has been published from Bangladesh.¹¹⁰²⁻¹¹⁰⁴ An investigation study showed that 85% biogas plants are functioning at full capacity whereas 15% are not functioning at all in the district of Tangail.¹¹⁰⁵ A designed project has been suggested to produce 18 MW electricity and 72 ton bio-fertilizer annually from biogas in Bangladesh.¹¹⁰⁶ Biogas technology is one of the best means to provide natural gas to the largest number of rural people which can provide them with pollution free, efficient energy for cooking and at the same time protect them from dung-borne diseases by giving them a clear environment.

Miscellaneous research findings

Design of an ideal stanchion dairy barn,¹¹⁰⁷ participation of rural people in cattle management,¹¹⁰⁸ non-genetic effects on birth weight,¹¹⁰⁹ colostrum and transition milk,¹¹¹⁰ effect of parity on calving pattern,¹¹¹¹ influence of season on birth,¹¹¹² sex ratio of calves,¹¹¹³ genetic lift in the birth weight,¹¹¹⁴ growth curves of local × Jersey,¹¹¹⁵ body weight and milk yield,¹¹¹⁶ milk production trend and F1 crossbred cows of Milk-vita,^{1117,1118} chemical and microbial qualities of morning and evening milk,¹¹¹⁹ lactation milk record,¹¹²⁰ milk yield and composition of RCC,^{1121,1122} relationship of milk vein and milk production,¹¹²³ nutritional content and bacteriological contamination and analysis of milk,^{1124,1125,1126} evaluation of fermented milk-wheat flour,¹¹²⁷ preparation of fermented beverage from whey-based watermelon,¹¹²⁸ utilization of whey in fermented and non-fermented drinks,¹¹²⁹ preservation of butter,¹¹³⁰ lactic acid bacteria in dahi,¹¹³¹ limitation of crossbreeding,¹¹³² comparison of dairy traits of crossbred cows,¹¹³³ variation of morphological features and growth of Pabna cattle,¹¹³⁴ supplementation of fish meal on growth and reproductive performance,¹¹³⁵ production of cowpea forage,¹¹³⁶ maize fodder production,¹¹³⁷ identification of naturally available forage species,¹¹³⁸ importance of vitamin A in dairy cattle,¹¹³⁹ productive and reproductive performance of dairy cows,¹¹⁴⁰⁻¹¹⁴⁹ genetic and phenotypic parameter on fertility traits,^{1150,1151} genotype and environment interaction in growth

Cattle production, management and dairy products

trait,¹¹⁵² genetic evaluation of BLRI cattle,¹¹⁵³ breeding soundness of stud bulls,¹¹⁵⁴ evaluation of semen of Brahman bulls,^{1155,1156} AI and pregnancy rate,¹¹⁵⁷ suitability of temperature and tropical crossbred of cattle,¹¹⁵⁸ cow feces for *in vitro* digestibility assay of forages,^{1159,1160,1161} *in vitro* digestibility of hay,¹¹⁶² wheat bran supplementation in native bulls,¹¹⁶³ feeding of urea-molasses straw based diet,^{1164,1165,1166} urea-molasses multi-nutrient blocks in rural cattle,¹¹⁶⁷ lime treated rice straw,¹¹⁶⁸ moringa oleifera leaf as protein supplement,¹¹⁶⁹ frequency of feeding on growth and carcass characteristics,¹¹⁷⁰ psychrophilic bacteria in dairy barns,¹¹⁷¹ livestock credit,¹¹⁷² profitability of loaned dairy farms,^{1173,1174} livestock technology¹¹⁷⁵ and biotechnology,¹¹⁷⁶ matching technology in flood affected area,¹¹⁷⁷ urine collecting device,¹¹⁷⁸ evaluation of milk urea nitrogen,¹¹⁷⁹ manure yield by cattle and buffalo,¹¹⁸⁰ preparation of hygienic compost,¹¹⁸¹ garbage waste induced heavy metals on roaming cattle,¹¹⁸² statistical analysis of some economic traits of cattle,¹¹⁸³ indigenous knowledge on livestock practices,¹¹⁸⁴ and quality of chocolate milk made of different source of fat and solid-not-fat.¹¹⁸⁵

Limitations due to inappropriate data and plagiarism

Review of inland published reports on cattle production, management and dairy products reveals that the repetition of research works have been practiced, moreover multiple articles have been published with same data or in duplicate in the same and different journals especially feeding practices of draught animals,^{81,82} cow feces has been used as a source of microorganisms for *in vitro*³⁰⁴ and *in vivo*^{307,312} digestibility, reproductive parameters of L × HF cows,^{752,753} feeding schedule of different groups of calves from birth to 90 days of age^{1072,1073} and same dairy farm data published as breed-wise¹⁰⁹³ and age-wise¹⁰⁹⁴ culling of dairy cattle in different journals. Authors, reviewers, editors, academicians, readers and science community need a more caution approach to deal these types of articles. This article at least would help to identify the future plagiarism on the submitted articles before publication in different journals.

CONCLUSIONS

The status of cattle breeds and varieties with their characteristics, productive and reproductive performances, feeds and fodder production, fattening of cattle and beef production and milk production and milk products, semen collection and crossbreeding by AI, economics of dairy farming and calf rearing with milk replacer and calf starter have been reviewed. It appears from this review that HF × L crossbred cows has been suggested for highest profit, feeding of German fodder for maximum milk production, AI at the mid-cycle (12 to 15 hours) for highest CR (80.36%) and higher birth weight in male calves than female calves.

ETHICAL APPROVAL

This review article does not contain any research studies with animals or human participants performed by the author. Therefore, ethical approval is not required for this review article.

CONFLICT OF INTEREST

The author declares that this review work was completed without any commercial or financial relationships that could be construed as a potential conflict of interest.

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