STUDIES ON THE MEAT QUALITIES AND MEAT POTENTIALITIES OF BUFFALO CALVES

BY
THACHANAT GOPALAN RAJAGOPALAN

THESIS
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Faculty of Veterinary and Animal Sciences
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Department of Physiology
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
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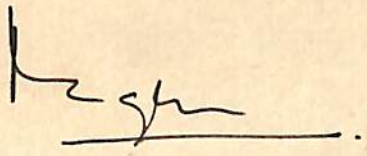
DECLARATION

I hereby declare that this thesis entitled "STUDIES ON THE MEAT QUALITIES AND POTENTIALITIES OF BUFFALO CALVES" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.



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T.G.Rajagopalan

CERTIFICATE

Certified that this thesis entitled "STUDIES ON THE MEAT QUALITIES AND POTENTIALITIES OF BUFFALO CALVES" is a record of research work done independently by Sri.T.G.Rajagopalan under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Dr. G.Nirmalan
Professor
(Chairman, Advisory Committee)

Mannuthy,
27-7-81

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T.G.RAJAGOPALAN

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CHAPTER I

GENERAL INTRODUCTION

"The greatest problem facing mankind is not nuclear warfare, pollution, taxes or inflation. Instead it is the problem of what to eat" (Campbell and Lasley, 1977).

Malnutrition is the foremost health problem facing nearly 641 million people of India. It adversely affects the mental and physical development, productivity, the span of working hours and ultimately the economic potential of man.

India is confronted with an increasingly severe protein shortage that threatens much of its present and future population. The material and human resources required to arrest this impending protein crisis are

indeed large. But, the current trends do not indicate that the situation will improve in the near future.

The present population of breeding buffaloes in the country is estimated to be about 40 million which may produce about 10 million calves each year (Ranjan, 1980). It is quite paradoxical that, on the one hand, we are extremely short of animal protein in our country and on the other hand, about five million male buffalo calves are allowed to die without any economic contribution thereby loosing about 6000 tonnes of valuable animal protein every year.

With better management and feeding, this species of farm animal can contribute much towards the increased availability of meat in the protein deficient diets of our countrymen. The exploitation of buffaloes to meet the present and long term future requirement of meat for the rapidly growing population of our country deserves special emphasis because of the remarkable capacity of buffaloes to convert the poor quality feed into appreciable muscle growth economically under our agro-climatic conditions.

Data pertaining to the quality of buffalo meat and

its potentiality as a source of animal protein are scanty and scattered. This study has been undertaken to find out the suitability of buffaloes as a source of animal protein.

CHAPTER II

MEAT POTENTIALITIES OF BUFFALO CALVES

Growth is characterised primarily by an increase in the levels of protein, mineral matter and water in tissues and necessitates the consumption of energy producing nutrients. A nutritional regime can be considered as optimal if it enables the organisms to take full advantage of its heredity. It had been established that severe and prolonged undernutrition during infancy leads on to stunted growth.

A significant portion of the nutritional intake is utilised for the maintenance of the animal. The ability of an animal to consume and utilise feed, over and above its maintenance needs, decides the net income

from feeding during growth.

Schloss (1911) defined growth as the correlated increase in the mass of the body in definite intervals of time, in a way characteristic of the species. Brody (1945) observed that each animal has an inherent natural body size towards which it grows at a genetically controlled rate.

In farm animals during the post-natal stages of growth, the increase in live-weight was much more appreciable compared to other linear body measurements (Brody and Ragsdale, 1924; Hammond, 1932; Sussman, 1963; Grizzle and Allen, 1969; Kowalski and Guire, 1974; Finney, 1978).

The values for the weights of buffalo calves, from birth to twelve months of age, reported by earlier workers, have been compiled and presented in Table II.1.

Table II.1. Literature data for average body weights (kg) of buffalo calves from birth to twelve months of age

a) Indian breeds of buffalo

Age in months	Indian buffalo average value	Murrah	Indian buffalo average value	Murrah	Murrah graded
1	2	3	4	5	6
at birth	31.1*	28.5	26.1	29.4	29.3
1	35.8*	38.8	47.8	..	..
2	..	46.7	..	..	..
3	..	56.4	93.2	77.7	76.7
4	..	66.3	..	..	..
5	..	76.0	..	..	..
6	48.2*	83.9	144.5	127.1	125.4
7	..	..	..	..	..
8	..	..	..	..	..
9	..	..	..	..	..
10	..	..	..	..	..
11	..	..	..	..	..
12	237.1*	141.9	224.1	212.6	211.1
Reference	Tomar and Desai (1965)	Kotayya and Rao (1972)	Rathi et al. (1973)	Johiri (1976)	Johiri (1976)

*converted

Table II.1. (continued)

a) Indian breeds of buffalo

Age in months	Nili	Nili graded	Indian buffalo average value	Surti	Murrah
	7	8	9	10	11
at birth	30.5	29.9	29.4	26.3	27.2
1	..	..	..	35.2	44.4
2	..	..	..	46.8	63.4
3	85.9	81.2	71.1	59.7	86.3
4	..	..	..	63.8	..
5	..	..	..	67.9	..
6	141.7	131.6	..	72.0	123.4
7	..	..	..	77.0	..
8	..	..	..	81.4	..
9	176.9	166.8	..	86.4	171.8
10	..	..	..	96.7	..
11	..	..	..	103.2	..
12	219.3	205.6	..	112.0	217.9
Reference	Johiri (1976)	Johiri (1976)	Nautiyal and Bhatt (1977)	Basaviah (1977)	Nagarcenkar (1978)

Table II.1. (continued)

a) Indian breeds of buffalo

Age in months	Indian buffalo average value	Murrah	Surti	Indian buffalo average value
	12	13	14	15
at birth	30.1	32.2	27.1	33.4
1	..	40.8	..	..
2	..	51.2	..	..
3	76.3	60.6	..	67.0
4	..	75.7	..	..
5	..	88.7	..	..
6	126.0	107.9	81.8	115.9
7	..	..	..	..
8	..	..	..	..
9	170.2	131.8	..	..
10	..	..	..	..
11	..	..	..	..
12	213.4	170.1	..	..
Reference	Bhatt (1978)	Balla et al. (1978)	Venkateswar and Sampath (1978)	Deshmukh and Gill (1980)

Table II.1. (continued)

b) Exotic breeds of buffaloes

Age in months	Buffaloes of Trinidad	Buffaloes of Near East	Buffaloes of Latin America	Buffaloes of Italy	Buffaloes of Egypt
1	2	3	4	5	6
at birth	..	..	33.6	41.4	40,9
1	..	..	..	..	..
2	..	74.0	..	97.8	..
3	..	..	..	..	121.6
4	..	..	..	..	..
5	..	..	..	..	..
6	195.0	157.0	..	178.5	155.5
7	..	..	..	..	..
8	..	..	..	..	..
9	253.0	..	..	237.6	..
10	..	..	..	..	..
11	..	..	..	..	..
12	299.0	230.3	181.0	297.1	221.6
Reference	Benet (1964)	Mullick (1964)	Cockrill (1974)	Salerno (1974)	Ragab (1978)

The rate at which an animal grows to attain the mature size is of great economic importance to the livestock owner. A close correlation between rapid growth and good life-time performance had been reported by Hammond (1955).

Increase in the mass of the body as a whole can be expressed in absolute terms as grammes per day or as a percentage of original mass at the start of the experiment. The rate and character of body mass increase vary with age and with species.

The rate of growth of buffaloes reported by earlier workers has been presented in Table II.2.

Table II.2. Average daily gain and total gain up to 6-12 months of age in male buffalo calves

Breed	Total gain up to 12 months (kg)	Average daily gain up to 6 months (g)	Average daily gain up to 12 months (g)	Reference
a) Indian breeds				
Indian buffalo	207.4	102	568	Tomar and Desai (1965)
Murrah	112.5	307	308	Kotayya and Rao (1972)
Indian buffalo	195.0	641	534	Rathi et al. (1973)
Murrah	183.1	543	502	Johiri (1976)
Murrah graded	181.8	534	498	Johiri (1976)
Nili	188.7	618	517	Johiri (1976)
Nili graded	175.6	565	418	Johiri (1976)
Indian buffalo	185.8	..	509	Nautiyal and Bhatt (1977)
Surti	85.6	253	234	Basaviah (1977)
Murrah	190.5	533	522	Nagarcenkar (1978)
Murrah	183.3	532	502	Bhatt (1978)
Murrah	152.2	358	417	Ranjan (1980)
Surti	85.5	252	234	Ranjan (1980)

Table II.2. (continued)

Breed	Total gain up to 12 months (kg)	Average daily gain up to 6 months (g)	Average daily gain up to 12 months (g)	Reference
b) Exotic breeds of buffaloes				
Latin American	147.4	..	403	Cockrill (1974)
Italian	255.7	761	700	Salerno (1974)
Egyptian	180.7	436	367	Ragab (1978)

Body size measurements can also be employed to study the growth of the body as a whole. Body measurements reported in literature for adult female buffaloes are tabulated in Table II.3.

Table II.3. Body measurements of adult female buffaloes

	Breeds			
	Yugoslavian	Rumanian	Italian	Bulgarian
Height at withers (cm)	120	134	136	130
Body length (cm)	126	143	150	150
Girth (cm)	175	189	208	190
Reference	Popovic (1949)	Rosa and Rusu (1958)	Ferrara (1964)	Ivanov and Zachariew (1963)

In the present work an attempt has been made to assess the growth of buffaloes by periodically recording the body weight as well as the body measurements.

MATERIALS AND METHODS

Growth studies were carried out on eleven male buffalo calves born and brought up at the Kerala Agricultural University buffalo project.

These animals were housed in conventional well-ventilated and lighted cattle sheds with cement concrete flooring and tile roofs.

Calves were given complete milk feed up to 3 months of age, the quantity being gradually reduced with concentrate supplementation and totally stopped by fourth month of age, and thereafter switched over completely to a commercial concentrate mixture, and green grass or silage according to availability. The concentrate ration was fixed in excess of requirements,

based on Morrison standards (Morrison, 1954). Fodder and water were given ad libitum.

The animals were weighed at birth and thereafter at monthly intervals in a platform balance (sensitivity ± 200 g). Linear measurements, as described by Brody (1945), were taken at birth and thereafter at monthly intervals.

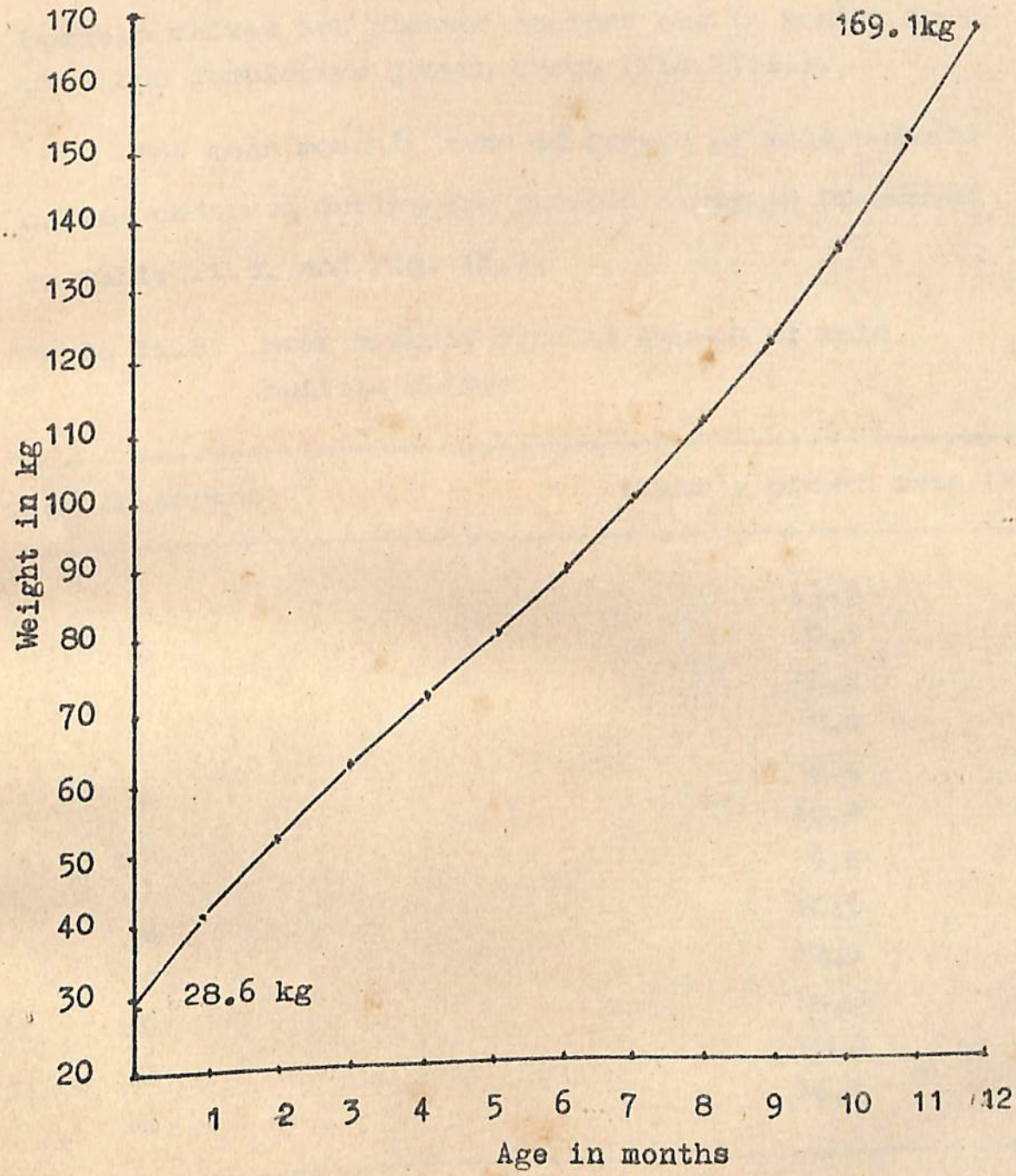
RESULTS

The values for mean monthly body weights of male buffalo calves up to 12 months of age are presented in Table II.4.

Table II.4.. Mean monthly body weight of male buffalo calves from birth to 12 months of age

Age in months	Average weight (kg)	SE	CV %
at birth	28.6	2.9	26.6
1	42.0	0.9	9.1
2	52.5	1.7	15.9
3	63.6	1.6	17.8
4	70.6	1.7	18.2
5	79.0	1.3	15.5
6	89.9	1.5	17.4
7	99.5	1.6	18.2
8	110.4	1.0	11.4
9	122.5	1.5	16.9
10	136.5	1.4	15.8
11	152.5	1.3	15.1
12	169.1	1.9	22.0

Fig. II.1. Cumulative growth curve of male buffalo calves


170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
Weight in kg
169.1kg
28.6 kg
1
2
3
4
5
6
7
8
9
10
11
12
Age in months

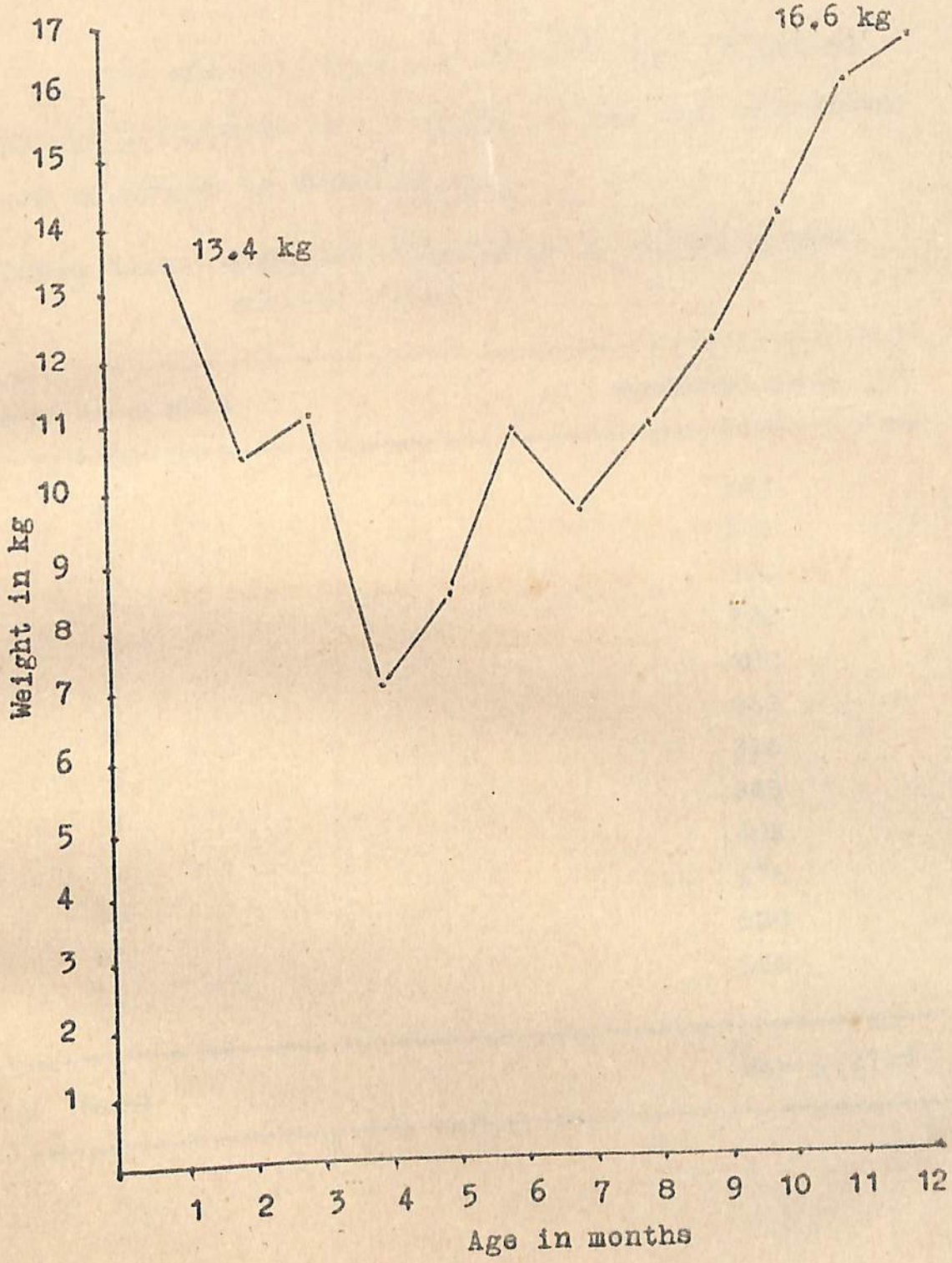
The values for the mean body weight of male buffalo calves are plotted against age in months to give the cumulative growth curve (Fig.II.1.).

The mean monthly rate of growth of male buffalo calves observed during the present study is presented in Table II.5. and Fig. II.2.

Table II.5. Mean monthly rate of growth of male buffalo calves

Age in months	Monthly growth rate (kg)
1	13.4
2	10.5
3	11.1
4	7.0
5	8.4
6	10.9
7	9.6
8	10.9
9	12.1
10	14.0
11	16.0
12	16.6
Mean	11.7 ± 0.8

Fig. II.2. Mean monthly growth rate of male buffalo calves


16.6 kg
13.4 kg
Weight in kg
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1 2 3 4 5 6 7 8 9 10 11 12
Age in months

The absolute gain in weight during different months from birth to 12 months of age was calculated and presented in Table II.6.

Table II.6. Absolute daily gain in weight in male buffalo calves

Age in months	Absolute gain (g)
1	443
2	346
3	370
4	230
5	280
6	363
7	316
8	363
9	403
10	476
11	520
12	550
Mean	388 ± 27.5

The growth rate of male buffalo calves expressed as percentage of the previous month's weight is presented in Table II.7.

Table II.7. Growth rate of male buffalo calves

Age in months	Percentage growth rate
1	46.7
2	24.9
3	21.1
4	10.9
5	11.9
6	13.0
7	10.5
8	10.0
9	10.9
10	11.4
11	11.7
12	10.8

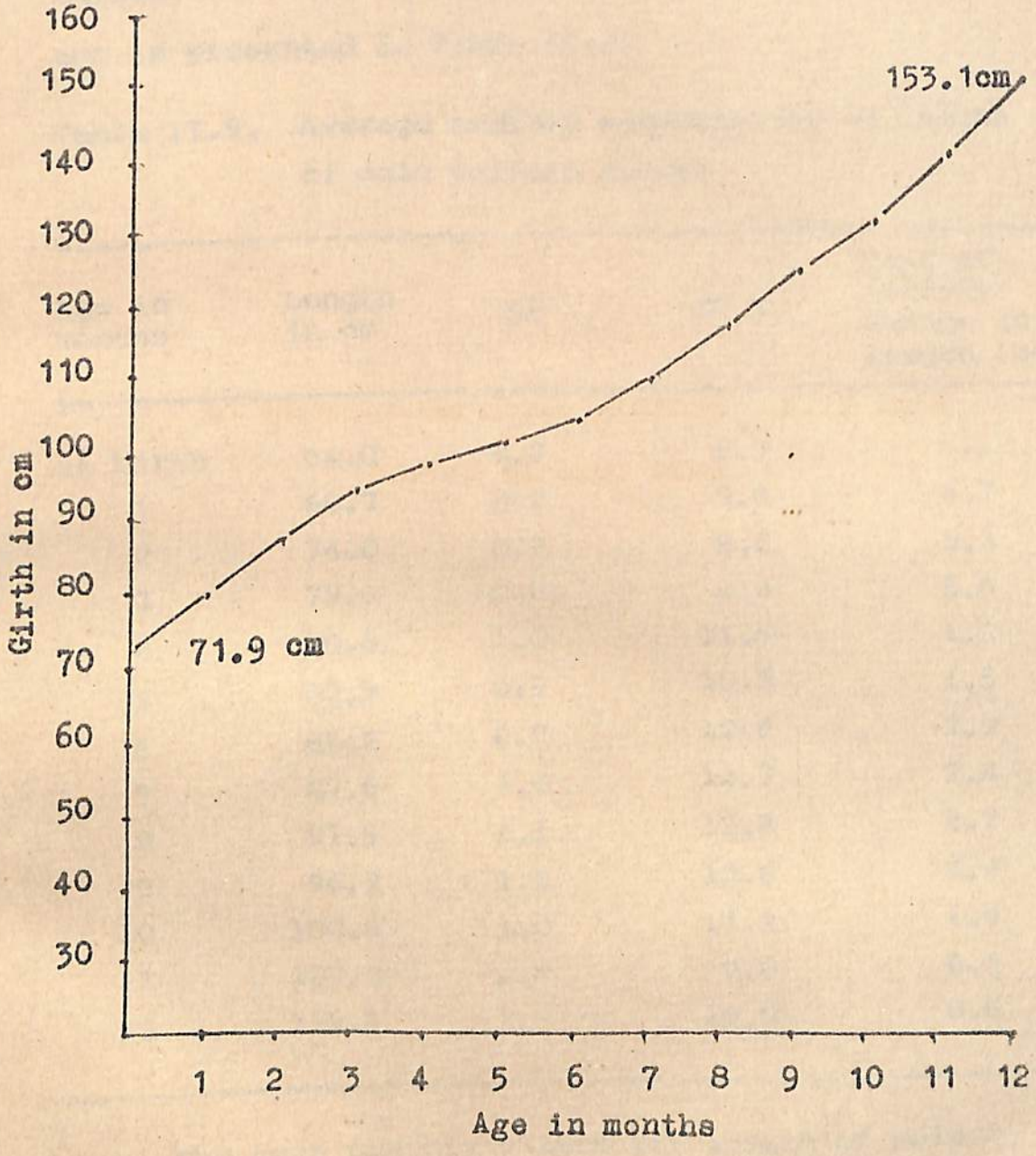
Mean monthly girth measurements of male buffalo calves from birth to 12 months of age are presented in Table II.8.

Table II.8. Average monthly increase in girth of male buffalo calves

Age in months	Girth in cm	SE	CV %	Monthly rate of change of girth (cm)
at birth	71.9	0.5	5.3	..
1	79.5	1.3	12.2	7.6
2	87.2	1.6	11.1	7.7
3	95.1	1.1	11.1	7.9
4	98.0	1.2	15.4	2.9
5	101.5	1.5	17.1	3.5
6	105.3	1.1	12.8	3.8
7	110.1	1.2	15.2	4.8
8	117.8	1.2	13.9	7.7
9	125.5	1.2	13.9	7.7
10	133.6	1.8	20.0	8.0
11	142.6	2.1	24.7	9.0
12	153.1	2.2	24.8	10.5

The mean monthly values for the girth measurements of the animals are plotted against the age in months (Fig. II.3.).

Fig. II.3. Monthly girth measurement of male buffalo calves


160
150
140
130
120
110
100
90
80
70
60
50
40
30
Girth in cm
153.1cm
71.9 cm
1 2 3 4 5 6 7 8 9 10 11 12
Age in months

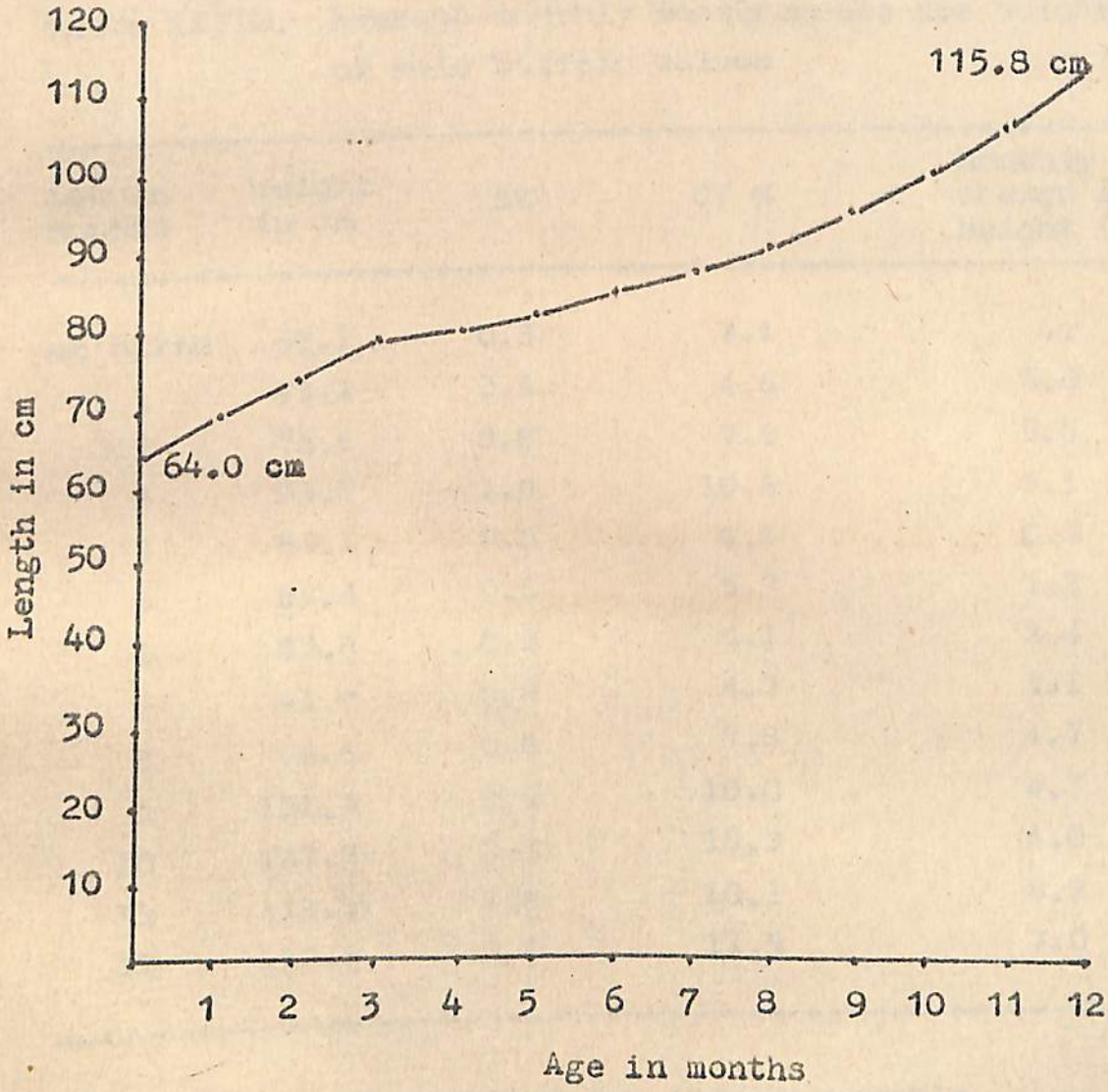
Average monthly increase in length of male buffalo calves recorded from birth to 12 months of age is presented in Table II.9.

Table II.9. Average monthly measurements of length of male buffalo calves

Age in months	Length in cm	SE	CV %	Rate of monthly change in length (cm)
at birth	64.0	0.9	8.7	..
1	68.7	0.9	9.8	4.7
2	74.0	0.9	8.8	5.3
3	79.6	0.8	8.4	5.6
4	80.8	1.0	11.6	1.2
5	82.3	0.9	10.5	1.5
6	85.2	0.9	10.9	2.9
7	87.6	1.0	11.7	2.4
8	91.8	1.1	12.9	4.2
9	96.2	1.1	12.6	4.4
10	100.8	1.0	11.2	4.6
11	107.2	0.8	9.0	6.4
12	115.8	1.4	16.0	8.6

The mean monthly values for length of male buffalo calves are plotted against the age in months (Fig. II.4.).

Fig. II.4. Mean monthly length of male buffalo claves


120
110
100
90
80
70
60
50
40
30
20
10
Length in cm
115.8 cm
64.0 cm
1
2
3
4
5
6
7
8
9
10
11
12
Age in months

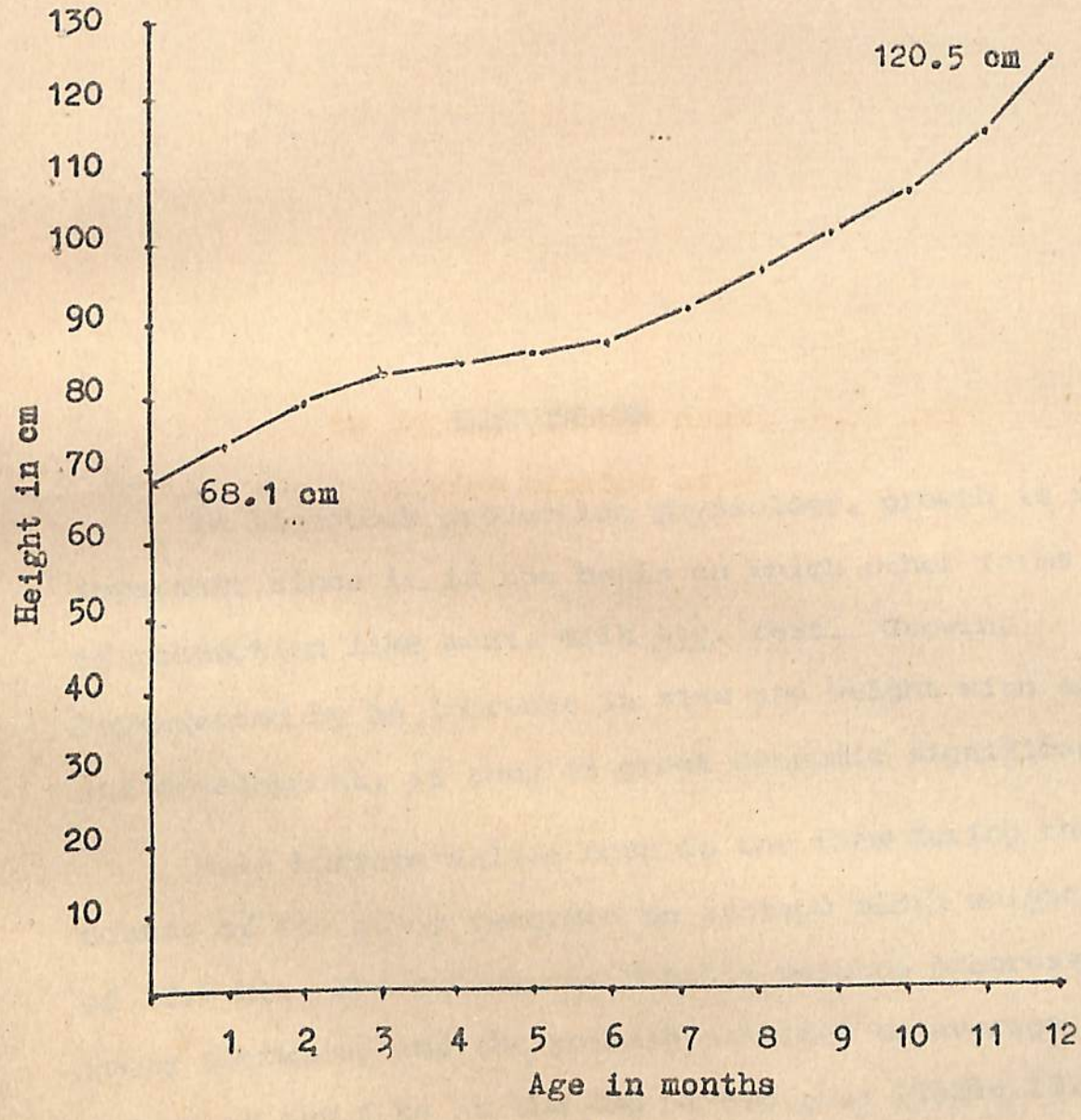
Mean monthly values for height of male buffalo calves from birth to 12 months of age are presented in Table II.10.

Table II.10. Average monthly measurements for height of male buffalo calves

Age in months	Height in cm	SE	CV %	Monthly change in height (cm)
at birth	68.1	0.3	3.1	..
1	73.1	0.5	4.6	5.0
2	78.6	0.8	7.6	5.5
3	83.7	1.0	10.5	5.1
4	84.1	0.5	6.1	0.4
5	85.4	0.5	5.7	1.3
6	87.8	0.3	4.1	2.4
7	91.9	0.4	4.7	4.1
8	96.6	0.6	7.3	4.7
9	101.3	0.9	10.0	4.7
10	107.3	1.3	15.3	6.0
11	113.5	1.6	18.1	6.2
12	120.5	1.0	11.5	7.0

The values obtained for average monthly measurements for height of animals are plotted against the age in months (Fig. II.5.).

Fig. II.5. Mean monthly height of male buffalo calves


130
120
110
100
90
80
70
60
50
40
30
20
10
Height in cm
120.5 cm
68.1 cm
1
2
3
4
5
6
7
8
9
10
11
12
Age in months

DISCUSSION

In livestock production physiology, growth is very important since it is the basis on which other forms of production like meat, milk etc. rest. Growth, represented by an increase in size and weight with age and development, is thus of great economic significance.

Male buffalo calves born in the farm during the course of the study recorded an average birth weight of 28.6 kg. The subsequent monthly weights progressively increased and the animals attained an average weight of 169.1 kg at the end of one year (Table II.4; Fig. II.1.). The rate of growth is related to a certain extent on the final mature weight of the animal. The animals studied in the experiment were all Surti

cross-breds and so the low birth weight and rate of gain observed in this investigation could be attributed to the reduced mature weight of the Surti breed.

The birth weight observed during this study is in agreement with the report of Kotayya and Rao (1972) in Murrah buffaloes. However, Basaviah (1977) had observed a lower birth weight (26.3 kg) and weight at one year (112.0 kg) in Surti breed of buffaloes.

The birth weight as well as the subsequent weights up to 12 months of age and the twelfth month weight recorded in the present study are lower than those recorded by Johiri (1976), Nagarcenkar (1978), Bhatt (1978) and Balla et al. (1978) in Indian breeds of buffaloes and by Benet (1964), Mullick (1964), Cockrill (1974), Salerno (1974) and Ragab (1978) in exotic buffaloes.

As had been stated before, the lower birth weight and the weight at twelfth month recorded in the present study may be due to the predominant Surti blood of the foundation stock.

During the first month, the animals recorded a gain of 13.4 kg. The rate of growth thereafter

recorded a declining trend to 8.4 kg in the fifth month and later gradually increased to 16.6 kg in the twelfth month, thereby giving an overall average of 11.70 ± 0.8 kg up to 12 months of age (Table II.5.; Fig. II.2.).

Similarly, the absolute gain also showed a declining trend from 443 g in the first month to 280 g in the fifth month and thereafter gradually increased to 550 g at the twelfth month (Table II.6.).

The rate of growth and daily gain observed in this study were lower than those reported by Tomar and Desai (1965), Rathi et al. (1973), Cockrill (1974), Salerno (1974), Nautiyal and Bhatt (1977), Nagarcenkar (1978), Bhatt (1978), Balla et al. (1978) and Ragab (1978).

However, the values obtained in the present study were higher than those reported by Kotayya and Rao (1972) and Basaviah (1977) who observed a lower rate of growth and daily gain in male buffalo calves.

Data for the percentage growth rate revealed a declining rate as the age advanced (Table II.7.). This is only to be anticipated since the rate of formation of tissue shows a decrease with advancing age.

No attempt was made in the present work to determine the rate of bone growth, muscle formation and fat deposition. Hence, it is not possible to specify the causative agent for the growth pattern studied. In cattle, growth impetus of muscle and fat is reported to be higher than that of bone.

Male buffalo calves showed an average monthly increase of 6.8 ± 0.3 cm in the girth (from 71.9 cm at birth to 153.1 cm at 12 months of age), 4.3 ± 1.0 cm in length (from 64.0 cm at birth to 115.8 cm at 12 months of age) and 4.4 ± 0.6 cm in height (from 68.1 cm at birth to 120.5 cm at 12 months of age).

It appears from the data gathered that there is an appreciable depression in the rate of growth, in terms of weight, girth, length and height from the fourth month to the eighth month.

An initial reduction in the rate of growth during the first two months is normally anticipated as the calf is subjected to a change from the prenatal to the postnatal stage of life. The decline at fourth and fifth months may be attributed to the switch over from milk feed to complete concentrate and roughage

ration, as the calves need time to adapt to the changed nutritional regime. The animals recovered from the depressive trend gradually by the ninth month of age. The rumen had also attained full functional development at this time and the animals had fully acclimatised to the new regime of feeding. It appears from the data collected that the growth can be assessed truly by recording periodically the body weight along with the linear body measurements, recording of either one of the parameters alone being less effective.

CHAPTER III
MEAT CHARACTERISTICS

In many countries where buffaloes are bred, the meat is generally considered as a by-product of animals slaughtered in emergencies or on completion of their working or milking usefulness. Calves not needed for replacement are very rarely utilized for fattening. Buffaloes are known to convert poor quality ration into remarkable muscle mass.

The carcass tissue consists of muscle, fat and bone. Muscle is the one that is most sought for by customers. An acceptable proportion of fat combined with lean makes the best saleable meat.

The average values for carcass characteristics of buffalo and cattle, as reported by early workers, are presented in Table III.1., and the average values for percentage weight of internal organs in Table III.2.

Table III.1. Average values for carcass characteristics of buffaloes and cattle

a) Dressing percentage

Description	Dressing percentage	Reference
1	2	3
18 month male buffalo	49.3	Maymone (1942)
18 month female buffalo	49.3	Maymone (1942)
Adult female buffalo	47.7	Maymone (1942)
Male buffalo 6-12 months	45.0	Maymone (1945)
Male buffalo 12-18 months	47.0	Maymone (1945)
Adult male buffalo	52.0	Maymone (1945)
Italian adult buffalo	48.5	Salerno (1948)
Italian adult buffalo	45.3	Salerno (1948)
30-40 day old buffalo	65.7	Badruldin (1955)
Iraqi buffalo	48.4	Kassir et al. (1969)
Adult buffalo	50.8	Charles et al. (1970)
Bulgarian buffalo	53.7	Ognjanovic et al. (1970)
Murrah buffalo	54.6	Ognjanovic et al. (1970)
Bulgarian Murrah cross	54.1	Ognjanovic et al. (1970)

Table III.1. (continued)

Description	Dressing percentage	Reference
Adult buffalo	55.4	Charles and Johnson (1972)
Adult male buffalo	48.5	Cockrill (1974)
Castrated adult buffalo	48.2	Cockrill (1974)
Yearling buffalo	45.6	Cockrill (1974)
Murrah buffalo	50.5	Sarma et al. (1978)
Iraqi cattle	51.2	Kassir et al. (1969)
Adult cattle	55.8	Charles et al. (1970)

Table III.1. (continued)

(b) Other characteristics

Description	Slaughter weight (kg)	Warm carcass weight (kg)	Chilled carcass weight (kg)	Transit loss (%)
Thai buffalo	417.5	..	..	..
Egyptian buffalo calf	30.3	..	..	..
Egyptian adult buffalo	449.0	..	..	..
Adult buffalo	300.0	..	129.4	..
Bulgarian buffalo	362.2	..	194.6	..
Murrah buffalo	365.8	..	200.0	3.6
Bulgarian Murrah cross	387.8	..	209.5	2.1
Adult buffalo	314.0	..	170.0	3.3
Adult buffalo	542.6	263.2	..	..
Castrated buffalo	524.2	252.8	..	..
Yearling buffalo	279.5	127.5	..	..
Adult buffalo	..	138.4	..	..
Murrah buffalo	241.7	122.1	..	..
Young buffalo (Roughage ration 85% NRC)	230.0	..	93.2	..
Young buffalo (75% roughage, 25% concentrate, 85% NRC)	306.0	..	159.7	..
Adult cattle	343.0	..	180.9	..
Adult cattle	..	137.7	..	..

Table III.1. (continued)

(b) Other characteristics

Description	Percentage meat	Percentage bone	Percentage fat	Reference
Thai buffalo	78.8	21.2	..	Buranamanas (1963)
Egyptian buffalo calf	32.6	9.9	5.6	Ragab et al. (1968)
Egyptian adult buffalo	33.7	7.8	6.1	Ragab et al. (1968)
Adult buffalo	71.3	19.6	4.9	Charles et al. (1970)
Bulgarian buffalo	..	..	..	Ognjanovic et al. (1970)
Murrah buffalo	..	..	..	Ognjanovic et al. (1970)
Bulgarian Murrah cross	..	..	..	Ognjanovic et al. (1970)
Adult buffalo	68.2	17.4	10.6	Charles and Johnson (1972)
Adult buffalo	82.8	16.6	..	Cockrill (1974)
Castrated buffalo	81.9	17.5	..	Cockrill (1974)
Yearling buffalo	81.1	18.4	..	Cockrill (1974)
Adult buffalo	..	..	..	Cockrill (1974)
Murrah buffalo (kg)	83.9	33.2	9.0	Sarma et al. (1978)
Young buffalo (Roughage ration 85% NRC)	59.8	24.7	15.5	Raghavan et al. (1979)
Young buffalo (75% roughage, 25% concentrate, 85% NRC)	62.0	22.0	16.0	Raghavan et al. (1979)
Adult cattle	68.5	20.7	8.1	Charles et al. (1970)
Adult cattle	67.5	14.5	14.4	Cockrill (1974)

Table III.1. (continued)

c) Meat-bone ratio

Reference	Meat-bone ratio	Remarks
Buffaloes		
Buranamanas (1963)	3.7	Average value
Ragab et al. (1968)	3.2	Average value
Ragab et al. (1968)	4.3	Average value
Charles et al. (1970)	3.6	Average value
Charles and Johnson (1972)	3.9	Average value
Cockrill (1974)	4.6	Average value
Sarma et al. (1978)	2.5	Average value
Cattle		
Berg and Butterfield (1966)	3.1	Hereford
Berg and Butterfield (1966)	3.4	Half Brahman
Berg and Butterfield (1966)	3.6	Brahman
Berg and Butterfield (1966)	3.0	Shorthorn
Charles et al. (1970)	3.3	Average value
Cockrill (1974)	4.7	Average value

Table III.2. Average values for weight of organs as percentage to weight of animals in buffaloes and cattle

Sl. No.	Description	Hide	Head	Liver	Heart	Lungs	Kidney
1	Young buffalo	11.0	4.2	..	0.35	1.60	..
2	Castrated buffalo	9.9	..	..	..	..	..
3	Iraqi buffalo	10.7	4.0	1.4	0.41	..	0.27
4	Bulgarian buffalo	13.9	3.8	1.1	0.36	0.52	0.20
5	Murrah buffalo	12.4	3.6	1.2	0.43	0.56	0.26
6	Adult buffalo	11.6	..	..	..	..	0.59
7	Male buffalo	..	..	1.4	..	..	..
8	Castrated buffalo	..	..	..	..	..	0.31
9	Yearling buffalo	..	..	..	0.30	0.61	0.29
10	Murrah buffalo	11.5	4.1	..	0.32	0.64	0.24
11	Bull	8.6	..	..	..	..	..
12	Iraqi cattle	7.8	3.9	1.4	0.34	..	0.24
13	Adult cattle	10.8	..	1.4	..	..	..

Table III.2. (continued)

Sl. No.	Stomach and Intestine	Fore-quarter	Hind-quarter	Reference
1	..	..	..	Domingues (1956)
2	..	..	..	Cumburidze and Dalakishvilli (1959)
3	21.4	..	..	Kassir et al. (1969)
4	..	..	..	Ognjanovic et al. (1970)
5	..	56.0	44.0	Ognjanovic et al. (1970)
6	18.1	..	..	Charles et al. (1970)
7	..	57.4	42.6	Salerno (1974)
8	..	54.9	45.1	Salerno (1974)
9	19.2	52.9	47.1	Salerno (1974)
10	..	..	..	Cockrill (1974)
11	20.7	58.2	41.8	Cumburidze and Dalakishvilli (1959)
12	..	..	..	Kassir et al. (1969)
13	..	..	..	Charles et al. (1970)

In the present work the carcass characteristics as well as the weight of the internal organs had been studied in adult buffaloes and cross-bred cattle.

MATERIALS AND METHODS

After a period of 12 months' growth study, the animals were castrated by the Burdizzo method, and after subsequent fattening, 18 buffaloes (average age 43 months) and 22 cross-bred cattle (average age 47 months) were transported in trucks to the factory of Meat Products of India at Koothattukulam, Kerala, at a distance of 105 km away from the Kerala Agricultural University farm. These animals were weighed at the project before loading and again at the factory after 30 hours of fasting.

Animals were stunned using standard captive bolt pistol. Bleeding was done by severing the jugular vein and the artery by a transverse cut just posterior to the angle of the jaw.

After flaying, the trachea and gullet were loosened and a knot was put on the gullet. Head was removed at the occipito-atlantal junction. The tail was removed between the second and third coccygeal vertebrae. Metacarpal and metatarsal bones along with hooves were removed at their joints. After splitting the breast, a midline longitudinal incision was made on the abdomen. The thoracic and abdominal organs were then removed and weights recorded separately. The kidneys were left intact in the carcass. The carcass weight was then recorded. The fore-and hind-quarters were divided by cutting transversely between the twelfth and thirteenth rib and recorded the weight of each quarter separately. The separable fat was dissected out from subcutaneous tissues, and from around the kidney.

For the study of edible meat, the carcass was split into two halves through the vertebral column and after noting the weight, one half was stripped into bone and meat.

Statistical testing of the means for significance was done by the method of analysis of variance as described by Snedecor and Cochran (1967).

RESULTS

The data obtained during the course of the study are presented in Tables III.3. to III.6.

Table III.3. Carcass characteristics of buffaloes and cattle

Characteristics	Buffalo	SE	Cattle	SE
Weight at farm (kg)	318.4	14.9	404.5	16.4
Weight at slaughter (kg)	303.1	12.9	382.4	16.3
Loss due to transit and starvation for 30 hours (kg)	15.3	0.6	22.1	0.9
Carcass weight (kg)	154.8	8.9	210.9	12.8
Dressing percentage	51.1	0.8	55.2	1.3
Percentage of loss due to transit and starvation	5.1	0.3	5.8	0.3
Edible meat (kg)	108.9	6.2	152.6	9.0
Bone (kg)	37.9	2.0	44.0	1.5
Separable fat (kg)	7.3	1.1	15.3	2.6
Percentage of edible meat	70.4	0.9	72.4	1.0
Percentage of bone	24.5	0.7	20.9	0.8
Percentage of separable fat	4.7	0.6	7.3	1.1

It appeared from the result that the meat : bone ratio in buffaloes was 2.9 while in cattle it was 3.5. The percentage of muscle was around 70 in both buffaloes and cattle. Buffaloes had a higher percentage of bone compared to that of cattle (P $<$0.01.). significant difference could be detected between buffaloes and cattle in dressing percentage. Weight loss due to transit and starvation, and separable fat recorded no significant difference.

Table III.4. Weight of organs of buffaloes and cattle

Organs	Buffalo	SE	Cattle	SE
Oesophagus, reticulo-rumen, omasum, abomasum, intestine (washed) (kg)	13.6	0.6	16.2	0.5
Liver (kg)	3.4	0.2	4.0	0.2
Heart (kg)	1.2	0.1	1.2	0.1
Trachea, bronchi and lungs (kg)	3.2	0.2	3.5	0.2
Kidneys without fat (kg)	0.7	0.03	0.7	0.04
Fore-quarters (kg)	87.8	5.3	127.8	7.6
Hind-quarters (kg)	67.0	3.8	83.2	4.3
Head (kg)	12.3	0.5	13.4	0.4
Skin (kg)	37.1	1.9	32.7	1.8

Table III.5. Weight of organs, as percentage to weight of animals at slaughter/carcass weight, in buffaloes and cattle

Organs	Buffalo	SE	Cattle	SE	Significance
Fore-quarters to carcass weight	56.7	0.5	60.6	0.7	$P < 0.01$
Hind-quarters to carcass weight	43.3	0.5	39.5	0.7	$P < 0.01$
Kidneys to carcass weight	0.5	0.03	0.3	0.02	$P < 0.01$
Head to weight at slaughter	4.1	0.1	3.5	0.1	$P > 0.01$
Skin to weight at slaughter	12.2	0.3	8.6	0.2	$P < 0.01$
Oesophagus, reticulo-rumen, omasum, abomasum intestine to weight at slaughter	4.5	0.3	4.2	0.2	$P > 0.01$
Liver to weight at slaughter	1.1	0.1	1.1	0.1	$P > 0.01$
Lungs to weight at slaughter	1.1	0.1	0.9	0.1	$P > 0.01$
Heart to weight at slaughter	0.4	0.02	0.3	0.01	$P < 0.01$

The values for the parameters studied were found to be higher in buffaloes than those in cattle except the percentage of fore-quarters to carcass weight which was higher in cattle than that in buffaloes.

DISCUSSION

The weight loss due to transport by trucks and subsequent starvation is less in buffalces than in cattle although the results were statistically non-significant. The weight of the animal was not recorded immediately on arrival at the factory and hence the true transit weight loss could not be determined. Hence, the weight loss due to transit and starvation recorded in the present study is not being compared with literature values for transit weight loss.

Transit weight loss is attributed primarily to sweating, exhalation, excretion of faeces and urine and is controlled by the physical conditions of the

animal, season of the year and duration of the journey. The lesser weight loss in buffalo observed in the present study is attributable to its thick skin, scanty sweat glands and also to its more sturdy nature. This is suggestive of the possibility of transporting buffaloes for long distances by even trekking with comparatively lesser loss in weight than cattle.

Dressing percentage is the first criterion of production to be considered at slaughter. Buffaloes recorded a lesser dressing percentage than cattle ($P < 0.01$). The dressing percentage observed in this study is almost similar to those reported by Charles et al. (1970) (50.8 per cent in buffaloes and 55.8 per cent in cattle). Kassir et al. (1969) also reported a similar trend in the dressing percentage in buffaloes (48.4 per cent) and cattle (51.2 per cent).

Maymone (1945), Ognjanovic et al. (1970) and Charles and Johnson (1972) have reported higher dressing percentages in various breeds of adult buffaloes. However, lower dressing percentages have also been reported in buffaloes (Maymone, 1942: 47.7 to 49.3 per cent; Maymone, 1945: 45 to 47 per cent; Salerno, 1948:

45.3 to 48.5 per cent and Cockrill, 1974 : 45.6 to 48.5 per cent.).

The lower dressing percentage recorded in the buffaloes, as compared to cattle, may be due to its higher percentage weight of hide and head. The combined weight of the hide and head was about 4.2 per cent higher in buffaloes than in cattle. Berg and Butterfield (1975) and Geay (1978) considered dressing percentage as a poor criterion for evaluating edible meat in animals when carcass weight was related to live weight. However, when carcass weight was related to empty body weight the dressing percentage appeared to be a useful and cheap measurement in comparing animals for any given type of production. Expressed in relation to empty body weight, independently of the gut content, dressing percentage might vary according to weight and genotype.

In the case of fore-quarters and hind-quarters, it was noticed that the fore-quarters weighed much more than the hind-quarters in both the species. This result is in agreement with the result of Salerno (1974) who also reported a higher percentage weight of the fore-quarter in buffaloes (52.9 to 57.4 per cent) than the

hind-quarter (42.6 to 47.1 per cent). Between the species, the percentage weight of fore-quarter in cattle was significantly more (3.9 per cent) than in buffaloes. This could be attributed to the increased development of the rhomboideus muscle in cattle (Norman and De Felico, 1981). It is well known that the neck, thorax and thoracic limb muscles grow more quickly than the muscles of the hind limb. However, the hind-quarters recorded a significantly higher weight in buffaloes (3.8 per cent) than in the cattle.

The weight of head in buffaloes, as percentage to weight of animals at salughter, was found to be more than that of cattle (Table III.5.). This could be attributed to the presence of the well-developed horns in buffaloes which were absent in the cross-bred cattle due to debudding of the horns.

Domingues (1956), Kassir et al. (1969) and Cockrill (1974) have also reported a similar percentage of weight for the head in buffaloes.

In the case of skin, buffaloes recorded a significantly higher weight (3.6 per cent) than cattle (Table III.5.). It is reported that the thickness of the epidermis in buffaloes is about 1.5 to 2 per cent of the

thickness of the skin, whereas it is only less than 1.2 per cent in cattle (Cockrill, 1974).

The present study is in agreement with those of majority of the earlier workers (Domingues, 1956; Cumburidze and Dalakishvilli, 1959; Charles et al., 1970; Ognjanovic et al., 1970; Cockrill, 1974; Salerno, 1974).

The weight of oesophagus, reticulo-rumen, omasum, abomasum and intestine, expressed as percentage to live weight, did not record any statistically significant difference between cattle and buffalo. Even though the same was the trend in the percentage of weight in buffaloes and cattle reported by other workers (Kassir et al., 1969) and Cockrill, 1974), the absolute value in the present report was lower than those of the above workers.

Although non-significant, the results revealed that the capacity of the gastro-intestinal tract in buffalo was slightly more than that of cattle (4.5 per cent, against 4.2 per cent in cattle).

The weights of liver, lungs, heart and kidney appeared to be higher in buffaloes (1.1, 1.1, 0.4 and 0.5 per cent respectively) than in cattle (1.1, 0.9, 0.3 and 0.3 per cent respectively) (Table III.5.), though the values for the

first two were not significantly different. These findings are in agreement with those of Kassir et al., (1969), Charles et al., (1970) and Ognjanovic et al., (1970), who also observed higher percentage of weight for the internal organs in buffaloes than in cattle.

The values for the weight of bone as percentage to carcass weight was significantly higher in buffaloes (3.6 per cent) than in cattle. However, cattle had a higher value, though non-significant, for edible meat and separable fat (2.0 per cent and 2.6 per cent respectively).

The percentage weight of bone to carcass weight obtained in this study was much higher in buffaloes than the earlier reports (Kassir et al., 1969; Charles et al., 1970; Ognjanovic et al., 1970; Charles and Johnson, 1972; Salerno, 1974).

In the case of the percentage of meat to carcass weight, the results obtained in the present study, in buffalo and cattle, were higher than the earlier reports. However, in majority of those reports also, percentage of meat to carcass weight in cattle was found to be more than in buffaloes. (Kassir et al., 1969; Charles et al., 1970; Ognjanovic et al., 1970; Charles and Johnson, 1972;

Cockrill, 1974). The percentage of separable fat in buffaloes was 4.7 while in cattle it was 7.3

Muscle : bone ratio is often used as a criterion of muscle development. The present study indicated a meat : bone ratio of 3.5 (cattle) and 2.9 (buffalo). Even though these results are lower than the reports of Cockrill (1974) in cattle and Buranamanas (1963) and Charles et al., (1970) in buffaloes, the present study is in agreement with those of Cockrill (1974) and Berg and Butterfield (1966) in having higher meat : bone ratio for cattle than the buffalo. It appears that cattle had a higher percentage of edible meat than buffaloes.

CHAPTER IV

HISTOLOGY AND CHEMICAL COMPOSITION OF MEAT

Muscular tissue constitutes about 30 per cent of the body weight and is the largest single tissue component of the body. At rest, about 50 per cent and during strenuous excercise, about 75 per cent or more, of the total metabolism is due to muscular activity (Cantarow and Schepartz, 1967). Consequently, many metabolic intermediates are formed. The composition of muscle, therefore, largely depends upon the activity and type of muscle, the time and nature of slaughter, the method of preservation and the technique of analysis.

Buffalo meat is similar to beef in many basic properties. This is particularly obvious when buffalo

meat is compared with beef of corresponding class of cattle maintained under similar conditions (Joksimovic, 1969).

Since the pioneering work on the composition of meat by Lawes and Gilbert (1859), much data regarding the composition of beef from animals of different ages and in varying stages of nutrition had been gathered. Callow (1935, 1938, 1944, 1948, 1949 and 1954) had estimated the moisture, fat and protein contents of the muscle in various species of animals.

Water and organic substances in the body are known to exhibit wide variation according to age and nutritional state. On a percentage basis, the water content showed an appreciable decrease with advancing age.

The chemical constituents which make up the gross composition of the body are not evenly distributed among the various organs and tissues but, are more or less localised according to their function. In contrast to the wide variability reported for moisture and organic constituents, the ash content had been found to be practically constant when expressed on water-free and fat-free basis.

The relevant literature is summarised in Table IV.1.

Table IV.1. Average moisture content, dry matter and ash of meat of buffalo and cattle

a) Buffalo

Author/s	Moisture (%)	Dry matter (%)	Ash (%)	Remarks
Winton and Winton (1949)	75.5	24.5	1.5	Average value
Maymone and Bergonzini (1960)	71.6	28.4	..	New born calf
Kurbanov (1961)	64.4	35.5	1.0	High fat buffalo
Kurbanov (1961)	68.8	31.2	1.0	Medium fat buffalo
Kurbanov (1961)	73.3	26.6	1.0	Low fat buffalo
Ferrara et al. (1969)	71.6	28.3	1.0	Milk fed calves
Ferrara et al. (1969)	73.1	26.8	1.0	Milk fed calves
Yadava and Singh (1974)	77.9	22.0	..	Longissimus dorsi
Yadava and Singh (1974)	76.9	23.0	..	Sartorius
Yadava and Singh (1974)	76.6	23.3	..	Triceps
Lall (1977)	78.7	21.3	1.0	Average value
Joksimovic and Ognjanovic (1977)	76.8	23.1	..	Young buffalo
Joksimovic and Ognjanovic (1977)	76.9	23.0	..	Adult buffalo
Rao (1978)	78.2	21.8	0.9	Young buffalo

Table IV.1. (continued)

b) Cattle

Author/s	Moisture (%)	Dry matter (%)	Ash (%)	Remarks
Winton and Winton (1949)	66.3	33.7	0.8	Average value
Watson (1949)	75.80	20.25	1.7	At birth
Miller and West (1953)	75.0	25.0	5.1	Average value
Hawk et al. (1954)	75.0	25.0	..	Average value
Reid et al. (1955)	..	..	5.3	Average value
Lawrie (1961)	75.9	24.1	..	Average value
Harrow and Mazoor (1962)	75.0	25.0	..	Average value
Kleiner and Otten (1966)	75.0	25.0	..	Average value
Pearson (1966)	60.2	39.8	..	Minced beef
Hafez and Dyer (1969)	72.5	27.5	1.0	Average value
Cole and Rony (1974)	75.5	24.5	0.6	Average value
Cockrill (1974)	76.4	23.5	..	18-24 months
Cockrill (1974)	76.9	23.0	..	10-18 years
Libby (1975)	75.0	25.0	1.5	Average value
Dean et al. (1976)	72.1	27.9	..	Hereford breed
Dean et al. (1976)	72.4	27.6	..	Hereford Holstein cross
Dean et al. (1976)	71.3	28.7	..	Holstein

Table IV.1. (continued)

b) Cattle

Author/s	Moisture (%)	Dry matter (%)	Ash (%)	Remarks
Ferrara et al. (1969)	53.8	46.3	3.17	Average value
Pearson (1976)	76.8	23.2	..	Average value
Fox and Cameron (1977)	75.0	25.0	1.0	Average value
Lall (1977)	74.3	25.7	1.0	Average value
Joksimovic and Ognjanovic (1977)	76.4	23.5	..	Simmental
Joksimovic and Ognjanovic (1977)	76.5	23.5	..	Average value
Maynard et al. (1979)	75-80	20-25	..	At birth
Maynard et al. (1979)	66-72	28-34	..	Calves
Maynard et al. (1979)	40-65	35-60	..	Adult
Marian et al. (1980)	55.4	44.6	..	Angus steer
Marian et al. (1980)	52.9	47.1	..	Angus steer
Marian et al. (1980)	58.6	41.4	..	Simmental
Marian et al. (1980)	56.1	43.9	..	Simmental
Ranjan (1980)	57.0	43.0	5.0	Adult
Ranjan (1980)	74.0	26.0	4.0	New born

Muscles contain storage fat as well as essential lipids, with phospholipids predominating among the latter. Nutritional status exerts a direct influence on the fat content of the muscle tissue. Considerable variations exist in the composition and distribution of fat between animals and between regions of animals.

The relevant literature pertaining to the fat contents in buffalo meat and beef are presented in Table IV.2.

Table IV.2. Average fat percentage in the meat of buffalo and cattle

a) Buffalo

Author/s	Fat percentage	Remarks
Ognjanovic et al. (1970)	1.3	Bulgarian buffalo
Ognjanovic et al. (1970)	0.6	Murrah buffalo
Ognjanovic et al. (1970)	1.0	Murrah - Bulgarian cross
Cockrill (1974)	15.4	High fat buffalo
Cockrill (1974)	9.6	Medium fat buffalo
Cockrill (1974)	1.1	Low fat buffalo
Lall (1977)	0.9	Average value
Rao (1978)	1.2	Young buffalo

Table IV.2. (continued)

b) Cattle

Author/s	Fat percentage	Remarks
Winton and Winton (1949)	16.2	Average value
Sherman (1952)	12.5	Lean beef
Miller and West (1953)	3.0	Average (mammalian muscle)
Maymone and Bergonzini (1960)	3.0	Average value
Prince and Schweigert (1960)	20.0	Average value
Lawrie (1974)	3.0	Average value
Kleiner and Otten (1966)	3.0	Average value
Hafez and Dyer (1969)	1-20	Average value
Cole and Rony (1974)	3.0	Mammalian muscle
Libby (1975)	3.0	Average value
Lall (1977)	2.6	Average value
Fox and Cameron (1977)	16.5	Average value
Marian et al. (1980)	27.9	Angus Hereford steer
Marian et al. (1980)	30.4	Angus Hereford steer
Marian et al. (1980)	23.6	Simmental
Marian et al. (1980)	26.1	Simmental heifer
Ranjan (1980)	3.0	New born calf
Ranjan (1980)	20.6	Dry cows

The fat percentage in buffalo is reported to vary from 0.64 to 15.4 per cent while in cattle it varied from 1 to 30.4 per cent depending upon the age and nutritional status of the animal.

In a comparative study of the fatty acids in the meat of buffalo and cattle, Romita et al. (1976) observed that many of the fatty acids were found at significantly higher level in cattle than in buffaloes. They have also observed that the levels of the acid 18:0 (stearic acid) and 18:1 (oleic acid) were constantly high in buffaloes.

Pyne et al. (1977) studied the fatty acid composition of brisket fat obtained from Angus cows crossed with thirteen different breeds of cattle and observed significant differences between the crosses in the percentage of palmitoleic, stearic and octadecenoic acids. Significant differences were also noted in the ratio of palmitic to stearic acid, and in the percentages of subcutaneous, intra-muscular and internal fats between the various crosses.

Proteins as a group constitute the major portion of the animal body on a dry matter basis. The essential unit of muscle tissue is the myofibril. The sarcoplasm and the sarcoplasmic reticulum are situated between the

myofibrils. The fibre is covered by a very thin membrane called as sarcolemma.

Harrow and Mazoor (1962) classified the muscle proteins into myogen, globulin, myosin and stroma protein.

Cantarow and Schepartz (1967) broadly classified the muscle proteins into intracellular and extracellular proteins. The extracellular protein (stroma) is formed by connective tissue protein. The intracellular protein is again subgrouped as fibrillar (actin and myosin) and sarcoplasmic (myogen, globulin and myoglobin) proteins. Hawk et al. (1954) also has followed a similar classification.

Kartz (1970) classified the contractile protein into myosin, actin, tropin and tropogen.

Bourne (1973) reported that about 60 per cent of the proteins of the muscle are concentrated in myofibrils. These proteins are further classified as contractile proteins (actin and myosin) and regulatory proteins (troponin, tropomyosin, paramyosin, alpha-actinin, beta-actinin and M-protein).

Libby (1975) classified the muscle protein of cattle as sarcoplasmic protein, myofibrillar protein

and connective tissue protein.

Proteins of the muscle can be broadly classified into those which are soluble in water or in dilute salt solution (sarcoplasmic protein), those which are soluble in concentrated salt solution (myofibrillar protein) and those which are insoluble in the latter (proteins of the muscular tissue and other formed structure).

The literature gathered on the protein content of the meat of buffalo and cattle is presented in Table IV.4., the different protein fractions in Table IV.5. and the amino acid composition of buffalo and cattle meat in Table IV.6.

Table IV.4. Average values for protein content of meat

Reference	Protein content (g/100 g meat)		Remarks
	Buffalo	Cattle	
Winton and Winton (1949)	21.8	17.8	Average value
Sherman (1952)	..	19.2	Average value
Miller and West (1953)	..	20.2	Average value
Reid et al. (1955)	..	20.2	Average value
Lawrie (1961)	..	3.6	Nitrogen
Harrow and Mazoor (1962)	..	20.0	Average value
Lawrie et al. (1964)	..	3.1	Nitrogen
Pearson (1966)	..	22.8	Minced beef
Abraham and Bernard (1967)	..	20.0	Average value
Hafez and Dyer (1969)	..	18.0	Average value
Cole and Rony (1974)	..	18.0	Average value
Libby (1975)	..	19.5	Average value
Libby (1975)	..	18.5	Lean beef
Dean et al. (1976)	..	20.9	Hereford
Dean et al. (1976)	..	20.7	Hereford cross
Dean et al. (1976)	21.8	21.0	Holstein
Joksimovic and Ognjanovic (1977)	21.4	..	Adult buffalo
Lall (1977)	19.4	22.6	Average value
Fox and Cameron (1977)	..	18.0	Average value
Rao (1978)	18.8	..	Average value
Ranjan (1980)	..	19.0	New born calf
Ranjan (1980)	..	17.2	Dry cows

Table IV.5. Average values of the different protein fractions of meat of cattle

Reference	Values of the different protein fractions			Non-protein nitrogen
	Myofibrillar protein	Sarcoplasmic protein	Stroma protein	
As percentage of total protein				
Helander (1961)	54.7	18.5	14.4	12.6
Harrow and Mazoor (1962)	57.0	27.0	16.0	..
Lawrie *et al.* (1964)	53 to 56.5	19.5 to 23.9	9.1 to 16.0	11.5 to 12.8
Penny (1970)	80 to 85	..	..	..
Abraham and Bernard (1967)	40 to 60	30 to 40	10 to 20	..
As percentage of total nitrogen				
Lawrie (1961)	1.83	0.94	0.39	0.42
Lawrie (1961)	1.93	0.94	0.36	0.38
Lawrie (1961)	1.84	1.08	0.28	0.41

Table IV.6. Amino acid composition of the meat of buffalo and cattle

a) Buffalo

Amino acid (as percentage of fresh sample)	Buffalo		
	Bulgarian	Murrah	Murrah-Bulgarian cross
Lysine	1.800	2.162	1.722
Histidine	0.767	0.868	0.833
Arginine	1.280	1.430	1.420
Aspartic acid	2.550	2.510	2.620
Threonine	1.170	1.180	1.230
Serine	0.870	0.890	0.920
Glutamic acid	3.960	4.310	4.150
Proline	1.180	0.910	0.920
Tryptophan	..	..	..
Glycine	1.066	1.053	1.051
Alanine	1.410	1.570	1.480
Cystine	0.360	0.520	0.540
Valine	1.310	1.370	1.350
Methionine	0.640	0.660	0.650
Isoleucine	1.227	1.159	1.233
Leucine	1.878	1.825	1.952
Tyrosine	0.810	0.870	0.890
Phenylalanine	0.904	0.955	0.966
Reference	Cockrill (1974)	Cockrill (1974)	Cockrill (1974)

Table IV.6. (continued)

b) Cattle

Amino acid (as percentage of fresh sample)	Beef	Beef
Lysine	9.0	8.4
Histidine	3.3	2.9
Arginine	7.0	6.6
Aspartic acid	10.5	8.8
Threonine	5.0	4.0
Serine	6.0	3.8
Glutamic acid	17.0	14.4
Proline	6.0	5.4
Tryptophan	1.4	1.1
Glycine	5.0	7.1
Alanine	7.4	6.4
Cystine	1.2	1.4
Valine	5.5	5.7
Methionine	3.2	2.3
Isoleucine	6.0	5.1
Leucine	8.0	8.4
Tyrosine	4.0	3.2
Phenylalanine	5.0	4.0
Hydroxyproline	1.0	..
Reference	Kleiner and Otten (1966)	Lall (1977)

MATERIALS AND METHODS

The slaughter of the 18 male buffaloes and 22 male cross-bred cattle was carried out at the Meat Products of India, Koothattukulam, as described earlier in chapter III.

Histology

Pieces of muscle from the gluteal region were collected for histological examination. Tissues about 0.5 cm thickness were cut from three sites and fixed in 10 per cent neutral formalin. They were sliced into 3 mm thick pieces and washed in running water for 6 to 12 hours to remove the formalin completely, dehydrated using ascending grades of alcohol, cleared in xylene, and embedded in paraffin wax. Sections cut at 5 microns

thickness were stained with hematoxylin and eosin.

Individual samples from fore-quarter and hind-quarter were collected in polythene bags, labelled, and then sealed. These bags were packed inside an ice-box with ice and were immediately transported to the Central Institute of Fisheries Technology at Cochin. On arrival at Cochin, about an hour later, the samples for protein fractionation were taken out, pooled and prepared immediately. Other samples were kept in a freezer at -20°C till further use.

Pooled sampling of meat was done as per the Official method of analysis of A.O.A.C. (1980). The representative samples of meat were carefully minced, homogenised and kept at -20°C until the analysis was over.

Moisture

Moisture in the meat was determined as per A.O.A.C. (1980), by drying a weighed known sample of meat at 110°C and weighing till concordant values were obtained.

Ash

Ash in the meat was estimated by incinerating a weighed sample at 525°C in the muffle furnace and

recording the weight of contents left behind.

Glycogen

Glycogen in the sample of post-rigor meat was estimated according to the procedure of Umbreit et al. (1959).

Ten grammes of the sample were minced with 5 ml of 30 per cent potassium hydroxide and heated in a boiling water bath until completely dissolved. This was then treated with 6 ml of 95 per cent ethanol while hot, cooled and the glycogen precipitated was centrifuged out. The supernatant was discarded and the precipitate was hydrolysed two hours in 1 N hydrochloric acid at 100°C. The hydrolysate was neutralised and the reducing sugar was measured with a copper reagent. The factor of 0.927 was used to convert glycogen measured into glucose.

Crude fat

Crude fat in the meat was isolated by wet extraction using a chloroform-methanol (2:1 v/v) solvent mixture (Bligh and Dyer, 1959).

Muscle was minced thoroughly in a mechanical meat mincer. Minced meat (100g) was blended with 300 ml of chloroform-methanol mixture and chilled on ice and

filtered through Whatman filter paper (No.41). The residue was taken and again blended with 300 ml of the same solvent mixture and filtered as above. The residue was re-extracted again using 300 ml of the same solvent mixture. The colourless meat residue after the third extraction was discarded.

Added 10 per cent by volume water to the pooled liquid extract, shook well, and kept over-night. The liquid extract got separated into a top layer of water and methanol and a bottom layer of choroform containing all the lipids. The chloroform was dried over anhydrous sodium sulphate and the volume of the chloroform layer was noted.

Twenty five millilitres of the dried chloroform solution containing the lipids were quantitatively transferred to a dried and accurately weighed 100 ml beaker. The chloroform extract was evaporated on a water bath and the dried lipids were again dried under vacuum. Drying and weighing were repeated until constant weight was obtained. From this weight and the initial weight of the beaker the weight of the lipids was obtained. The quantity of the lipids was expressed as g/100g of wet muscle.

Total lipids were extracted from the muscle by the method of Bligh and Dyer (1959). For the preparation of methyl esters, the lipid samples were saponified, the unsaponified matter was removed and the fatty acids were collected. The free fatty acids were esterified with 14 per cent (w/v) methanolic-boron trifluoride according to the method of Morrison and Smith (1964) under nitrogen atmosphere.

Fatty acids

The methyl esters were analysed on a gas chromatograph using flame ionization detector and strip chart recorder (Varian 10 mv). The column was a stainless steel tube, six feet by one fourth inch outer diameter, filled with solid support gaschrom Q (80-150 mesh, Applied Science Laboratories, U.S.A.) coated with 10 per cent silar 10 c (Applied Science Laboratories, U.S.A.). Operating conditions were as follows:-

Column temperature	190°C Isothermal
Detector temperature	250°C
Injection port temperature	250°C
Carrier gas	Nitrogen 50 ml/minute

The following standards were used in the gas chromatograph.

Saturated acids : The methyl esters of C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18} and C_{20} acids (E.Merck).

Unsaturated acids : The methyl esters of oleic, linoleic, linolenic, arachidonic, erucic and decosahexaenoic ($C_{22:6}$) (Sigma 99 per cent), 5, 8, 11, 14, 17, eicosapentaenoic acids (94.6 per cent; NIH standard)

The instrument was calibrated with fatty acid-methyl as described by Horning et al.(1964). Identification and quantification of peaks were done as described by Gopakumar and Nair (1972).

Proteins

Fractionation of muscle protein was done according to Khan (1962) as modified by Hashimoto et al. (1979).

Samples of homogenised muscle (10 g) were taken in a centrifuge tube and 10 ml of phosphate buffer, pH 7.5 (15.6 mM $Na_2 HPO_4$: 3.5 mM $KH_2 PO_4$) was added to it and

mixed well with a glass rod. After 30 minutes, added 10 ml of the same buffer and stirred well. This was repeated until the buffer volume reached 40 ml. All these operations were carried out in a cold room at 5-10°C. The tubes were then kept at 0-5°C over-night. The homogenate was centrifuged at 0°C in the ultra-centrifuge (G.D.R.; 7000 x g; 30 min).

The supernatant fluid was collected in a 100 ml volumetric flask and kept at 0-5°C. To the precipitate added 10 ml of the same buffer and mixed well by stirring. This procedure was repeated thrice. This tube was centrifuged at 0°C (7000 x g; 30 min). The supernatant fluid was collected in the same volumetric flask and kept at 0-5°C.

The precipitate was again treated with 10 ml of the same buffer twice making the volume to 20 ml and centri-fuged at 0°C (7000 x g; 30 min). The supernatant fluid was collected as before into the same volumetric flask. The volume was made up to 100 ml by using the same buffer. The precipitate was reserved for estimation of myofibrillar protein.

Sarcoplasmic protein and non-protein nitrogen

The supernatant fluid thus collected contained sarcoplasmic as well as non-protein nitrogen fractions. Transferred into a digestion flask 10 ml of this for estimation of nitrogen.

Twenty millilitres of the supernatant fluid were transferred into a conical flask and added 20 ml of 10 per cent trichloroacetic acid and the filtrate was separated. The filtrate was used for estimation of non-protein nitrogen fraction. The precipitate contained sarcoplasmic nitrogen fraction. Non-protein nitrogen fraction (10 ml) was collected in a digestion flask for nitrogen estimation.

Myofibrillar protein

The precipitate obtained after third centrifugation was used for myofibrillar nitrogen extraction using KCl-phosphate buffer, pH 7.5 (0.45 M KCl; 15.6 mM Na_2HPO_4 : 3.5 mM KH_2PO_4). The precipitate was mixed well with 10 ml of the above buffer in the same centrifuge tube, stirring well with the same glass rod. Repeated this process thrice making the final volume to 40 ml in the centrifuge tube and kept the contents over-night.

This suspension was centrifuged at 0°C at 7000 x g for 30 minutes. The supernatant fluid was collected in a 100 ml volumetric flask. The precipitate was again extracted with the same buffer twice making the volume to 30 ml in the tube and centrifuged as before. The supernatant was collected in the same volumetric flask. The extraction, centrifugation and collection were repeated. The final volume of the supernatant fluid thus collected was made to 100 ml with the same buffer.

Took 10 ml of this fluid in a digestion flask for estimation of myofibrillar nitrogen fraction.

Alkali Soluble Protein

The precipitate in the centrifuge tube was treated with 10 ml of 0.1 N sodium hydroxide over-night.

The suspension was centrifuged at 10,000 x g for 30 minutes. The supernatant fluid was filtered using glass wool. The extraction using alkali and centrifugation were repeated three times at one-hour interval, collecting the filtrate each time in the same volumetric flask. The volume in this flask was made up to 100 ml. Transferred 10 ml of this into a digestion flask for estimation of alkali soluble nitrogen fraction.

The final residue was used for the estimation of the stroma protein fraction.

To determine the total protein content of the muscle, a small quantity of the homogenised sample was taken, weighed in a polythene paper and transferred into a digestion flask for digestion.

The protein and non-protein fractions extracted as above were analysed for nitrogen by micro-Kjeldahl method according to A.O.A.C. (1980) and the protein content of each sample was calculated.

Myosin

Myosin was extracted by the direct extraction method, as described by **Mackie (1972)**.

Blended 100 g of homogenised sample with 150 ml of KCl - Tris buffer containing 0.7 M KCl and 0.05 Tris. The sample was centrifuged at 10,000 x g for 30 minutes. The supernatant fluid was diluted 5 times its volume with distilled water and allowed to stand for 30 min and again centrifuged as above. The precipitate was dissolved in a buffer containing 0.95 M KCl and 0.05 M Tris, and diluted to ionic strength μ = 0.23 with distilled water

and again centrifuged. The myosin was taken up in 0.6 M KCl.

Actin

The actin content of the muscle was calculated as described by Cornell (1960).

Blended 50 g minced muscle with 500 ml of 0.4 per cent $NaHCO_3$ twice and then once with 500 ml distilled water. The washings were removed each time by squeezing through a cloth. The minced muscle was treated several times with acetone, the fluid being squeezed out each time and fresh acetone applied until the washings were clear. The residue was allowed to dry over-night at room temperature.

Extracted 10 g of the above acetone-dried powder with 200 ml of distilled water at room temperature for one hour. It was then filtered through a Buchner filter and the volume noted.

The actin thus obtained was treated with 0.5 M KCl and kept at 0°C over-night for converting it from its globular form into fibrous actin.

Sulphhydryl content

Sulphhydryl content of the myosin was determined as per Ellman (1959).

In a clean tube, took 0.1 ml of myosin solution and added immediately 2.9 ml of 0.1 μ buffer solution. The optical density was measured at 412 nm. Calculation was done using extinction coefficient, 1.36×10^4, of the thiophenol anion (dithionitrobenzoic acid) as described by Ellman (1959). (The dithionitrobenzoic acid solution was prepared by dissolving 39.6 mg of DTNB in 10 ml of phosphate buffer (pH 7.0); 0.02 ml of DTNB was used). The calculation was carried out using the formula:

$Co = \frac{A}{E} D$; where

Co = Original concentration

A = absorbance at 412 nm

E = extinction coefficient 1.36×10^4

D = dilution factor

ATP-ase activity

Adenosine triphosphatase (ATP-ase) activity of the myosin was calculated as reported by Mackie (1972). To 2 ml of myosin sample, added 2.5 ml of 0.1 M $CaCl_2$,

20.5 ml of KCl-Tris buffer (ionic strength 0.5; pH 7.5) and 0.003 M ATP.

ATP was added at a specified time; withdrew 2 ml samples at intervals of 5 minutes and added to 2 ml of 20 per cent trichloroacetic acid. This was centrifuged at 2000 rpm for 15 minutes. The phosphorus content in the filtrate was estimated by the method of Fiske and Subba Row (1925).

Electrophoresis

Portions of the protein fractions were used for Poly acrylamide gel electrophoresis according to Ornstein and Davis (1964).

Mixed 10 ml of the acrylamide-Tris buffer (14.3 per cent acrylamide in 0.37 M Tris, pH 8.8) with 0.72 ml of 0.5 per cent NNN 'N' tetramethyl 1:2 diaminoethane and 0.72 ml of 0.06 per cent ammonium persulphate. This solution was immediately run into electrophoresis tube, having 8 mm diameter inside and closed at bottom, to a depth of a 7 cm. This layer was covered with 3 mm distilled water without disturbing the gel. The layer of water was removed after 20 minutes by a piece of filter paper. The space above the gel was filled with

Tris-glycine buffer. The tubes were kept in front of a fluorescent light for 2-3 hours for the gel to set. Before use the buffer solution on top of the gel was changed twice.

The sample was introduced to a depth of 3 mm into the tube. Placed the tubes in the electrophoresis apparatus and set it.

Amino acids

Hydrolysed 100 mg sample of meat with 6 N HCl for 24 hours at 100° ± 5°C in a sealed tube and then made up to 10 ml and analysed in Technicon NC-2P auto-analyser for the amino acid analysis.

RESULTS

Histological studies revealed appreciable differences in the structure of buffalo and cattle muscles (Fig. IV. 1. and 2.).

Buffaloes

The muscle fibres were loosely arranged. The stromal tissue was sparse. Many of the muscle fibres contained large amounts of sarcoplasm. The adipose tissue was sparse or absent. The muscle fibres were arranged in loose wavy less tight bundles (Fig.IV.1.).

Cattle

Densely packed wavy bundles of muscle fibres were arranged in tight bundles. The sarcolemma was firmly bound to the muscle fibres. The myofibrils were abundant

and sarcoplasm was relatively less in many of the muscle fibres. The connective tissue was relatively more and there was moderate amount of adipose tissue separating the muscle fibres (Fig. IV.2.).

The values for moisture dry matter and ash in pooled samples of meat obtained for buffalo and cattle are presented in Table IV.7.

Table IV.7. Moisture, dry matter and ash content of meat

Species	Moisture per cent	Dry matter per cent	Ash per cent
Buffalo	76.1	23.9	1.2
Cattle	77.9	22.1	1.0

Mean glycogen content in the meat of buffalo was 0.078 g per cent, which in cattle was 0.017 g per cent.

Mean values for the fat content in pooled samples of meat of buffalo and cattle were 1.22 g per cent and 1.72 g per cent respectively.

The fatty acid composition of the muscle lipids of buffalo and cattle is presented in Table IV.8.

Fig.IV.1. Buffalo Loosely arranged muscle fibres containing relatively abundant sarcoplasm

H & E x 200

Fig.IV.2. Cattle Closely packed tight waves of muscle bundles containing relatively less amount of sarcoplasm

H & E x 200

Table IV.8. Fatty acid composition of muscle lipids of buffalo and cattle

Fatty acids	Buffalo (weight %)	Cattle (weight %)
Saturated acids		
12:0	0.6	1.2
13:0	0.7	1.6
14:0	2.5	3.9
15:0	0.9	1.7
16:0	16.9	16.1
18:0	22.7	18.6
	44.3	43.1
Mono-unsaturated acids		
14:1	1.1	1.3
15:1	0.4	0.7
16:1	8.0	5.8
18:1	32.8	31.8
20:1	0.6	1.0
	42.9	40.6
Poly-unsaturated acids		
18:2	8.6	12.5
18:3	0.6	1.1
20:4	3.6	2.7
	12.8	16.3

Data for the different protein fractions of the meat of buffalo and cattle are presented in Table IV.9.

Table IV.9. Protein fractions of the meat

Fractions	Buffalo	Cattle
Total nitrogen g per cent (including non-protein nitrogen)	3.585	3.190
Total protein g per cent	20.031	18.125
Total nitrogen g per cent (less non-protein nitrogen)	3.205	2.900
Protein pattern immediately after slaughter		
Myofibrillar protein nitrogen g per 100 g	1.900	1.540
as percentage of nitrogen	59.280	53.100
Sarcoplasmic protein nitrogen g per 100 g	0.900	0.780
as percentage of nitrogen	28.080	26.900
Stroma protein nitrogen g per 100 g	0.400	0.580
as percentage of nitrogen	12.480	20.000
Non-protein nitrogen g per 100 g	0.380	0.290
as percentage of total nitrogen	10.590	9.090

Table IV.9. (continued)

Fractions	Buffalo	Cattle
Protein pattern 36 hours after slaughter		
Myofibrillar protein nitrogen g per 100 g	0.79	0.71
as percentage of nitrogen	24.76	24.57
Sarcoplasmic protein nitrogen g per 100 g	0.91	0.78
as percentage of nitrogen	28.53	26.99
Stroma protein nitrogen g per 100 g	0.39	0.54
as percentage of nitrogen	12.23	18.66
Alkali soluble protein nitrogen g per 100 g	1.10	0.86
as percentage of nitrogen	34.48	29.76
Non-protein nitrogen g per 100 g	0.39	0.30
as percentage of total nitrogen	10.89	9.40

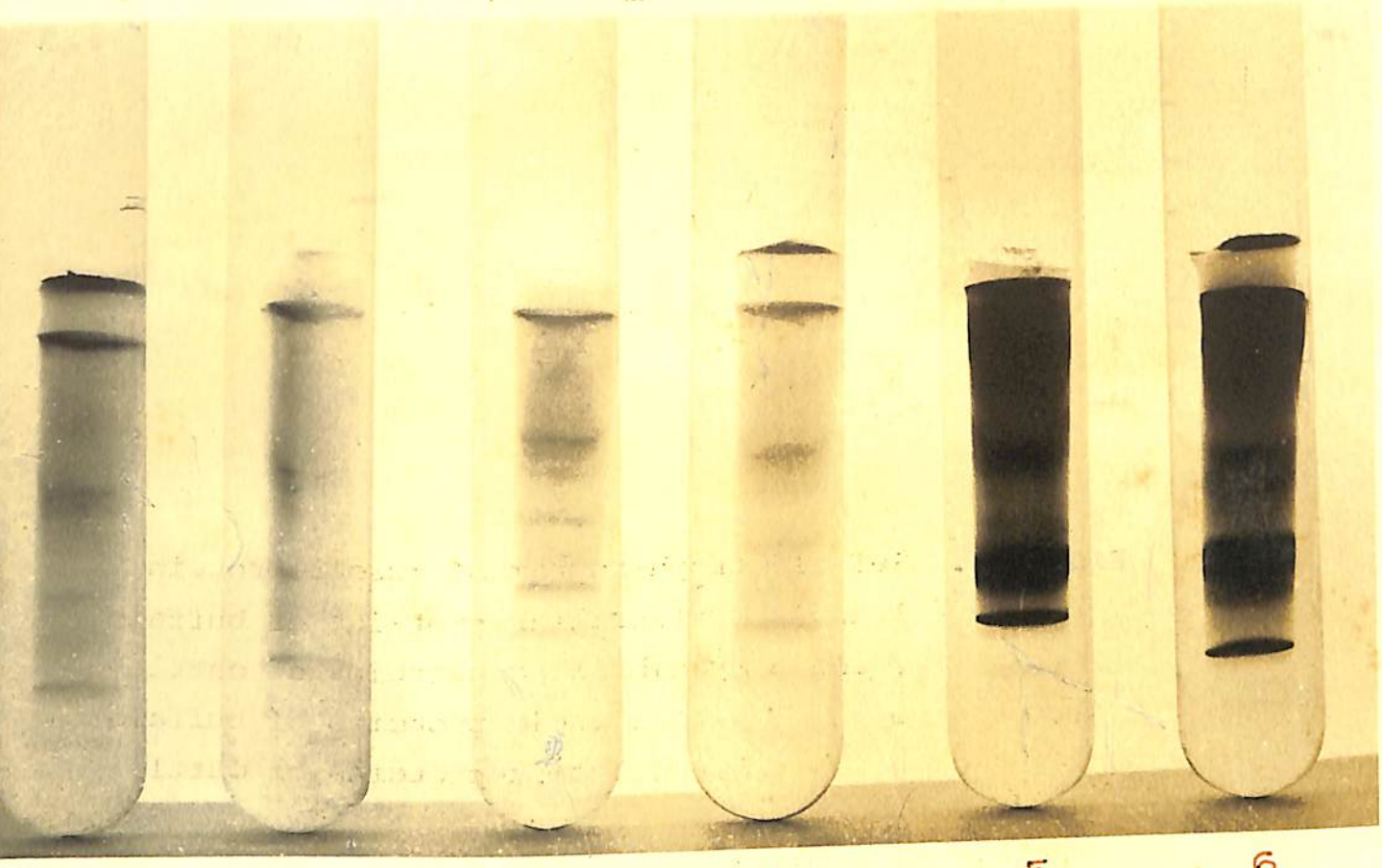
Gel electropherograms of the sarcoplasmic as well as myofibrillar fractions of the muscle proteins of buffalo and cattle are presented in Figure IV.3.

Sarcoplasmic protein fraction showed five dense bands in both buffalo and cattle. However, one additional band was noticed in cattle in the low molecular weight region.

Electropherograms of myofibrillar fractions showed seven bands in buffalo and cattle. One additional band could also be noticed in buffalo in the low molecular weight region.

The amino acid composition of the muscle protein of buffalo and cattle obtained during the study are presented in Table IV.10.

Fig.IV.3. Gel electropherogram of muscle protein
1 and 2 Myofibrillar proteins of buffalo
3 and 4 Myofibrillar proteins of cattle
5 Sarcoplasmic proteins of buffalo
6 Sarcoplasmic proteins of cattle



1 2 3 4 5 6

Table IV.10. Amino acid composition of meat

Amino acid	Buffalo		Cattle	
	Molar ratio	Molar weight per cent	Molar ratio	Molar weight per cent
Aspartic acid	0.14	5.9	0.23	9.0
Threonine	0.07	2.9	0.10	3.9
Serine	0.06	2.5	0.09	3.5
Glutamic acid	0.68	29.0	0.73	28.6
Proline	0.09	3.8	0.07	2.7
Glycine	0.18	7.6	0.16	6.2
Alanine	0.18	7.6	0.23	9.0
Arginine	0.20	8.5	0.25	9.8
Valine	0.01	0.4	0.05	1.9
Methionine	0.05	2.1	0.05	1.9
Isoleucine	0.14	5.9	0.14	5.4
Leucine	0.18	7.6	0.16	6.2
Tyrosine	0.06	2.5	0.05	1.9
Phenylalanine	0.07	2.9	0.07	2.7
Histidine	0.11	4.7	0.06	2.3
Lysine	0.09	3.8	0.08	3.4
Tryptophan	0.009	0.3	0.01	0.3
Cystine	0.021	0.8	0.018	0.7

Note: Hydroxyproline was not determined.

The actin and myosin contents of the muscle protein and its ATP-ase activity and sulphhydryl content are presented in Table IV.11.

Table IV.11. Actin and myosin contents, sulphhydryl content and ATP-ase activity of the muscle protein

Parameter	Buffalo	Cattle
Actin (mg/100 g)	9.5	7.1
Myosin (mg/100 g)	29.7	27.1
Sulphhydryl content of myosin (moles per 10^5 g)	3.7	3.1
Sulphhydryl content of actin (moles per 10^5 g)	2.4	1.8
ATP-ase activity of myosin (μ mole of P_i per mg protein per minute)	0.77	1.71

Both actin and myosin were found to be higher in buffalo meat than in cattle meat. The sulphhydryl contents of both actin and myosin were higher in buffalo meat than in cattle meat. At the same time the ATP-ase activity was less in buffalo meat than in cattle meat.

DISCUSSION

In human nourishment, meat provides high value biological proteins.

It is well established that the chemical composition of meat is dependent on a number of factors like age, sex, breed, plane of nutrition, hormonal influence and type of muscle. In the present study the subjects were all adults of nearly identical age group, maintained on similar nutritional regime. The meat samples were pooled and the determinations were carried out on a pooled homogenate.

In developing countries like India, the consumer seldom has a choice over cuts and hence "preferential cuts" are not usually available in the market. Moreover, in India

the export of beef is banned by law. Often cases are referred from the Customs Department to verify whether the product for export labelled as buffalo meat is actually buffalo meat or beef. Knowledge of the differences in the chemical composition of the meat will be of great importance in such cases for proper assessment.

The percentages of moisture, dry matter and ash in the meat of buffaloes (76.1, 23.9 and 1.2 per cent respectively) were found to be similar ($P > 0.01$) to those observed in cattle (77.9, 22.1 and 1.0 per cent respectively) (Table IV.7.).

The results obtained from the studies in buffalo meat agreed with the reports of Winton and Winton (1949), Yadava and Singh (1974) and Joksimovic and Ognjanovic (1977). However, the values obtained in the present study are higher than those reported by Maymone and Bergonzini (1960). Kurbanov (1961) and Ferrara *et al.* (1969).

In cattle, the percentage of moisture obtained was more and dry matter less than that in the published reports presented earlier. The percentage of ash content obtained agreed with the results of Prince and Schweigert (1960), Hafez and Dyer (1969) and Lall (1977). On the contrary,

it was less than those reported by Libby (1975), Ferrara et al. (1969) and Ranjan (1980).

Buffalo meat contained more glycogen (around 4.6 times) than the meat of cattle under identical conditions. This is suggestive of a higher nutritive value of buffalo meat. The values for the glycogen were, however, lower than the literature value. The animals were fasted for a period of 30 hours prior to slaughter and this could account for the low glycogen reserve in these post-rigor muscle samples.

Muscle fat content of buffalo was found to be less (1.2 per cent) than that of cattle (1.7 per cent). Histological studies also showed that the intramuscular adipose tissue was found to be sparse in buffalo compared to cattle thereby substantiating the observations based on biochemical studies. The results obtained from studies in buffaloes agreed with the earlier reports of Ognjanovic et al. (1970) in Bulgarian buffaloes and Cockrill (1974) in low fat buffaloes. But, the values were more than those observed by Ognjanovic et al. (1970) in Murrah and cross-bred buffaloes. Results of the present study were lower than those reported by Cockrill

(1974) in high fat buffaloes. Fat is the obvious source of energy for animals and it is also well established that depot fat content and composition are influenced by factors like diet, environmental temperature, feeding habits and maturation (Hilditch and Williams, 1964). Hence, such factors would have contributed significantly to this difference in values. The value obtained for fat content in cattle was lower than many of the reports published earlier (Fox and Cameron, 1977; Marian et al., 1980 and Ranjan, 1980).

The distribution of the subcutaneous fat was found to be less in buffalo than in cattle. Also, it was found that the proportion of total fat in the pelvic channel and around the kidneys appeared to be less in the buffalo than in cattle. With the trend towards preference for lean meat, it would seem that the buffalo appears to be more suited for the modern meat market. Tests for intramuscular fat content revealed a lower value in buffaloes than in cattle.

Odour and flavour of meat are dependent to a large extent on the fat content. Fat meat has a higher satiety value than lean meat.

Fat with a high stearin content is more consistant. It appears from the data gathered that buffalo fat is more consistant than that of cattle.

Palmitic acid and octadecenoic acids are the major fatty acids of depot fat. In old animals, the normally low hexadecenoic acid ($C_{16:1}$) tends to show an increase.

Out of the fatty acids studied, $C_{18:1}$ was the major acid for both groups followed by $C_{18:0}$, $C_{16:0}$, $C_{18:2}$, $C_{16:1}$ and $C_{14:0}$ in that order. But Wildman *et al.* (1968) and Borghese *et al.* (1978) observed the order as $C_{18:1} > C_{16:0} > C_{18:0} > C_{16:1} > C_{18:2} > C_{14:0}$. The outstanding observation made in this study is that $C_{18:0} > C_{16:0}$ and $C_{18:2} > C_{16:1}$ for both buffaloes and cattle. On the whole, there was an accumulation of C_{18} acids in muscle fat compared to C_{16} acids as observed by Borghese *et al.* (1978). This can well be interpreted as the effect of environmental temperature on the depot fat constitution. The animals employed in the present work were maintained at an ambient temperature of about 30 ± 2°C. The elevated amount of long chain C_{18} (saturated and mono-unsaturated) fatty acids at the expense of C_{16} (saturated and mono-unsaturated) acids appears to be a general feature of tropical climate.

Studies on the fatty acid composition of the muscle fat in buffaloes and cattle of this region are scanty. However, studies conducted by several workers on tropical fish showed that muscle fat of fish of this region contained elevated amounts of saturated long chain fatty acids compared to fish of colder regions (Gopakumar and Nair, 1972; Viswanathan and Gopakumar, 1978; Yamada and Hayashi, 1975).

Dietary fat exerts probably little influence on the depot fat of ruminants, for, ingested and unsaturated fatty acids are hydrogenated by rumen microbes. Ruminants regulate the degree of unsaturation of the fat by interchange between stearic acid and hexadecenoic acids. The higher level of hexadecenoic acid in buffaloes could reflect its increased ability to regulate the degree of unsaturation of its fat.

Buffalo lipids contained higher levels of both total saturated and mono-unsaturated fatty acids (44.3 per cent and 42.9 per cent respectively) compared to that of cattle (43.1 per cent and 40.6 per cent). It appears that buffalo lipids can be distinguished from beef lipids by the higher levels of $C_{18:0}$ acid. This could well be used

to detect substitution of meat.

As regards poly-unsaturated fatty acids, cattle lipids recorded a much higher value (16.3 per cent) compared to that of buffalo (12.8 per cent), $C_{18:2}$ being the most dominant (12.5 per cent to 8.6 per cent). This definitely indicates that cattle lipids are more susceptible to auto-oxidation compared to buffalo lipids. Auto-oxidation of lipids is reported to produce yellow discolouration by the production of hydroperoxides and ultimately carbonyl compounds in muscles. According to Olcott (1934) oxidation of the meat is directly proportional to the amount of poly-unsaturated fatty acids in the lipids of meat. Hence, it can well be interpreted that cattle meat is more prone to oxidation. Auto-oxidation of lipids produced malonaldehyde which caused the yellow discolouration of the fat(Banks, 1939). Hence, this study could very well explain the lesser discolouration observed in buffalo meat as time passes as compared to that in cattle.

Consequent to the higher level of unsaturated acids, the iodine value for beef fat should be higher than that in buffaloes.

Linoleic, linolenic and arachidonic acids appear to be essential for health. Values for these three acids are higher in beef than buffaloes and so, it appears that beef is a better source for these acids than buffalo meat.

The saturated/unsaturated fatty acids ratio in buffalo is 0.795, which in cattle is 0.757. Feeding a diet rich in concentrates as in this experiment might have favoured deposition of more unsaturated fatty acids in tissues. It has been reported that feeding of forage diet favours deposition of mainly palmitic acid.

Buffalo meat had more total nitrogen (3.585 g per cent) than cattle meat (3.190 g per cent). The information on percentage of protein in buffalo meat is scanty. The value obtained in the present study is higher than those reported by Winton and Winton (1949), Joksimovic and Ognjanovic (1977) and Lall (1977).

The myofibrillar protein, sarcoplasmic protein and non-protein nitrogen fractions in buffalo meat were found to be more than those in cattle.

The stroma protein fraction was found to be 7.5 per cent less in buffalo meat. The stroma protein fraction consists of sarcolemma, collagen, reticulum and elastin

fibres and of insoluble enzymes involved in oxidative phosphorylation. Higher content of stroma protein in beef is indicative of the stiffer structure of the muscle compared to that in buffalo. It may be pointed out here that in histological studies a higher connective tissue content was observed in cattle.

The value for sarcoplasmic protein of the protein fraction in samples collected immediately after slaughter was found to be slighdy higher in buffaloes. Sarcoplasmic proteins consist of a complex mixture, mainly myogen and globulins, many of which are enzymes of the glycolytic cycle.

The myofibrillar protein of the protein fraction was found to be 6.18 per cent more in buffalo meat (Table IV.9.). This could mean that buffaloes have a higher work output than cattle. Since the meat samples collected immediately after slaughter were not denatured, the alkali soluble portion of the protein was virtually absent.

By comparing the protein fractions, it can well be summarised that buffalo meat is superior to beef. Further, it may be seen that buffalo meat is less fibrous (Table IV.9.) compared to beef indicating that it is softer to

chew than the meat of cattle which is more fibrous and hence, tougher. Such a conclusion is justified by the histological findings. In the muscle of buffaloes the fibres were loosely arranged with little stromal tissue. The connective tissue was also relatively less compared to cattle.

The muscle fractions when examined 36 hours after slaughter revealed that in both the species it was myofibrillar portion of the protein fraction that got denatured mostly and correspondingly the alkali soluble fraction was found to be elevated.

The loss of myofibrillar portion of the protein was more in buffalo than in cattle. The other fractions of the muscle protein remained practically unaffected especially the sarcoplasmic fraction of the muscle protein (Table IV.9.). The alkali soluble portion of protein was high in buffaloes. This is suggestive of a tendency for rapid denaturing of buffalo meat than beef.

In fresh muscle samples, the actin and myosin are firmly bound to the myofibrillar structure. When the myofibrils were cut up by the homogenation process into much smaller fragments these portions became much more

accessible to the extracting solutions and became more extractable. This also increased the alkali soluble portion of the protein thereby reducing the myofibrillar portion of the protein structure. The changes in the pattern were probably caused by an alteration of the binding of proteins to each other.

From the result of the loss of structural protein it may very well be presumed that the keeping quality of buffalo meat is less compared to beef. This view is also supported by the increased sulphhydryl content of both actin and myosin and decreased ATP-ase activity of myosin in buffalo meat, indicative of the unfolding of the protein structure due to quick denaturing in buffalo meat than in the meat of cattle.

A comparison of the electropherogram of the sarcoplasmic protein from cattle and buffalo showed that the patterns were basically similar in both cases. However, the fast moving albumin band in the case of cattle was found to have slightly higher mobility. This might be attributed to either low molecular weight or minor differences in the net charge of the protein molecules.

The patterns of myofibrillar proteins showed bands

of actin, myosin and other fractions in both the cases. Here also, the pattern showed similarity in both the species even though the relative mobility showed minor variations. The buffalo myofibrillar protein also revealed an additional band of low molecular weight.

It appears from the data collected that the presence of an additional band in the low molecular weight region in sarcoplasmic protein fraction as well as the absence of such a band in the low molecular weight region in myofibrillar protein fraction could be used as a test to differentiate beef from buffalo meat.

The study revealed that glutamic acid, aspartic acid, alanine, leucine, isoleucine, glycine and arginine were predominant amino acids contributing to the protein structure in both buffalo and beef. However, the molar distribution of amino acids in the two species did not exhibit any significant variation. Histidine content of buffalo meat was higher than beef.

A comparison of the data reveals that the total contents of essential amino acids in beef (0.977) is higher than in buffaloes (0.933). From the nutritionist's point of view, it is seen that buffalo meat has a much

more balanced amino acid pattern than beef, with much less stroma protein content,

CHAPTER V

GENERAL DISCUSSION

People of Kerala, unlike those in other regions of India, have no taboo or sentiments over eating animal proteins including beef. According to the 1977 Livestock census, 30.1 lakh heads of cattle and 4.54 lakh heads of buffaloes have been enumerated in Kerala. The 1981 census revealed the total human population in the State as 254 lakhs with a density per sq. km as 654. It is highly doubtful whether increase in food production alone in the State could meet the future requirements of the population. Hence, search should be made for readily available cheap sources of animal proteins.

The male buffalo calves are normally left uncared

for and the farmer utilises all the available milk of the dam, since it is commercially more valuable than the life of an unwanted extra animal, and hence, are callously allowed to starve to death. Much useful raw material for animal protein is thus lost. It was felt that rearing these discarded male calves on an ideal nutritional regime and studying their meat potentialities and meat qualities could very well make a notable contribution to human welfare and thereby the internal economy of the State. The present study was undertaken with this objective in mind. The animals procured for the study were all Surti cross-breds and were maintained in the University farm under ideal conditions of management. Calves born from these Surti cross-breds were subjected for growth studies. Growth studies were largely concentrated on external body measurements and increases in gross live weight. The rate of growth recorded a declining trend from birth to the second month of age, attributable to the change from pre-natal to post-natal life. A subsequent depression was also noted from the fourth month to the seventh month of age probably due to the switch over from a complete milk feed to an all-concentrate ration, and to the absence of a fully

developed functional rumen. During this latter period, the external body measurements, namely, girth, length and height, also recorded a similar declining trend. The animals recovered from this depressive trend by the ninth month of age. The processes of change involved in growth and development exert an impact on the efficiency of meat production and also on the nature of the final product. The calves employed in the study were Surti cross-breds and hence the lower weight at the twelfth month of age obtained could be correlated to the reduced mature weight of these animals. No attempt was, however, made to determine the rate of bone growth, muscle formation and fat deposition so as to specify the causative agent for the growth pattern observed. It appears from the data collected that recording either the increase in gross live weight or external body measurement alone is not sufficient to project the growth profile.

Dressing percentage is the primary criterion of production to be considered at slaughter by personnel involved in meat production. When the carcass weight is related to the weight at slaughter, the dressing percentage obtained depends on the gut content of the

animals and therefore on the type of diet, food intake and duration of starvation prior to slaughter. In the present study, when dressing percentage was calculated by relating the carcass weight to the empty body weight, cattle was found to be superior (57.6 per cent) to buffalo (53.5 per cent). The same was the trend even when the carcass weight was related to weight at slaughter (cattle, 55.2 per cent; buffalo, 51.1 per cent). It appears that dressing percentage can be considered as a poor criterion for evaluating edible meat in animals when carcass weight is related to live weight. It may be noted that the animals employed in the study were fasted for 30 hours before the slaughter. This might have resulted in a decrease in the weight at slaughter leading to an increase in the dressing percentage attributable to a reduction in the weight of gut content. The dressing percentage increases with fatness of animals. In the present study, the percentage of separable fat in cattle was 7.3 compared to 4.7 in buffalo. This might also account for the lower dressing percentage in buffalo. The lower dressing percentage in buffalo could also be due to the higher weights of head and hide. The elevated percentage weight of bone in buffaloes (24.5 per cent)

compared to cattle (20.9 per cent) has resulted in variations in the percentage weights of edible meat (buffalo, 70.4; cattle, 72.4). The lower meat-bone ratio (2.9) observed in buffaloes in the present study justifies the lower percentage of edible meat recorded in buffalo as compared to that in cattle.

It appears from the data that, excepting for liver, all the internal organs studied, namely, kidneys, digestive organs, lungs and heart exhibited higher percentage of weight in buffalo compared to those in cattle.

Buffalo had a lower content of muscular fat than cattle. Light microscopic studies also revealed identical results. Several factors influence the composition of depot fat. Deposition of stearic acid formed by hydrogenation in rumen results in a higher saturation of fat as the animal increases in age from birth to one year. The depot fat becomes unsaturated when the animals enter the fattening phase. It has been established that subcutaneous fat is more unsaturated than the muscular fat which in turn is more unsaturated than the internal depots. A high concentrate ration results in deposition

of more unsaturated fat in the fat depots. In the present study, the animals were maintained on a concentrate ration in excess of the requirements based on Morrison standards. The higher percentage distribution of unsaturated fatty acids observed in the present study in both the species could be attributed to this dietary regime. The animals employed in the present study had been castrated at twelfth month of age. Castration of animals is known to increase the degree of unsaturation of depot fat. The content of stearic acid was also high in buffalo and this could explain the high consistancy of buffalo fat. One of the notable observations in the present study is the prepond-arance of stearic acid over palmitic acid in muscular fat in both the species. This could be attributed to the tropical environment in which these animals are reared. The results are, thus, highly suggestive of an environmental influence on the composition of depot fat.

In recent times a correlation has been shown between coronary disease and raised plasma cholesterol level. This has resulted in curtailing the consumption of saturated animal fat particularly that of ruminant origin. The percentages of saturated fatty acids in both buffalo

and cattle were almost identical. Triglyceride level is presently believed to be more critical than cholesterol in inducing coronary diseases. No attempt was made to determine the triglyceride level in the present study.

The depot fats in animals are derived mainly from two sources: endogenous synthesis within the body and from exogenous food materials. In the case of ruminants the fatty acid composition in depot fat is unaffected by variations in the dietary fat since dietary fats are hydrogenated in the rumen. The high level of hexadecenoic acid in buffalo could reflect its increased ability to regulate the degree of unsaturation of depot fat. Buffalo lipids are also less prone to auto-oxidation.

Meat provide higher value biological proteins. The percentage of total protein was higher in buffalo (20.0) as compared to cattle (18.1). The percentage of stroma protein nitrogen in fresh samples was also less in buffalo (12.5) compared to cattle (20.0). This indicates the higher nutritive value of buffalo meat compared to cattle. Light microscopic studies also revealed a lesser fibrous structure of buffalo meat. When the muscle samples were examined after a lapse of 36 hours, the

myofibrillar protein content in buffalo meat was found to exhibit an appreciable decrease compared to that in cattle. Simultaneous with this there was an increase in the alkali soluble protein fraction in buffalo meat, indicative of a rapid denaturation of protein. This is suggestive of a lower keeping quality of buffalo meat compared to beef. The higher sulphhydryl content with lesser ATP-ase activity observed in buffalo meat also justifies such a conclusion.

Buffalo meat appears to have a better nutritive value compared to beef because of a lesser fat content, elevated glycogen level, high protein content, reduced stroma protein concentration and a more balanced distribution of the essential amino acids.

It appears from the data that the relative dominance of stearic acid, the higher total protein content, the lesser stroma protein nitrogen, the presence of an additional band in the low molecular weight region in myofibrillar protein fraction and the absence of a distinguishing band in the low molecular weight region of the sarcoplasmic protein fraction in gel electropherograms, the presence of scanty adipose tissue and the

loose wavy tight bundles of the muscle fibres with lesser stromal tissue in light microscopic studies could be used as distinguishing characteristics that could be safely employed to identify buffalo meat from beef. It is felt that these tests will be of great help to prevent fraudulent practices in meat industry.

SUMMARY

SUMMARY

The meat potentialities and meat qualities of buffaloes have been studied in Surti cross-breds and the results compared with those of cross-bred cattle.

Male buffalo calves born in the farm recorded an average birth weight of 28.6 kg and attained an average weight of 169.1 kg at the twelfth month. Due to the predominant Surti blood of the foundation stock, the calves recorded lower birth weight and lower weight at one year of age.

The rate of growth of the calves recorded a declining trend from first month (13.4 kg) to seventh month (9.6 kg) and thereafter gradually increased to twelfth month of age (16.6 kg).

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The rate of growth of the calves recorded a declining trend from first month (13.4 kg) to seventh month (9.6 kg) and thereafter gradually increased to twelfth month of age (16.6 kg).

The absolute weight gain also showed a declining trend from 443 g in the first month of age to 316 g in the seventh month, and thereafter gradually increased to 550 g at the twelfth month.

The girth and length also increased from 71.9 cm and 64.0 cm respectively from birth to 153.1 cm and 115.8 cm respectively at twelfth month of age, with a declining trend up to seventh month of age. A similar decline was also noted for height from birth to the seventh month of age.

From the data collected, it appears that true growth can be assessed by recording periodically the body weight along with the external body measurements.

Transit loss due to transportation and subsequent starvation was found to be less in buffaloes than in cattle. This is suggestive of the possibility of transporting buffaloes for long distances by even trekking, with comparatively lesser loss in weight than cattle.

Due to higher percentage of weight of hide and head, buffaloes gave a lower dressing percentage (51.1) than cattle (55.2).

The weight of fore-quarters was more than the hind-quarters in both buffaloes and cattle. Also, the percentage weight of fore-quarters in cattle was significantly more (3.9) than in buffalo. This could be due to the greater development of the rhomboideus muscle in cattle.

The skin of buffalo recorded a significantly higher weight (3.6 per cent) than cattle.

The weight of all the internal organs, excepting liver, was found to be more in buffalo than in cattle.

The percentages of weight of edible meat and separable fat were more in cattle (2.0 and 2.6 respectively). The percentage weight of bone was found to be higher in buffaloes (3.6). Cattle recorded a higher meat-bone ratio (3.5) than buffalo (2.9).

The percentages of moisture, dry matter and ash in the meat of buffalo (76.1, 23.9 and 1.2 respectively) were found to be similar to those observed in cattle (77.9, 22.1 and 1.0 respectively). The glycogen content of the post-rigor samples of buffalo meat was found to be more (4.6 times) than that in cattle.

Buffalo meat was found to have less muscular fat than cattle. This was also supported by the histological

findings. Buffallo appears to be more suited for the modern meat market considering the trend towards the preference for lean meat.

Due to the higher content of stearic acid, the buffalo fat appeared more consistant than cattle fat. Out of the fatty acids studied, $C_{18:1}$ was the major acid for both the species, followed by $C_{18:0}$, $C_{16:0}$, $C_{18:2}$, $C_{16:1}$ and $C_{14:0}$ in that decreasing order. The preponderance of C_{18} acids over C_{16} acids could be attributed to the effect of environmental temperature on the depot fat constitution.

It appears that buffalo lipids can be distinguished from beef lipids by the higher level of $C_{18:0}$ acid.

Cattle lipids recorded a much higher amount of poly-unsaturated fatty acids (16.3 per cent) compared to buffalo (12.8 per cent) indicating that cattle lipids are more susceptible to auto-oxidation, producing malonaldehyde, and hence the yellow discolouration of the fat.

Buffalo meat was found to be a better source for linoleic, linolenic and arachidonic acids than beef.

Buffalo meat had more total nitrogen (3.585 g per cent) than cattle meat (3.190 g per cent).

The myofibrillar, sarcoplasmic and non-protein nitrogen fractions were more in buffalo than in cattle. The stroma protein fraction was, however, found to be 7.5 per cent less in buffalo meat. The higher stroma protein content in the meat of cattle is indicative of a stiffer structure of the muscle than buffalo meat. This view is also supported by the histological studies.

By comparing the protein fractions, it can well be surmised that buffalo meat is superior to beef. Further, it was found that buffalo meat was less fibrous than beef indicating that it is softer to chew than beef.

Thirty six hours after slaughter, the myofibrillar portion of the protein was found to be reduced due to denaturation and correspondingly the alkali soluble fraction was found to be elevated. This fraction was found to be more in buffalo meat than beef indicating rapid denaturation of buffalo meat than beef. This is suggestive of a poor keeping quality of buffalo meat. This view is also supported by the increased sulphhydryl contents of both actin and myosin and decreased ATP-ase

activity of myosin in buffalo meat indicating rapid unfolding of the protein structure.

Comparing the electropherograms of the muscle proteins, it appears that the presence of an additional band in the low molecular weight region in sarcoplasmic protein fraction as well as the absence of such a band in the low molecular weight region in myofibrillar protein fraction could be used as a test to differentiate beef from buffalo meat.

The molar distribution of amino acids of buffalo and cattle did not exhibit any significant variation. Total content of essential amino acids in beef was found to be higher (0.977) than in buffalo (0.933).

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STUDIES ON THE MEAT QUALITIES AND MEAT POTENTIALITIES OF BUFFALO CALVES

BY
THACHANAT GOPALAN RAJAGOPALAN

ABSTRACT OF A THESIS

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Kerala Agricultural University

Department of Physiology
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
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ABSTRACT

Meat potentialities and meat qualities of buffaloes were studied and compared with those in cattle.

Surti cross-bred male buffalo calves recorded an appreciable depression in the growth rate, as measured by external body measurements and increase in gross live weight, initially after the pre-natal stage and thereafter from fourth to seventh month of age from which they recovered gradually by the ninth month of age.

Transit weight loss due to transportation and subsequent fasting was found to be less in buffalo due to its thick skin, scanty sweat glands and sturdy nature.

Dressing percentage in buffalo was less than in cattle. The percentage weight of fore-quarters was more in cattle, while the percentage weight of hind-quarters was more in buffalo.

Percentage weights of all the internal organs, excepting liver, were found to be more in buffalo than in cattle. The percentage weights of edible meat, separable fat, and meat-bone ratio were also high in cattle than in buffalo.

The percentage of moisture, dry matter and ash

were found to be similar in the meats of both buffalo and cattle. Glycogen content was 4.6 times more in post-rigor samples of buffalo meat than in the meat of cattle.

Total lipid content in buffalo meat was less than in beef. Higher levels of C_{18} fatty acids at the expense of C_{16} (saturated and mono unsaturated) acids were noticed in both buffalo and cattle. Buffalo lipids had higher concentration of $C_{18:0}$ acid. Cattle lipids contained higher levels of poly-unsaturated fatty acids.

Buffalo meat had more total nitrogen than the meat of cattle. Among the different fractions, myofibrillar protein, sarcoplasmic protein and non-protein nitrogen were more in buffalo meat than in cattle. But, the stroma protein fraction was found to be much less in buffalo meat. Histological studies also substantiated this conclusion.

Myofibrillar protein fraction of buffalo meat, 36 hours after slaughter, showed considerable reduction. Also, higher levels of alkali soluble protein were observed. The sulphhydryl contents of both actin and myosin were found to be higher and the ATP-ase activity

was found to be less in buffalo meat than in the meat of cattle.

Gel electropherograms of sarcoplasmic protein showed six bands in cattle as against five in buffalo while myofibrillar protein fraction of buffalo showed eight bands compared to seven in cattle.

Essential amino acid contents appeared to be slighly more in cattle than buffalo. But, the distribution of amino acid was found to be more balanced in buffalo meat.