

**DEVELOPMENT OF DECISION SUPPORT SYSTEM
FOR BODY CONDITION SCORE (BCS) IN COWS
THROUGH ARTIFICIAL INTELLIGENCE (AI)**

THESIS

Submitted

In partial fulfillment of the requirements for the Degree of

MASTER OF VETERINARY SCIENCE

IN

LIVESTOCK PRODUCTION AND MANAGEMENT

BY

**WANKHADE TEJAS SUNIL
Enrolment No. V/11/148**

Nagpur Veterinary College, Nagpur

**MAHARASHTRA ANIMAL AND FISHERY SCIENCES
UNIVERSITY, NAGPUR - 440 001**

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DECLARATION OF STUDENT

I hereby declare that the experimental research work and interpretation of the thesis entitled “**DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR BODY CONDITION SCORE (BCS) IN COWS THROUGH ARTIFICIAL INTELLIGENCE (AI)**” or part thereof has not been submitted for any other degree or diploma of any University, nor have the data been derived from any thesis/publication of any University or scientific organization. The sources of materials used and all assistance received during the course of investigation have been duly acknowledged.

Date:

Place:

(Wankhade Tejas Sunil)

Enrollment No: V/11/148

Counter signed by

(Dr. S. S. Chopade)

Chairman

Advisory Committee

DECLARATION OF ADVISORY COMMITTEE

Wankhade Tejas Sunil has satisfactorily prosecuted his course of research for a period of not less than one semester and that the thesis entitled “**DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR BODY CONDITION SCORE (BCS) IN COWS THROUGH ARTIFICIAL INTELLIGENCE (AI)**” submitted by him is the result of research work is sufficient to warrant its presentation to the examination in the subject of **LIVESTOCK PRODUCTION AND MANAGEMENT**

for the award of **MASTER OF VETERINARY SCIENCE** degree by the Maharashtra Animal and Fishery Sciences University, Nagpur.

We also certify that the thesis or part thereof has not been previously submitted by him for a degree of any other University.

Place: Nagpur

Date:

(Dr. S. S. CHOPADE)

Advisor/Guide

Professor

Dept. of Livestock Production and Management

Advisory Committee

Name	Designation	Signature
1) Dr. S. S. CHOPADE (Chairman)	Professor, Livestock Production and Management	_____
2) Dr. J. M. CHAHANDE (Member)	Professor & Head, Livestock Production and Management	_____
3) Dr. D. S. RAGHUWANSHI (Member)	Professor Deputy Director of Research Cattle Breeding Farm	_____
4) Dr. M. S. PATIL (Member)	Dr. M. S. PATIL Assistant Professor, ARGO	_____
5) Prof. ANKIT BHURANE (Member)	Assistant Professor, Dept. of Elect and Communication VNIT, Nagpur	_____

CERTIFICATE

This is to certify that the thesis entitled, “**DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR BODY CONDITION SCORE (BCS) IN COWS THROUGH ARTIFICIAL INTELLIGENCE (AI)**” submitted by **WANKHADE TEJAS SUNIL** to the Maharashtra Animal and Fishery Sciences University in partial fulfillment of the requirement for the degree of **MASTER OF VETERINARY SCIENCE** has been approved by the Student's Advisory Committee after examination in collaboration with the External Examiner.

Name & Signature of
External Examiner

Signature with Seal
Head of Department

(Dr. S. S. CHOPADE)
Advisor/Guide
Professor
Dept. of Livestock Production
and Management

Advisory Committee

Name	Designation	Signature
1) Dr. S. S. CHOPADE (Chairman)	Associate Professor, Livestock Production and Management	_____
2) Dr. J. M. CHAHANDE (Member)	Professor & Head, Livestock Production and Management	_____
3) Dr. D. S. RAGHUWANSHI (Member)	Dr. D. S. RAGHUWANSHI Associate Professor Farm Incharge CBF, Nagpur	_____
4) Dr. M. S. PATIL (Member)	Dr. M. S. PATIL Assistant professor, ARGO	_____
5) Prof. ANKIT BHURANE (Member)	Prof. ANKIT BHURANE Assistant Professor, Dept. of Elect and Communication VNIT, Nagpur	_____

**Associate Dean
Nagpur Veterinary College,
Nagpur.**

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LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL FORM
/	Per
<i>et al.</i>	et alii /alia, And others
No.	Number
Sr. No.	Serial Number
AI	Artificial Intelligence
<i>viz.</i>	Videlicet
BCS	Body Condition Score
BCS +	Body Condition Score plus
BCS -	Body Condition Score minus

INTRODUCTION

The dairy animals maintained by various dairy producers are either too fat or too thin at various stages of lactation. It is essential to determine body condition of each dairy cows at different stages of lactation for taking timely action. Failure in taking timely action may result in bad effect on health of cows and ultimately increased loss of milk production and decreased fertility.

Body condition score (BCS) is an important technique to evaluate body fat stores and estimate cumulative energy balance through visual or tactile inspection of dairy cow. It reflects the body fat reserves carried by the animal which can be used by the cow when she is unable to eat enough to satisfy her energy needs. This condition may arise during early lactation in high producing cows and when cows get sick, fed poor quality feeds, or feed intake is restricted. After a period of weight loss, cows should be fed more than their requirements to restore normal body condition. Due to its simplicity and repeatability BCS is considered as an important factor for management of dairy cattle.

By looking and handling of the backbone, loin and rump areas of Cows body condition score should be determined. The pin bone, hip bone, top of the backbone and ends of the short ribs do not have muscle tissue covering, hence, any covering on these areas felt is the combination of skin and fat deposits. Cows should be scored regularly in each stage of lactation to evaluate the fat reserves in the body. The analysis of health problems, feed intake, and optimal time interval between calving and first service of cattle is evaluated by BCS. For cattle, sheep and goats, the scoring systems most commonly used for BCS numerical scales with 5-point, 6-point, 8-point or 10-point scales.

The body condition score of dairy cows is normally a number in a scale that spans from 1 to 5 (0.25 increments) or from 1 to 9 (1 increment). Generally, the dairy management experts describe thin animals with lower body scores (1 represents

emaciated cows) and fat animals with higher scores (5 represents obese cows) in 5-point system. An ideal body condition scores of cow at dry off and calving is 3.0-4.0 and at peak lactation is 2.5-3.5. The change in body condition score of cows during any lactation period should not be more than 1 condition score class.

Most of the existing methods for measuring Body Condition Scores of dairy cows have been based on a subjective assessment of tissue reserves of lactating dairy cows. Body condition scoring is best described by Schroder and Staufenbiel (2006) as a “subjective estimate of the metabolizable energy reserves in the adipose tissue”. The method of scoring the body condition is a scale using visual or tactile evaluation of body shape of a cow to categorize the amount of adipose tissue and the body condition is divided into categories represented by numbers. For dairy cattle, the most used scales have 5, 8 or 10 points (Roche *et al.*, 2004) but the unit increments may vary and therefore, number of scores is quite similar. Some scales score the body as a whole unit while others only score certain body locations, these are scored separately and then integrated to an absolute score (Wildman *et al.*, 1982; Ferguson *et al.*, 1994; Roche *et al.*, 2004). Combinations of both methods exist as well (Edmonson *et al.*, 1989; Gillund *et al.*, 1999). For instance, some of the most cited scales are described by Wildman *et al.* (1982), Edmonson *et al.* (1989) and Ferguson *et al.* (1994) and have certain common characteristics; the scales are 1 to 5 point scales with 0.25 units of increment. With such a scoring system the cow can receive 17 different scores. Usually, low numbers represent thin animals and high numbers represent obese animals (Bewely and Schutz, 2008).

Among the many attempts for estimating body condition scores automatically, the first attempt by Coffey *et al.* (2003) tested using line patterns painted with laser light over the tail head area of the cows. Some attempts apply digital images or some system used videos and an analysis of the cow’s contour and shape that commonly involved. Røiivik *et al.* (2016) have taken 3D images from the above view of the cow acquisition of data automatically. Halachmi *et al.* (2008) have also taken thermal images and they made decision that fatter cow’s shape is rounder.

A computer program Mat lab 2015 was used for preprocessing of cows' back view images to extract the computationally manageable representation of the anatomy of the back shape of cows. Twenty five anatomical points are identified and they are important for representation of the shape. Three points of body of cow are used for measuring angles according to law of cosine method. In all five angles including two angles around the left and right hooks; two angles around the tail head depression area and one angle at the peak of the tail head are computed.

BCS is necessary to judge animal's production & reproduction status; to fine tune herd nutrition and health management and to take corrective measures to improve animal's performance. As a matter of importance of the BCS in relevance to the farmers, it can be stated that by accurate estimation of BCS of animal the farmers may take corrective steps for improvement of health and performance of the animal through various management practices. In view of this, the aim of the proposed research is to develop a system that models the body shape of a cow from the back and lateral view images and then assesses the BCS with observed angle features in score estimation. The farmers may take help of these angle features to decide the score of the animal on his mobile phone via developed mobile application. The research work is undertaken with the following objectives.

11. OBJECTIVES

1. To develop AI based decision support system for estimating body condition score in cows.
2. To suggest corrective measure to farmers through mobile based BCS application.

REVIEW OF LITERATURE

Wayne Kellogg (1914) stated that by using body condition scores can allow the dairy producer to more accurately achieve adjustments in the nutritional status of the herd.

Reid and Robb (1971) studied fat is the most variable component in the body of lactating dairy cows (as well as the most important energy store.) The amount of fat in the body is similar in first and second lactation but higher in third and higher lactation

Wildman *et al.* (1982) stated that body condition score (BCS) refers to the relative amount of subcutaneous body fat or energy reserve in cows regardless of body weight and frame size.

Edmonson *et al.* (1989) stated that the overall score was most closely related to the condition scores of the pelvic and tailhead areas of the cow and BCS chart is an effective field tool for body condition scoring Holstein cows.

Otto *et al.* (1991) stated relationship between BCS and protein content in the body seems to be diverse depending on body condition; for lower BCS there is a wide range in the percentage of body protein between individuals while for higher BCS the percentage of body protein seems to be similar between individuals. The relationship between BCS and amount of total body protein is however negative.

Shirley (1993) revealed that the body condition scoring provides a tool to help the dairy herd manager evaluate his/her nutrition and management program. It takes time, has an associated cost, and will result in a positive economic return if one makes management changes suggested by the results. Body condition scoring done simultaneously with other herd events reduces the time required and provides the herd manager with coordinated information.

Andrew *et al.* (1994) stated that the variation in water content in the body is greater for pre partum and early lactation cows than for late lactation.

Ferguson *et al.* (1994) stated that BCS using a 5-point scale system with 0.25-point increments, ranging from 1 representing emaciated cows, to 5 representing obese cows.

Ferguson (1996) found that the BCS system of monitoring herds by assessing extremes fairly simple and easy to implement for herds of all sizes.

Markusfeld *et al.* (1997) conclude that the body condition score at calving can have a direct effect on the health, milk yield and fertility of cows. It shows the cumulative effects of the dry period, the body condition score at drying off and the loss of body condition during the dry period.

Gregory *et al.* (1998) showed that there was a curvilinear (quadratic) relationship between condition score and body fatness in addition to measuring dewlap thickness can be used to assess body fat reserves.

Apple . (1999) found that marketing cull beef cows at a BCS of 6 could optimize economic returns to both cow-calf producers and non-fed beef packers.

Koenen *et al.* (2001) found that some breed differences regarding negative energy balance have been noted, some breeds like Friesian seem to recover from it at a much faster rate than for Jersey or Ayrshire.

Broring *et al.* (2002) said that the visual assessment could be improved by more specific scoring, although for research purposes visual assessment would still be inadequate in measuring condition relative to ultrasonic measurements.

Coffey *et al.*(2003) found that breeding values for energy balance can be calculated from single observations of BCS and linear type traits, data that can routinely be collected in national conformation assessment schemes.

Pauline et al. (2003) drawn two main conclusions. First, most N'Dama heifers are scored above 2.5 points. Their subsequent reproductive performances are probably not limited by body condition. On the contrary, multiparous cows, that have higher nutritional requirements, are subjected to a decrease in body fat and mineral reserves during their reproductive life.

Roche, et al.(2004) said that scoring body condition and assessing changes in the body condition of dairy cattle have become strategic tools in both farm management and research.

Schroder et al.(2006) found that the BCS and BFT (back fat thickness) are comparable, ultrasound measurements also may be used to train herd personnel in BCS to increase its precision.

Berry et al. (2007) said that the significant and sometimes curvilinear association between BCS at calving or nadir and milk production. Cows that lost more condition in early lactation produced more milk of greater fat and protein concentration, although a negative marginal effect was observed in cows that lost large amounts of condition post-calving. Milk yield increased with live wt. with the marginal effect decreasing as cows got heavier. Milk composition in early lactation also increased with live wt. pre-calving, calving and nadir, although live weight. did not significantly affect average lactation milk fat and protein concentration.

José Carlos et al. 2007) conclude that when the objective is to use artificial insemination in cows suckling their calves, the cows should present a BCS of at least 3 at one-month postpartum, and with sufficient feed to allow them to increasing their body weight during the breeding period while, suckling cows maintaining BCS 3 throughout the breeding period, the expected pregnancy rate should be around 50%.

Rasby, et al. (2007) described by using body condition scoring as a management tool can increase the profit potential of the cow/calf enterprise, a tool that may help you or your customer do a better job of producing beef

Bewley and Schuntz (2008) stated that genetics also influence energy balance, thus cows selected for a higher milk yield mobilize the reserves in their adipose tissue faster.

Jilek *et al.* (2008) conclude that the higher BCS before calving was associated with higher BCS after calving and those cows showed the shortest calving to first service interval.

Roche *et al.* (2009) found that Cows that calve in greater BCS will have a reduced dry matter intake, will produce less milk, and are more likely to succumb to per parturient metabolic disorders.

Yan *et al.* (2009) revealed that composition of the dairy cow body is in constant change because of the adaptations to lactation and pregnancy. Variation in body water content is positively correlated to lactation stage as well as milk yield, and their relationship is linear.

Anglart (2010) studied that the 3D imaging technique show even small changes in body weight, BCS or eating behavior (rumen fill degree) it can be a powerful tool monitoring health, fertility and welfare on large dairy farms.

Sebastiano *et al.* (2010) conclude that BCS estimation systems are desired to cut down time and costs of the traditional BCS estimation techniques in the context of dairy cattle research.

Azzaro *et al.* (2011) confirmed that the body condition score estimation systems that work fully automatically (with no user intervention) or at least semi automatically (with minimal user intervention) are desired in order to cut down time and costs of the traditional BCS estimation techniques .

Glenn Selk (2013) said that Cows should have a body condition score of 5 to 6, and first calf heifers should have a body condition score of 6 at calving time. It is

very expensive and very difficult to regain body condition after calving and still achieve an acceptable rebreeding percentage.

Bercovich *et al.* (2013) noticed that BCS estimation is a time-consuming process measured manually by trained evaluators. The subjectivity in the judgment of evaluators can lead to different scores for the same cow under consideration, and could be influenced by previously observed cows.

Halachmi *et al.* (2013) stated that the model based on thermal camera and image processing algorithms, intended for evaluation of dairy cow body condition score was designed and implemented.

Ohnstad (2013) said that body condition scoring represents a proactive approach in planning for good health, fertility and milking performance.

Shelley (2016) stated that the increase in advances in technology availability at a accessible cost, automation, and digitalization of livestock farming tasks offer multiple opportunities. In this context, different studies have particularly focused on BCS automation.

Barbara *et al.* (2016) revealed that the body condition on the dry-off day and at calving, as well as its deterioration in the first month of lactation, have a considerable effect on fertility indices in dairy cows, thus confirming the advisability of its regular monitoring during routine operations connected with the management of a dairy cattle herd.

Lukuyu *et al.* (2016) Predicted live weight of over 95 % of crossbred dairy cattle in the range of about 100–450 kg in regardless of age and breed group, using heart girth measurements, which was a great improvement on visual estimation for BCS.

Roi, et al.(2016) estimated that body condition scoring (BCS) is a farm-management tool for estimating dairy cows' energy reserves by using using a low-cost 3-dimensional Kinect camera.

Mishra et al. (2016) stated that the body condition scoring (BCS) provides non-invasive, quick and inexpensive method of estimating of dairy cow energy reserves while,the changes in BCS occurs according to the different stages of cow, i.e., during dry period, gestation, calving, early, mid and late lactation.

Juan et al. (2017) said that the BCS assessment look promising as a tool for supporting cattle decision-making, in a context where information and communication technology (ICT) is becoming more efficient, productive, and cheaper. Acceptable accuracy within the range of human error has been reported, with room for improvement as more effective computing processing methods became available.

Nay et al. (2017) studied on automatic assessing Body Condition Score from digital Images by active shape model and multiple regression technique in cows. The BCS of the cows are estimated using the 5 point scale. Experimental results showed that this method is effective in assessing the BCS of the cow as the predicted scores are closed to the actual scores. Moreover, an experiment also hold the same impression with the assumption of the rounder shape have the higher scores. In the future, a more robust method for extraction of shape and a dataset of back view cow images useful for cattle management will be addressed.

Wangchuk et al. (2017) found that Schaeffer's formula provides good estimate of body weight followed by weigh tape. Agarwal's formula and Rondo tape over- estimate the body weight; therefore, these techniques are not recommended and their use should be discontinued

AshAq *et al.* (2018) said that body condition scoring provides a yardstick for determining the condition of cow without aid of any high technology and investment and It gives an instant evaluation of the body state of the animal and is readily incorporated in operational decision making.

Juan Alvarez *et al.* (2018) stated that it is important to consider that when the BCS system starts to work in a farm, a huge number of images and body condition values will be periodically generated.

Patel *et al.* (2018) observed that BCS subsequently related to the production and fertility status of an animal. Thus, BCS may be used as a tool to aid in the management of nutritional and production programs in dairy herds. However, additional long term studies are required with more number of animals observing the impact of BCS to test the marginal condition effect.

Bell *et al.* (2018) evaluated that the digital BCS can provide a more accurate assessment of cow body fat than manual BCS observations, with the added benefit of more automated and frequent monitoring potentially improving the welfare and sustainability of high production systems.

Thi *et al.* (2018) revealed that an analytic geometry method combining with image processing techniques for automatic evaluation of dairy cow body condition scoring was developed. Introducing a new type of analytic geometric image feature, the authors were able to estimate the BCS of dairy cow with high accuracy.

Song *et al.* (2018) conclude that the sensitivity of automated BCS classification has been improved by expanding the selection of body condition related features extracted from multiple body regions.

Wissal *et al.* (2019) conclude that BCS has clear effects around calving and early lactation where energy intake exceeds energy needs which leads to Negative energy balance.

Sun et al. (2019) found that automatic monitoring system for estimating BCS could help production decision-makers reduce negative energy balance in early lactation through the accurate observation of individuals experiencing rapid declines in body condition.

Sarah et al. (2019) suggested that the beef heifers with body condition score=6 and reproductive tract score ≥ 4 are more likely to become pregnant to artificial insemination. Careful assessment should be undertaken when developing replacement heifers that will not reach 12months of age by the beginning of the breeding season.

Mullins et al. (2019) stated that BCS technology has the potential to serve as a reliable source of BCS scores, which can be incorporated into management practices. Automated BCS technology will allow producers to get more accurate and efficient BCS evaluations on a herd level compared to the more subjective, labor intensive, and error prone manual scoring.

Azafack et al. (2019) showed that the ovaries of local zebu cows raised in Cameroon were a good and nonexpensive source of oocyte for IVEP (in vitro embryo Production). The females oocyte donors with BCS of 3 could be the best choice to improve IVEP and selected cows should be well fed to preserve oocyte yield and quality.

Abhishek et al. (2020) conclude that automated BCS assessment can be used as a tool for supporting cattle decision-making, in a context where ICT technology is becoming more efficient, productive and cheaper.

Thi et al. (2020) revealed that BCS is a frequent topic of research and most important tools for evaluating nutritional status.

The net/web search did not review development of any mobile application on estimation of body condition score by using artificial intelligence & hence, no review cited.

MATERIAL AND METHODS

The present research work entitled “**DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR BODY CONDITION SCORE (BCS) IN COWS THROUGH ARTIFICIAL INTELLIGENCE (AI)**” was carried out during the period of **December 2019 to May 2020** this experiment was conducted in Nagpur Region nearby villages, and District Nagpur.

3.1 Climatic Condition

NAGPUR is located in subtropical region at 21°08'46" N latitude and 79°05'05" E longitudes at an altitude of Elevation above sea level: 319 m = 1046 ft. above mean level of sea, having extreme climatic condition with minimum temperature in winter season 10-12 degree Celsius, Winter lasts from November to February and maximum temperature in summer 44-47 degree Celsius, lasting from March to June, with May being the hottest month

3.2 Sources of Animals

The Study was conducted on the field, at different Gaushalas and Government and well organized private cattle farms. The photographs of 1000 animals was clicked by the camera of the mobile phone. The photograph of each animal was clicked as 1) Rear View and 2) Lateral View. In all 2000 Photographs of 1000 animals was taken during the study.

The photographs was processed on computer by a computerized program *viz;* Image Analysis & Machine Learning Technique.

3.3 Selection of Animals

Data on 1000 cows was generated from different organized farms, NGOs, Gaushalas for completing the need of 1000 cows, by which 2000 photographs was clicked.

All the data of the selected cow was saved for developing of software.

All the corrective measures was given to the farmer after the evaluations of the BCS for improving the quality of the herd and for increasing the economic wealth of the farmer.

The mobile application may be introduced to the farmers by the farm guider.

3.4 Experimental Procedure

3.4.1 Execution of the Experiment

The cows from different cattle farms at different places was selected and then the photograph of each selected cows was clicked about 2 meter from cow in two views i.e. rear and lateral view of animal, by mobile phone camera of 16 mega pixel. While clicking the photographs care was taken that the angle of the rear and lateral view should be perfect.

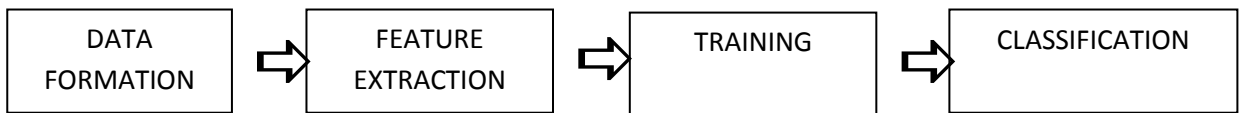
Table 3.1: Sorting of 1000 different types of cattle breeds of which photograph taken

Sr.no	Breeds	No.of animals
1	Gir	Not Specified
2	Kankrej	Not Specified
3	Jersey	Not Specified
4	HF	Not Specified
5	Sahiwal	Not Specified
6	Gaolao	Not Specified
7	Non descript	Not Specified

3.5.2 Developing of mobile application

The mobile application was developed by computerized technology in the Department of Electronics and Communication, Indian Institute of Information Technology (IIIT), Nagpur by the Image Analysis Technique after processing of the photographs. The developed mobile application may be installed in the mobile phone of the farmers and they may judge the cows by comparing BCS by their own for better improvement of performance of their cows which will be beneficial to farmers.

The process of development of mobile application by Image Analysis Technique was as given below;



BCS Between 1 - 2

Table 3.2 Number of Animals comes under Different BCS

Sr No	Sr No of Photograph		Body condition Score
	Lateral View	Rear View	
1	3	3.1	2.00
2	51	51.1	1.00
3	171	171.1	1.50
4	172	172.1	2.00

BCS between 2.1 – 3

Sr No	Sr No of Photograph		Body condition Score
	Lateral View	Rear View	
1	1	1.1	3.00
2	14	14.1	2.75
3	17	17.1	2.50
4	21	21.1	2.25
5	24	24.1	3.00
6	30	30.1	3.00
7	45	45.1	3.00
8	73	73.1	2.75
9	75	75.1	2.75
10	76	76.1	2.75
11	78	78.1	2.50
12	81	81.1	3.00
13	82	82.1	2.25

14	85	85.1	2.75
15	89	89.1	2.75
16	110	110.1	2.50
17	112	112.1	2.50
18	124	124.1	2.50
19	125	125.1	2.25
20	127	127.1	2.50
21	132	132.1	2.75
22	138	138.1	3.00
23	149	149.1	3.00
24	151	151.1	2.75
25	165	165.1	2.75
26	166	166.1	2.50
27	168	168.1	2.75
28	173	173.1	2.50

BCS Between 3.1 – 4

42	145	145.1	3.50
43	152	152.1	3.25
44	154	154.1	3.75
45	156	156.1	4.00
46	157	157.1	3.50
47	160	160.1	3.50
48	161	161.1	3.25
49	163	163.1	3.50
50	167	167.1	3.25

BCS Between 4.1 - 5

Sr No	Sr No of Photograph		Body condition Score
	Lateral View	Rear View	
1.	4	4.1	4.50
2.	5	5.1	4.50
3.	8	8.1	4.75
4.	10	10.1	4.25
5.	13	13.1	4.50
6.	15	15.1	4.25
7.	16	16.1	4.50
8.	23	23.1	4.25
9.	25	25.1	4.25
10.	26	26.1	5.00
11.	27	27.1	4.25
12.	28	28.1	5.00
13.	29	29.1	4.50
14.	32	32.1	4.25
15.	33	33.1	5.00
16.	34	34.1	5.00
17.	35	35.1	4.25
18.	37	37.1	4.25
19.	38	38.1	4.25
20.	41	41.1	4.25
21.	47	47.1	4.50
22.	48	48.1	4.50
23.	49	49.1	4.25
24.	50	50.1	4.50
25.	52	52.1	5.00
26.	53	53.1	4.50
27.	54	54.1	4.75

28.	55	55.1	4.50
29.	56	56.1	4.50
30.	58	58.1	5.00
31.	59	59.1	4.50
32.	60	60.1	5.00
33.	61	61.1	5.00
34.	62	62.1	5.00
35.	63	63.1	4.50
36.	64	64.1	5.00
37.	65	65.1	5.00
38.	66	66.1	5.00
39.	67	67.1	5.00

Sr No	Sr No of Photograph		Body condition Score
	Lateral View	Rear View	
40	67	67.1	5.00
41	68	68.1	5.00
42	69	69.1	4.50
43	70	70.1	5.00
44	71	71.1	5.00
45	74	74.1	4.50
46	80	80.1	5.00
47	83	83.1	5.00
48	84	84.1	4.25
49	86	86.1	4.75
50	90	90.1	4.75
51	91	91.1	4.75
52	92	92.1	5.00
53	93	93.1	4.25
54	94	94.1	4.75
55	95	95.1	4.25
56	96	96.1	4.50
57	97	97.1	4.75
58	98	98.1	4.25
59	99	99.1	4.50
60	100	100.1	4.25
61	103	103.1	4.50
62	104	104.1	4.75
63	105	105.1	4.50
64	106	106.1	4.50
65	108	108.1	4.50
66	113	113.1	4.75
67	115	115.1	4.50
68	118	118.1	4.25
69	119	119.1	5.00
70	126	126.1	4.75
71	129	129.1	4.25
72	130	130.1	4.75
73	131	131.1	4.25
74	134	134.1	4.25
75	136	136.1	4.75
76	140	140.1	4.50
77	141	141.1	4.25

78	142	142.1	4.75
79	143	143.1	4.25
80	146	146.1	4.50
81	147	147.1	4.50
82	148	148.1	4.25
83	150	150.1	5.00
84	153	153.1	4.75
85	155	155.1	4.75
86	158	158.1	4.50
87	159	159.1	4.25
88	162	162.1	4.75
89	164	164.1	4.25
90	169	169.1	5.00
91	170	170.1	4.75

RESULTS AND DISCUSSION

It is proved by research that the body condition has relevance with the overall performance of cow and hence, Body Condition Scoring (BCS) is an important tool in dairy herd management. The two body parts of cow *viz*; the tail head and loin are the major areas to evaluate the body condition. The BCS is very helpful in analyzing health problems, feed intake, and optimal time interval between calving and first service of cow. The different body condition scores may be targeted during the different stages of lactation on regular basis which help in improvement of dairy herd nutrition, health, and production.

As a matter of importance of the BCS in relevance to the farmers, it can be stated that by accurate estimation of BCS of animal, the farmers may take corrective steps for improvement of health and performance of the animal through various management practices. In view of this, the research entitled “Development of Decision Support System for Body Condition Score (BCS) in Cows through Artificial Intelligence (AI)” was carried out to develop a system that models the body shape of a cow from the back and lateral view images and then assesses the BCS with observed angle features in score estimation. The farmers may take help of these angle features to decide the score of the animal on his mobile phone via developed mobile application (BCS *App*).

The objectives of the research work were to develop AI based decision support system for estimating body condition score in cows and to suggest corrective measures to farmers through mobile based BCS application (BCS *App*).

The data was generated after clicking 2000 photographs of 1000 cows (1000 ventral view + 1000 rear view) from different organized farms and NGOs’ Goshalas and the mobile application was developed by computerized technology by the Image Analysis Technique after processing of the photographs. The farmers may installed the developed mobile application (BCS *App*) in mobile phone; capture the

photograph of cow and decide body condition score (BCS) by *App* and implement the corrective measures according to score of cow as suggested in *App* for better improvement of performance of the cow.

The results and discussion on the observations obtained during the present research work is given below.

4.1 Body Condition Score 1.00

In all 100 cows recorded body condition score 1.00 to 1.75.

It is noticed that the cows were very weak and emaciated with very poor body condition. The condition of the tail head, pelvis, hook and pin bones, thurl region and anal area from the rear view was evaluated. There was deep cavity under tail and around tail head; the skin over pelvis was drawn tight without any detectable tissue; the thurl region and the thighs found sunken and in-curving; the anal area has receded and the vulva appears prominent.

By observation of lateral view of cows, it is found that the ends of the short ribs were sharp and gave a prominent shelf-like appearance to the loin. No fatty tissue felt at loin. The individual vertebrae (spinous processes) of the backbone were prominent. The hook bones were angular in shape; hooks, pins were found very prominent and edges felt sharp.

4.2 Body Condition Score 2.00

In all 150 cows recorded body condition score 2.00 to 2.75.

It is seen that the cows between 2.00 to 2.75 body condition score were thin with poor body conformation. The rear view of the cows revealed less prominent cavity around the tail head in comparison to the cows those recorded body condition score less than 2.00. The skin over pelvis was flexible but the fatty tissue between skin and pelvis was not felt. The hook bones were found angular and both hook and

pin bones were prominent. The depression of the thurl region between hooks and pin bones was less severe. The area around the anus was less sunken and the vulva less prominent.

By observing lateral view of cows it is seen that the ends of the short ribs were sharp and felt to the touch however the ribs and the individual vertebrae were visibly less prominent. It is found that the short ribs did not form an overhang or shelf effect to the loin as found in cows scoring BCS less than 2.00. The hook bones were angular and easily distinguished by touch. The cows with BCS 2.00 showed thin, saw-tooth spine and the ribs were visible $\frac{3}{4}$ of the distance to the spine. The cows with 2.25 BCS showed the ribs visible $\frac{1}{2}$ to the spine and no fat pad on pins. The cows with BCS 2.50 showed the angular pins with fat pad on it where as the cows with 2.75 BCS showed visibly padded pins.

4.3 Body Condition Score 3.00

In all 250 cows recorded body condition score 3.00 to 3.75.

The health status of these cows was good with average body condition. By observation of rear view it is noticed that the cows showed slight cavity at tail head lined with apparent fatty tissue and the area between pins has smoothed out. It is also seen that the anal area was filled out but there was no evidence of fat deposit.

By observation of lateral view it is seen that with moderate pressure the ends of the short ribs felt to the fingers, however, there was no overhanging shelf-like appearance of these bones. It is also noticed that there was slight depression visible in loin area. The hook and pin bones were felt to touch but have some covering of flesh on them. The hook, pin and back appeared smooth, round and they lost the angularity.

Apart from above mentioned observations, the cows with BCS 3.25 showed sacral and tail head and both ligaments visible to the eyes. In cows with 3.50, the tail head ligament was found partly covered in fat and it was barely visible, however, the sacral was visible. The sacral was barely visible and tail head was not visible; similarly sacral and tail head ligament was not seen in cows with BCS 3.75.

4.4 Body Condition Score 4.00

In all 250 cows recorded body condition score 4.00 to 4.75.

The health status of the cows with BCS 4.00 was Fatty with heavy body condition. By observation of rear view of the cows it is found that there was no depression between pins and tail head because of patches of fat under the skin. The pelvis of the cows felt only with application of firm pressure. The back and area between hooks and pins was found flat. The sacral and tail head; similarly sacral and tail ligaments were not visible. The thurl was noticed flat and tail head was invisible, the area between hooks and pins were found to be filled with fat and the tips of the short ribs were slightly seen.

By observation of lateral view of cows it is seen that the individual short ribs felt only when firm pressure applied. No shelf effect was found as the short ribs were rounded over. The depression in loin between backbone and hip bones was not visible. The hook bones were found to be round and smoothed over and the span between the hook bones over the backbone was flat. The patches of fat deposit were seen in area around the pin bones. The ridge of the backbone was flattened over the loin and rump areas and rounded over the chine.

The cows with BCS 4.25 showed flat thurl, short ribs barely visible and area between hooks and pins barely visible. The cows with BCS 4.50 showed flat thurl and area between hooks and pins filled with fat; however, pins and tips of short ribs were invisible. It is seen that the cows with BCS 4.75 showed the area between

hooks and pins filled with fat where as pins and hooks and tips of short ribs were invisible.

4.5 Body Condition Score 5.00

In all 250 cows recorded body condition score 5.0

The health status of cows with BCS 5.00 was grossly fat. By observation of rear view of the cows it is noticed that the tail head was buried in fatty tissue and the fat deposited around the tailbone and over the ribs. The area between pins and tailbone was round and skin distended. The thighs of the cows were curve out, the brisket and flanks were heavy and the chins were round.

By observation of the lateral view of the cows it is found that even with firm pressure, no part of pelvis and bony structure felt. It was observed that there were folds of fatty tissue over short ribs. The bony structure of the top line, hook and pin bones and the short ribs was not visible. All bony prominences well rounded & fat covered no bones visible. The hooks, pins, and backbone almost disappeared.

4.6 Body Condition Score of Cow required for optimum performance

As per the investigation by Sniffen and Ferguson, 1991 for optimum performance, the recommended ideal body condition score for cows at different stages of lactation is given below

Stage of Lactation	Ideal Score
Dry	3.5
Calving	3.5
Early Lactation	3.0
Mid Lactation	3.25
Late Lactation	3.5
Growing Heifers	3.0
Heifers at Calving	3.5

4.7 Indication of Body Condition Score

Cows with BCS 1.5 are too thin, unhealthy and not milk well or reproduce. The health of cows with BCS 2.0 is all right but the cows are very thin, produce less milk and poor in reproduction. Body condition score 2.5 is acceptable score and the number of breeding cows should not exceed 10 % of the herd. Cow with BCS 3.0 seems healthy but she may not have sufficient body fat for high peak milk production, if a cow calves at or less this BCS.

The cows with BCS 1+ and 3- are weak, very thin, under conditioned and emaciated with very poor body constitution due to insufficient energy supply and shortage of protein reserves in body. It is difficult to maintain production level and hence, it results in lower production and low milk fat in such cows. The body weight of cow is important; hence a cow did not show heat or conceive until she regains body weight. Cows with BCS 1+ and 3- are not able to produce sufficient milk,

shows late post-partum heat and 20 % less conception rate for first service as compare to cows with good body condition. They are more prone to calving problems. The calves born from thin, emaciated cows receive less amount low quality immunoglobulin IGA and IGG in colostrums, hence, tend to have more illness. It is very essential to increase body reserves (energy & protein) to maintain health and production of cow, while feeding the cows with low score.

Thin, weak and emaciated heifers could not reach puberty at proper age as they are unable to grow rapidly enough to attain required body weight. Age at puberty may vary from 11 to 13 months to 18 to 24 months of age in exotic, crossbred and indigenous heifers. The age at first calving of exotic, crossbred and indigenous heifers may also be between 22 to 24 months to 30 to 36 months or they are unable to carry enough weight to maintain a normal first lactation production.

Over conditioning or fatness (BCS > 4), may result from poor nutrition or reproduction management. A fat cow is more susceptible to metabolic problems and infections, and is more likely to have difficulty at and after calving. Over conditioning usually begins during the last 3-4 months of lactation, when milk production has decreased, but dietary energy and total nutrient levels have not been reduced accordingly. Other common causes of over conditioning are prolonged dry periods or overfeeding during the dry period. The fat heifers have been shown to be difficult to breed, and if fat when they are near calving, have difficult calving and produce less milk after calving.

The cows carrying excess condition before calving have a greater risk for low feed

intake in the critical transition period around the time of calving. This can lead to loss of body condition and deepen the negative energy balance cows experience after calving. Reduced dry matter intake has obvious effects on milk production and can contribute to ketosis, a displaced abomasums, or other metabolic and production consequences of nutritional stress.

4.8 Corrective measures for cows with BCS 1+ and 3- during various stages of production

Feeding of low quality roughage to weak or very poor conditioned cows may not supply enough energy or protein, hence, cows with BCS 1+ and 3- should be fed main nutrients from supplements such as molasses, grain, urea or vegetable protein meals. Low quality roughage should only be used as filler. Good quality hay like lucerne, sorghum and oats has lots of highly digestible leaf and free from mould and weeds.

Depending on the body condition and stage of production the amount of feed to be required to cow should be decided and fed. Wean the calf as soon as possible. Feed high quality forage with high energy content and reduce the quantity of straw in ration. Grain feeding increases total energy intake and improves rate of gain of cows. Gain of 90 kg of body weight of a cow may help to improve condition score from 2 to 3.

The fertility, productivity and overall health of cows affected adversely if they are fed without estimating their body condition. Feeding of cows for body condition helps to reduce health problems. As suggested by Sniffen and Ferguson, 1991, the ideal score of 3.5 should be maintained at dry off and at calving of cows for optimum performance. Due to various reason like underfeeding to lose excessive weight or feeding of poor quality forages or restricted feeding of dry cow leads to mobilize body fat and increase incidence of ketosis. It is important to fed balanced, palatable and formulated diet to dry cows and in early lactation period. Energy density of ration can be increased by increasing grain moderately in diet of cows well before calving which will help to prevent body condition losses of cows. This practice of feeding should be continued in early lactation period of cows.

It's OK to lose $\frac{1}{2}$ to $\frac{3}{4}$ condition score or less during 1 to 1^{1/2} months of calving. Loss of 1 body condition score means loss of 50 kg and 70 kg body weight respectively in mature cows and growing heifers. If cows lose 1 body condition score

during early lactation, they will require 6 months to gain required body weight. Loss of less than ½ or more than 1 body condition score of cows in early lactation is an indication of ineffective feeding programme or management which did not allow cows to produce maximum milk production though remains healthy. A loss of ½ body condition score in 1 to 1^{1/2} months is normal and indicates proper, effective herd management.

Body fat utilization by high-producing dairy cows during first 60 -90 days of lactation prevents reduction in high milk production and weight loss even though there is no enough feed consumption. The energy balance is related to loss or gain of body condition of cow and it is the difference between intake of feed energy and output in the form of milk. Mostly cows shows maximum negative energy balance during 2-3 weeks and may reach positive energy balance by 2 months of calving. Implementation of proper feeding programme manipulate body condition loss and minimize duration of negative energy balance in high producing cows and this helps to prevent excessive weight loss.

As soon as feed intake by early lactating cows reaches at maximum level, they move out of negative energy balance and increased milk production and reproductive performance. Addition of adequate fiber in the diet of cows improves feed intake and ultimately performance of cows. Properly formulated diets always meet energy and protein requirement of cows, essential for higher milk yield throughout lactation. The high energy diets should come from high quality forages, grains or fats.

If body condition score of cows reduce rapidly below 3.0 to 2.5 during first month of

lactation, it is necessary to examine feed intake, fiber content of forages, dietary energy and protein and feeding strategy. If body condition score of cows remain 3.0 to 3.5 during 1 to 4 months of lactation but produce less peak milk yield, check for inadequate protein, macro minerals or water intake. During mid lactation of cows slightly feed extra energy in diet to built- up body reserves. Low energy diet

during mid lactation results in reducing body condition score (2.0 to 2.5) of cows so it is also necessary to check early lactation diet for the cause. For recoup of body fat reserves of cows during late lactation period (8 months to dry-off) feeding plan should be formulated. Prevent over-conditioning of cows during this period and maintain body condition score at 3.5.

4.9 Corrective measures for cows with BCS 3+ during various stages of production

Fat can be felt on the backbone, short ribs and ligaments in cow having 3.5 BCS. This score is essential during dry off period and at the time of calving of a cow. The fat filled in over the back of a cow having BCS 4.0, hence the back seems flat. Such cows will eat less and have more loss of weight and more metabolic problems. Cow with BCS 5.0 is extremely fat and she will have metabolic and breeding problems. Body condition in excess of 3.5 to 3.75 during the dry period can lead to increased incidences of fat cow syndrome and fatty livers at calving, compared with condition gained during lactation.

British research indicates cows that are fat and overly fat at calving (condition score 4 to 5) lose body condition, experience a longer delay between peak milk yield and peak intake, prolonging negative energy balance. Body fat appears to inhibit feed intake, so cows fat at calving cannot reach maximum feed intake until they lose some of the excess conditioning. Cows may have a "target body condition" in early lactation, which they try to reach if diets are properly formulated.

Reduction of energy intake, correction of crude protein level of ration is the measure for over-conditioned cows (3.5 to 4+ score) during mid-lactation and late lactation. This may happen due to decrease in milk production but grain intake remains too high. Longer dry periods and extra feeding of grain or corn silage are reasons for over-conditioning of cows.

Do not put on diet; instead reduce the energy content of the diet of fat cows during dry period in late lactation. Two weeks prior to calving cows with 3.75+ body condition score are more prone to decreased feed intake, weight loss, fatty liver, ketosis, calving and reproductive problems.

To maintain cows at calving at score 3+ to 4- separate feeding of low-energy ration with adequate protein, minerals and vitamins is recommended. Cows having body condition score 3 to 3+ during early and mid lactation, if did not produce ample milk, then correct ration for inadequate protein, mineral or water. Cows with score above 3+ during this period may over-condition, hence it is better to reduce energy intake of cows. The drying period of cows generally coincide with late lactation and the expected body score during this period is 3+ to 4- to replenish energy and fat reserves to prepare cow for next lactation. Avoid over-condition of cows.

The body condition of heifers should be maintained at 3- to 3+ to avoid greater fat infiltration in the mammary glands at puberty so that they will produce to their full genetic potential at first calving. To maintain body condition of heifers in recommended range, it is important to feed balance ration with adequate amount of energy, protein, vitamins and minerals.

Tips for feeding cows

If body condition score is not proper, the performance of cows is affected. It is better to check the feeding program of animals.

- i. The feeding sequence, fiber level of ration, feeding frequency and ration palatability along with dry-matter intake is important for feeding of cows at different stages of production. The total dry-matter intake of cows should account for at least 45 percent through forage.

- ii. Check forage and grain for fineness of chop or grind, smell, acceptability and pH level. Test rations for amounts of bypass and soluble protein and for starch and fats. This is required for checking protein, energy, mineral and vitamin levels of ingredients and for balance of rations.
- iii. The dry cows may get over-condition and more susceptible to health problems if maintained only on large amounts of forage and grain are not fed.
- iv. To maintain dry cows in proper condition, feed minimum of 1.0 kg of hay-equivalent per 50 kg body weight. The dry-matter intake of dry cows may be controlled to 2 % of body weight. This may be possible by feeding complete ration of forages and grain between 85 and 88 percent forage dry matter.
- v. The milking cows may loss 50-70 kg body weight at the rate of 0.5-1.0 kg per day during first 60-80 days after calving. This much loss of body weight is normal, however, if the rate of weight loss rise to 1.25 – 1.75 kg per day then may leads to metabolic disorders. Ensure the nutrient requirement of milking cows during first 80-120 days after calving to gain 300 – 450 gm per day for replenishing body fat reserves and maintain production and health.



Plate 4.1. Pictures of (rear) cattles having different types of body condition score



Plate 4.2. Pictures of cattles (Lateral) having different types of body condition score



Plate 4.3. Pictures of cattles (Lateral) having different types of body condition score



Plate 4.4. Photograph of cow (Lateral) with BCS 1.00



Plate 4.5. Photograph of cow (Rear) with BCS 1.00



Plate 4.5. Photograph of cow (Lateral) with BCS 1.00



Plate 4.6. Photograph of cow (Rear) with BCS 1.00



Plate 4.7. Photograph of cow (Lateral) with BCS 1.00



Plate 4.8. Photograph of cow (Rear) with BCS 1.00



Plate 4.9. Photograph of cow (Rear) with BCS 2.00



Plate 4.10. Photograph of cow (Lateral) with BCS 2.00



Plate 4.11. Photograph of cow (Lateral) with BCS 2.00



Plate 4.12. Photograph of cow (Rear) with BCS 2.00



Plate 4.13. Photograph of cow (Lateral) with BCS 2.00

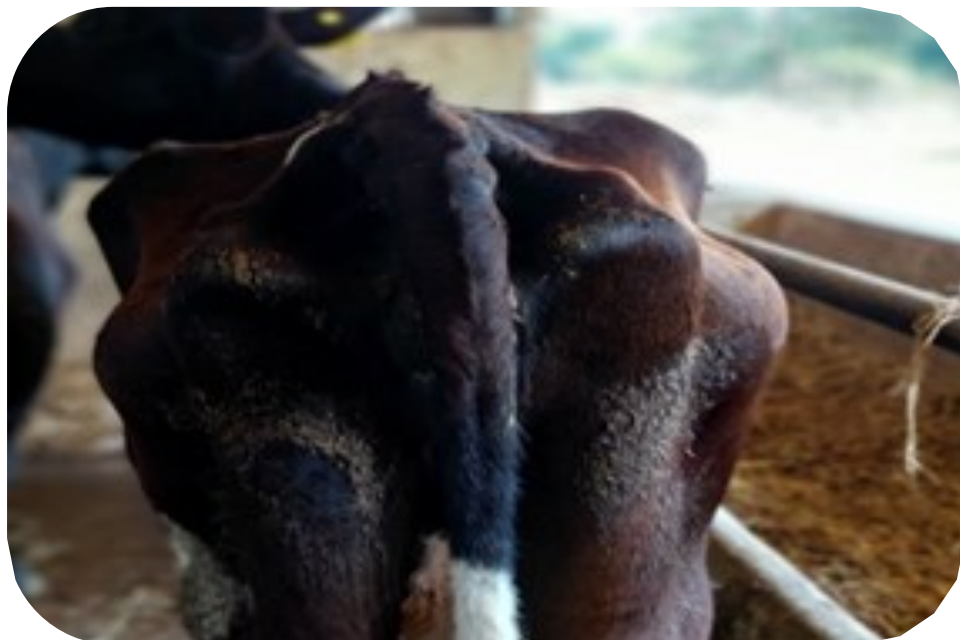


Plate 4.14. Photograph of cow (Rear) with BCS 2.00



Plate 4.15. Photograph of cow (Lateral) with BCS 2.75



Plate 4.16 Photograph of cow (Rear) with BCS 2.75



Plate 4.17. Photograph of cow (Lateral) with BCS 2.75



Plate 4.18 Photograph of cow (Rear) with BCS 2.75



Plate 4.19. Photograph of cow (Lateral) with BCS 3.00



Plate 4.20. Photograph of cow (Rear) with BCS 3.00



Plate 4.21. Photograph of cow (Lateral) with BCS 3.00

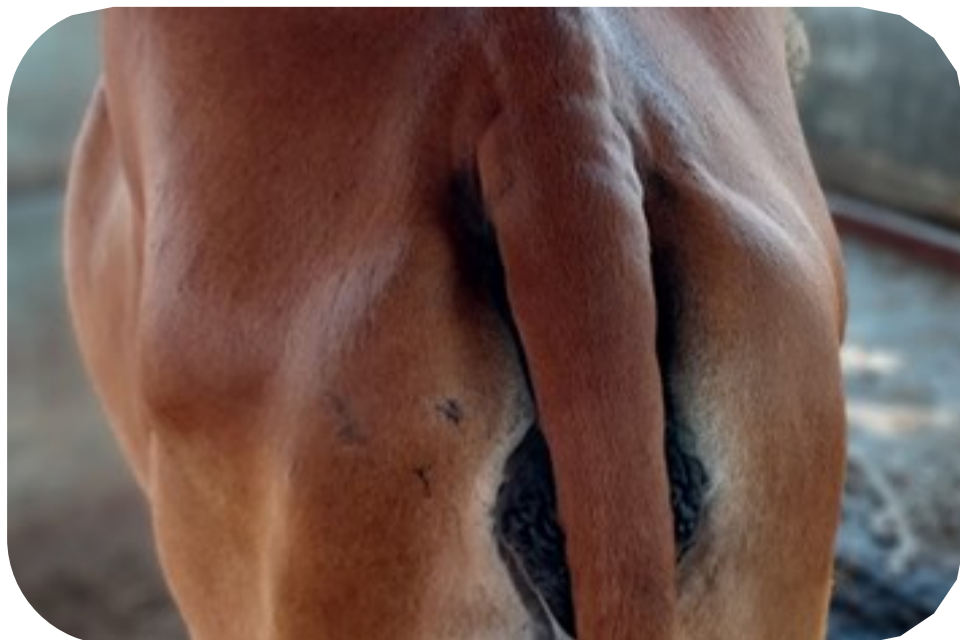


Plate 4.22. Photograph of cow (Rear) with BCS 3.00



Plate 4.23. Photograph of cow (Lateral) with BCS 3.00

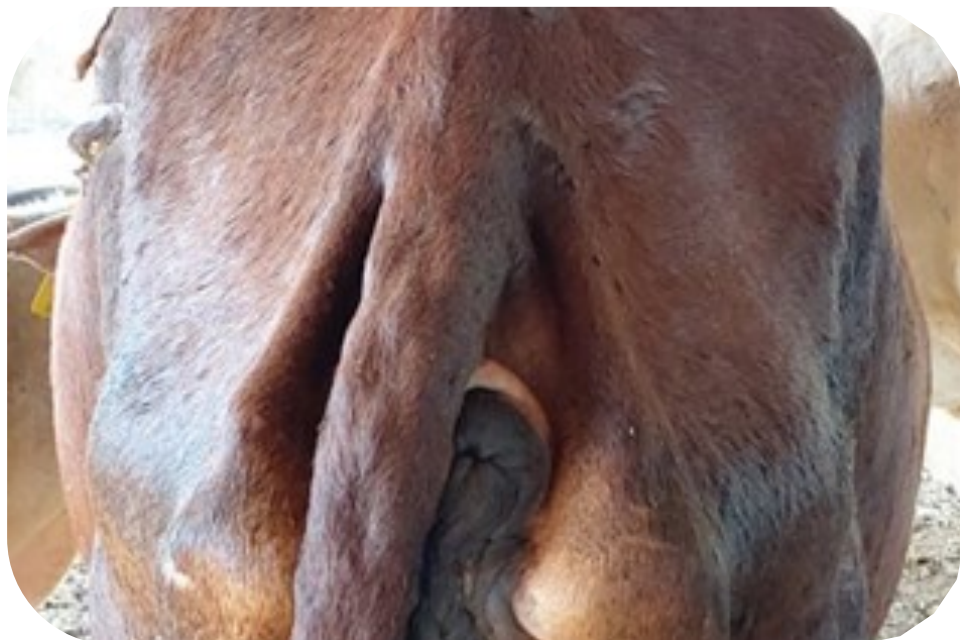


Plate 4.24. Photograph of cow (Rear) with BCS 3.00



Plate 4.25. Photograph of cow (Lateral) with BCS 3.00



Plate 4.26. Photograph of cow (Rear) with BCS 3.00

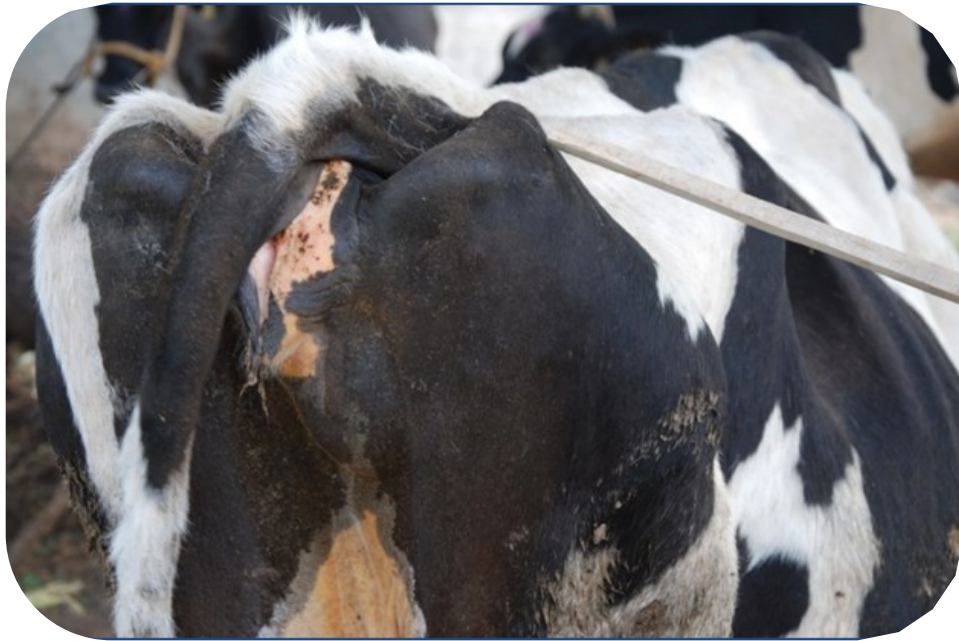


Plate 4.27. Photograph of cow (Rear) with BCS 3.00



Plate 4.28. Photograph of cow (Rear) with BCS 3.00



Plate 4.29. Photograph of cow (Lateral) with BCS 3.50



Plate 4.30. Photograph of cow (Rear) with BCS 3.50



Plate 4.31. Photograph of cow (Lateral) with BCS 4.00



Plate 4.32. Photograph of cow (Rear) with BCS 4.00



Plate 4.33. Photograph of cow (Lateral) with BCS 4.00



Plate 4.34. Photograph of cow (Rear) with BCS 4.00



Plate 4.35. Photograph of cow (Lateral) with BCS 4.25



Plate 4.36. Photograph of cow (Rear) with BCS 4.25



Plate 4.37. Photograph of cow (Lateral) with BCS 5.00



Plate 4.38. Photograph of cow (Rear) with BCS 5.00



Plate 4.40. Photograph of cow (Lateral) with BCS 5.00

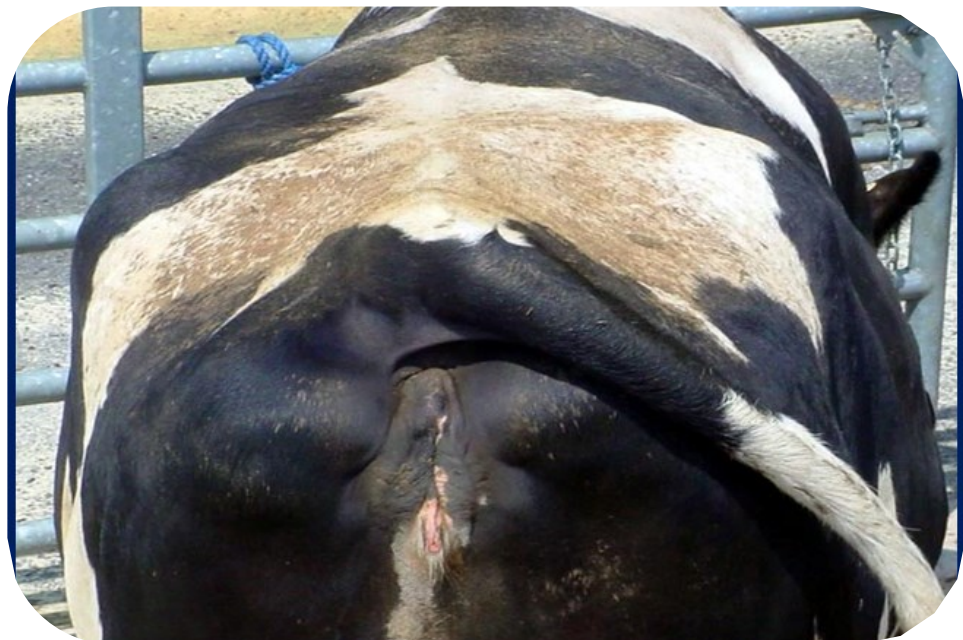


Plate 4.40. Photograph of cow (Rear) with BCS 5.00

SUMMARY AND CONCLUSIONS

As a matter of importance of the BCS in relevance to the farmers, it can be stated that by accurate estimation of BCS of animal, the farmers may take corrective steps for improvement of health and performance of the animal through various management practices. In view of this, the research entitled “Development of Decision Support System for Body Condition Score (BCS) in Cows through Artificial Intelligence (AI)” was carried out to develop a system that models the body shape of a cow from the back and lateral view images and then assesses the BCS with observed angle features in score estimation. The farmers may take help of these angle features to decide the score of the animal on his mobile phone via developed mobile application (*BCS App*).

In all 100. cows recorded 1.00 to 1.75 (1+ to 2-) body condition score. The cows were very weak and emaciated with very poor body condition. There was deep cavity under tail and around tail head; the skin over pelvis was drawn tight without any detectable tissue; the thurl region and the thighs found sunken and in-curving; the anal area has receded and the vulva appears prominent. The ends of the short ribs were sharp and gave a prominent shelf-like appearance to the loin. No fatty tissue felt at loin. The individual vertebrae (spinous processes) of the backbone were prominent. The hook bones were angular in shape; hooks, pins were found very prominent and edges felt sharp.

In all 150 cows recorded 2.00 to 2.75 body condition score. The rear view of the cows revealed less prominent cavity around the tail head in comparison to the cows those recorded body condition score less than 2.00. The skin over pelvis was flexible but the fatty tissue between skin and pelvis was not felt. The hook bones were found angular and both hook and pin bones were prominent. The depression of the thurl region between hooks and pin bones was less severe. The area around the anus was less sunken and the vulva less prominent. The ends of the short ribs were sharp and felt to the touch however the ribs and the individual vertebrae were visibly

less prominent. It is found that the short ribs did not form an overhang or shelf effect to the loin as found in cows scoring BCS less than 2.00. The hook bones were angular and easily distinguished by touch. The cows with BCS 2.00 showed thin, saw-tooth spine and the ribs were visible $\frac{3}{4}$ of the distance to the spine. The cows with 2.25 BCS showed the ribs visible $\frac{1}{2}$ to the spine and no fat pad on pins. The cows with BCS 2.50 showed the angular pins with fat pad on it where as the cows with 2.75 BCS showed visibly padded pins.

In all 250 cows recorded 3.00 to 3.75 body condition score. The health status of these cows was good with average body condition. The cows showed slight cavity at tail head lined with apparent fatty tissue and the area between pins has smoothed out. The anal area was filled out but there was no evidence of fat deposit. There was no overhanging shelf-like appearance of these bones. There was slight depression visible in loin area. The hook and pin bones were felt to touch but have some covering of flesh on them. The hook, pin and back appeared smooth, round and they lost the angularity. The cows with BCS 3.25 showed sacral and tail head and both ligaments visible to the eyes. In cows with 3.50, the tail head ligament was found partly covered in fat and it was barely visible, however, the sacral was visible. The sacral was barely visible and tail head was not visible; similarly sacral and tail head ligament was not seen in cows with BCS 3.75.

In all 250 cows recorded 4.00 to 4.75 body condition score. The health status of the cows with BCS 4.00 was fatty with heavy body condition. There was no depression between pins and tail head because of patches of fat under the skin. The pelvis of the cows felt only with application of firm pressure. The back and area between hooks and pins was found flat. The sacral and tail head; similarly sacral and tail ligaments were not visible. The thurl was noticed flat and tail head was invisible, the area between hooks and pins were found to be filled with fat and the tips of the short ribs were slightly seen. The individual short ribs felt only when firm pressure applied. No shelf effect was found as the short ribs were rounded over. The depression in loin between backbone and hip bones was not visible. The hook bones

were found to be round and smoothed over and the span between the hook bones over the backbone was flat. The patches of fat deposit were seen in area around the pin bones. The ridge of the backbone was flattened over the loin and rump areas and rounded over the chine. The cows with BCS 4.25 showed flat thurl, short ribs barely visible and area between hooks and pins barely visible. The cows with BCS 4.50 showed flat thurl and area between hooks and pins filled with fat; however, pins and tips of short ribs were invisible. It is seen that the cows with BCS 4.75 showed the area between hooks and pins filled with fat where as pins and hooks and tips of short ribs were invisible.

In all 250 cows recorded 5.0 body condition score. The health status of cows with BCS 5.00 was grossly fat. The tail head was buried in fatty tissue and the fat deposited around the tailbone and over the ribs. The area between pins and tailbone was round and skin distended. The thighs of the cows were curve out, the brisket and flanks were heavy and the chins were round. Even with firm pressure, no part of pelvis and bony structure felt. There were folds of fatty tissue over short ribs. The bony structure of the top line, hook and pin bones and the short ribs was not visible. All bony prominences well rounded & fat covered no bones visible. The hooks, pins, and backbone almost disappeared.

Cows with BCS 1.5 are too thin, unhealthy and not milk well or reproduce. The health of cows with BCS 2.0 is all right but the cows are very thin, produce less milk and poor in reproduction. Body condition score 2.5 is acceptable score and the number of breeding cows should not exceed 10 % of the herd. Cow with BCS 3.0 seems healthy but she may not have sufficient body fat for high peak milk production, if a cow calves at or less this BCS. The cows with BCS 1+ and 3- are weak, very thin, under conditioned and emaciated with very poor body constitution due to insufficient energy supply and shortage of protein reserves in body. The body weight of cow is important; hence a cow did not show heat or conceive until she regains body weight. It is very essential to increase body reserves (energy & protein) to maintain health and production of cow, while feeding the cows with low score.

Thin, weak and emaciated heifers could not reach puberty at proper age as they are unable to grow rapidly enough to attain required body weight. The age at first calving of exotic, crossbred and indigenous heifers may also be between 22 to 24 months to 30 to 36 months or they are unable to carry enough weight to maintain a normal first lactation production.

Over conditioning or fatness (BCS > 4), may result from poor nutrition or reproduction management. A fat cow is more susceptible to metabolic problems and infections, and is more likely to have difficulty at and after calving. Over conditioning usually begins during the last 3-4 months of lactation, when milk production has decreased, but dietary energy and total nutrient levels have not been reduced accordingly. Other common causes of over conditioning are prolonged dry periods or overfeeding during the dry period. The fat heifers have been shown to be difficult to breed, and if fat when they are near calving, have difficult calving and produce less milk after calving.

The cows carrying excess condition before calving have a greater risk for low feed

intake in the critical transition period around the time of calving. This can lead to loss of body condition and deepen the negative energy balance cows experience after calving. Reduced dry matter intake has obvious effects on milk production and can contribute to ketosis, a displaced abomasums, or other metabolic and production consequences of nutritional stress.

Feeding of low quality roughage to weak or very poor conditioned cows may not supply enough energy or protein, hence, cows with BCS 1+ and 3- should be fed main nutrients from supplements such as molasses, grain, urea or vegetable protein meals. Low quality roughage should only be used as filler. Good quality hay like lucerne, sorghum and oats has lots of highly digestible leaf and free from mould and weeds. Feed high quality forage with high energy content and reduce the quantity of straw in ration. Grain feeding increases total energy intake and improves rate of gain

of cows. Gain of 90 kg of body weight of a cow may help to improve condition score from 2 to 3.

A loss of $\frac{1}{2}$ body condition score in 1 to $1^{1/2}$ months is normal and indicates proper, effective herd management. Loss of 1 body condition score means loss of 50 kg and 70 kg body weight respectively in mature cows and growing heifers. Loss of less than $\frac{1}{2}$ or more than 1 body condition score of cows in early lactation is an indication of ineffective feeding programme or management which did not allow cows to produce maximum milk production though remains healthy. Body fat utilization by high-producing dairy cows during first 60 -90 days of lactation prevents reduction in high milk production and weight loss even though there is no enough feed consumption. Mostly cows shows maximum negative energy balance during 2-3 weeks and may reach positive energy balance by 2 months of calving. Implementation of proper feeding programme manipulate body condition loss and minimize duration of negative energy balance in high producing cows and this helps to prevent excessive weight loss.

If body condition score of cows reduce rapidly below 3.0 to 2.5 during first month of

lactation, it is necessary to examine feed intake, fiber content of forages, dietary energy and protein and feeding strategy. If body condition score of cows remain 3.0 to 3.5 during 1 to 4 months of lactation but produce less peak milk yield, check for inadequate protein, macro minerals or water intake. During mid lactation of cows slightly feed extra energy in diet to built-up body reserves. Low energy diet during mid lactation results in reducing body condition score (2.0 to 2.5) of cows so it is also necessary to check early lactation diet for the cause. For recoup of body fat reserves of cows during late lactation period (8 months to dry-off) feeding plan should be formulated. Prevent over-conditioning of cows during this period and maintain body condition score at 3.5.

Fat can be felt on the backbone, short ribs and ligaments in cow having 3.5 BCS. This score is essential during dry off period and at the time of calving of a cow. The fat filled in over the back of a cow having BCS 4.0, hence the back seems flat. Such cows will eat less and have more loss of weight and more metabolic problems. Cow with BCS 5.0 is extremely fat and she will have metabolic and breeding problems. Body condition in excess of 3.5 to 3.75 during the dry period can lead to increased incidences of fat cow syndrome and fatty livers at calving, compared with condition gained during lactation.

Reduction of energy intake, correction of crude protein level of ration is the measure for over-conditioned cows (3.5 to 4+ score) during mid-lactation and late lactation. This may happen due to decrease in milk production but grain intake remains too high. Longer dry periods and extra feeding of grain or corn silage are reasons for over-conditioning of cows. Do not put on diet; instead reduce the energy content of the diet of fat cows during dry period in late lactation. Two weeks prior to calving cows with 3.75+ body condition score are more prone to decreased feed intake, weight loss, fatty liver, ketosis, calving and reproductive problems.

To maintain cows at calving at score 3+ to 4- separate feeding of low-energy ration with adequate protein, minerals and vitamins is recommended. Cows having body condition score 3 to 3+ during early and mid lactation, if did not produce ample milk, then correct ration for inadequate protein, mineral or water. Cows with score above 3+ during this period may over-condition, hence it is better to reduce energy intake of cows. The drying period of cows generally coincide with late lactation and the expected body score during this period is 3+ to 4- to replenish energy and fat reserves to prepare cow for next lactation. Avoid over-condition of cows.

The body condition of heifers should be maintained at 3- to 3+ to avoid greater fat infiltration in the mammary glands at puberty so that they will produce to their full genetic potential at first calving. To maintain body condition of heifers in

recommended range, it is important to feed balance ration with adequate amount of energy, protein, vitamins and minerals.

Conclusion:

It is concluded from the present research work that the developed *BCS App* will be useful to the dairy farmers and dairy farms to decide the body condition score and to correct the body condition of the dairy cow by planning and executing the feeding programme.

BIBLIOGRAPHY

- Abhishek Paul, Santu Mondal, Suresh Kumar, Tripti Kumari (2020) Body Condition Scoring in Dairy Cows - A Conceptual and Systematic Review Indian Journal of Animal Research 10.18805/ijar.B-3859
- Andrew, S., Waldo, D. and R. Erdman (1994) Direct analyses of body composition of dairy cows at three physiological stages. *J. Dairy Sci.* 77: 3022-3033.
- Anglart Dorota (2010) Automatic estimation of body weight and body condition score in dairy cows using 3D imaging technique.
- Apple J. K. (1999) Influence of Body Condition Score on Live and Carcass Value of Cull Beef Cow. *J. Anim. Sci.* 1999. 77:2610–262
- AshAq MAnzoor MAdeehA Untoo, BUshrA zAffAr, InshA AfzAl, AAlIyA fAyAz, zAhoor AhMAd dAr, sehrIsh shAfIq (2018) Performance Profile of Dairy Animals Under Compromise with Dynamics in Body Condition Score. A Review. *Journal of Animal Health and Production* September 2018 | Volume 6 | Issue 3 | Page 8
- Azafack Kana Dorice, Ngoula Ferdinand , Kouamo Justin, Kenfack Augustave, and Kenne KazeLinda (2019) Effects of Breed, Age, Body Condition Score, and Nutritional Status on Follicular Population, Oocyte Yield, and Quality in Three Cameroonian Zebus Cattle *Bos indicus* .*Hindawi Advances in Agriculture* Volume 2019, Article ID 2979740, 15 pages
- Azzaro G. , M. Caccamo , J. D. Ferguson , S. Battiato , G. M. Farinella , G . C. Guarnera G. Puglisi , R . Petriglieri , and G. Licitra.(2011) Objective estimation of body condition score by modeling cow body shape from digital images. *J. Dairy Sci.* 94 :2126–2137
- Barbara Stefańska, Agnieszka Poźniak, Włodzimierz Nowak (2016) Relationship between the pre- and postpartum body condition scores and periparturient

indices and fertility in high-yielding dairy cows. *J Vet Res* 60, 81-90, 2016
DOI: 10.1515/jvetres-2016-0012

Bell Matt J., Mareike Maak, Marion Sorley and Robert Proud (2018) Comparison of Methods for Monitoring the Body Condition of Dairy Cows. *Frontiers in sustainable food system* Volume-2, article 80

Bercovich, A., Y. Edan, V. Alchanatis, U. Moallem, Y. Parmet, H. Honig, E. Maltz, A. Antler and I. Halachmi (2013) *J. Dairy Sci.* 96 :8047–8059.

Berry D. P., F. Buckley and P. Dillon (2007) Body condition score and live-weight effects on milk production in Irish Holstein-Friesian dairy cows. *Animal* (2007), 1:9, pp 1351–1359 & The Animal Consortium 2007

J. Bewley, M. Schutz (2008) An Interdisciplinary Review of Body Condition Scoring for Dairy Cattle *Biology The Professional Animal Scientist* DOI:10.15232/S1080-7446(15)30901-3

Bewley, J.M., A.M. Peacock, O. Lewis, R.E. Boyce, D.J. Roberts, M.P. Coffey, S.J. Kenyon and M.M. Schutz (2008) Potential for Estimation of Body Condition Scores in Dairy Cattle from Digital Images. *J. Dairy Sci.* 91:3439-3453.

N. Broring, J. W. Wilton, and P. E. Colucci (2003) Body condition score and its relationship to ultrasound backfat measurements in beef cows. *Canadian Journal of Animal Science*, 83 (3)

Coffey, M.P., G. Simm, W.G. Hill and S. Brotherstone (2003) Genetic Evaluations of Dairy Bulls for Daughter Energy, Balance Profiles Using Linear Type Scores and Body Condition Score Analyzed Using Random Regression. *J. Dairy Sci.* 86:2205 – 2212.

Edmonson, A., I. Lean, L. Weaver, T. Farver and G. Webster (1989) A body condition scoring chart for Holstein dairy cows. *J. Dairy Sci.* 78:68-78.

Ferguson James D. (1996) Implementation of a Body Condition Scoring Program in Dairy Herds . Penn Conference 1996

- Ferguson, D., D.T. Galligan and N. Thomsen (1994) Principal descriptors of body condition in Holstein dairy cattle. *J. Dairy Sci.* 77: 2695-2703.
- Gillund, P., O. Reksen, K. Karberg, A. Randby, I. Engeland and B. Lutnaes (1999) Utprøving av en holdvurderingsmetode på NFR-kyr. *Norsk Veterinærtidsskrift.* 111: 623-632.
- Glenn Selk. (2013) Body Condition Scoring of Beef Cows. Division of Agricultural Sciences and Natural Resources ,Oklahoma State University. ANSI-3283
- Gregory N. G., J. K. Robins , D. G. Thomas & R. W. Purchas.(1998) Relationship between body condition score and body composition in dairy cows. *New Zealand Journal of Agricultural Research*, 1998, Vol. 41: 527-532
- Halachmi, I., Polak, P., Roberts, D.J. and M. Klopčič (2008) Cow Body Shape and Automation of Condition Scoring. *J. Dairy Sci.* 4444 : 4451.
- Halachmi, M. Klopčič, Polak, D.J. Roberts, J.M. Bewley (2013) Automatic assessment of dairy cattle body condition score using thermal imaging I. Halachmi et al. / *Computers and Electronics in Agriculture* 99 (2013) 35–40
- Jílek F., P. Pytloun, M. Kubešová, M. Štípková, J. Bouška, J. Volek, J. Frelich, R. Rajmon. (2008) Relationships among body condition score, milk yield and reproduction in Czech Fleckvieh cows. *Czech J. Anim. Sci.*, 53, 2008 (9): 357–367
- José Carlos Ferrugem Moraes, Carlos Miguel Jaume and Carlos José Hoff de Souza.(2007)Body condition score to predict the postpartum fertility of crossbred beef cows. *Pesq. agropec. bras.*, Brasília, v.42, n.5, p.741-746, maio 2007

Juan Rodríguez Alvarez, Mauricio Arroqui, Pablo Mangudo, Juan Toloza, Daniel Jatip, Juan M Rodríguez, Alejandro Zunino, Cristian Mateos, Claudio Machado.(2017) Advances in automatic detection of body condition score of cows: a mini review. *Journal of Dairy, Veterinary & Animal Research*, Volume 5 Issue 4 – 2017

Juan Rodríguez, Alfredo Teyseyre, Carlos Sanz, Alejandro Zunino, Claudio Machado, Cristian Mateos (2018) Body condition estimation on cows from depth images using Convolutional Neural Networks. *Computers and Electronics in Agriculture* 155 (2018) 12–22

Koenen, E., R. Veerkamp, P. Dobbelaar and G. De Jong (2001) Genetic analysis of body condition score of lactating Dutch Holstein and Red-and-white heifers. *J. Dairy Sci.* 84:1265-1270.

Lukuyu M. N., J. P. Gibson, D. B. Savage, A. J. Duncan, F. D. N. Mujibi and A. M. Okeyo (2016) Use of body linear measurements to estimate live weight of crossbred dairy cattle in smallholder farms in Kenya. *Lukuyu et al. Springer Plus* (2016) 5:63

Markusfeld O, N. Galon, E. Ezra (1997) Body condition score, health, yield and fertility in dairy cows. *Veterinary Record* (1997) 141, 67-72

Mishra Sharad, Kiran Kumari, Ashutosh Dubey, (2016) Body Condition Scoring of Dairy Cattle: A Review. *.58RRJVS | Volume 2 | Issue 1 | March, 2016*

Mullins Israel L., Carissa M. Truman, Magnus R. Campler, Jeffrey M. Bewley and Joao H. C. Costa (2019). Validation of a Commercial Automated Body Condition Scoring System on a Commercial Dairy Farm. *Animals* 2019, 9, 287

Nay Chi Lynn, Thi Thi Zin and Ikuo Kobayashi (2017) Automatic Assessing Body Condition Score from Digital Images by Active Shape Model and Multiple

Regression Technique. International Conference on Artificial Life and Robotics (ICAROB 2017), Jan. 19-22, Seagaia Convention Center, Miyazaki, Japan, pp. 311-314.

Ohnstad Ian (2013) Body condition scoring in dairy cattle: monitoring health to improve milk yield and fertility *Livestock* May/June 2013, Vol 18

Otto, K., J. Ferguson, D. Fox and C. Sniffen (1991) Relationship between body condition score and composition of ninth to eleventh rib tissue in Holstein. *J. Dairy Sci.* 74: 852- 859.

Patel M., G.P. Lakhani, S. Ghosh, S. Nayak, B. Roy, R.P.S. Baghel and A. Jain(2018) Effect of Body Condition Score on Milk Production, Milk Composition and Reproductive Performance of Lactating Murrah Buffaloes. *Int.J.Curr.Microbiol.App.Sci* (2018) 7(11): 1204-1212

Pauline Ezanno, Alexandre Ickowicz, François Bocquier (2003). Factors affecting the body condition score of N'Dama cows under extensive range management in Southern Senegal. *Anim. Res.* 52 (2003) 37–48

Rasby, Richard J.; Stalker, Leslie Aaron; and Funston, Richard N., "EC07-281 Body Condition Scoring Beef Cows: A Tool for Managing the Nutrition Program for Beef Herds" (2007). Historical Materials from University of Nebraska-Lincoln Extension. 3541

Reid, J. and J. Robb (1971) Relationship of body composition to energy intake and energetic efficiency. *J. Dairy Sci.* 54: 559-564.

Roche J , N. C. Friggens , J. K. Kay , M. W. Fisher , K. J. Stafford , and D . P. Berry (2009) Invited review: Body condition score and its association with dairy cow productivity, health, and welfare. *J. Dairy Sci.* 92 :5769–5801
Vol. 92 No. 12, 2009

- Roche, J., P. Dilion, C. Stockdale, L. Baumgard and M. VanBaale (2004) Relationship among international body condition scoring system. *J. Dairy Sci.* 87:3076-3079.
- Roi, Spoliansky, Yael Edan, Yisrael Parmet and Ilan Halachmi (2016) Development of automatic body condition scoring using a low-cost 3-dimensional Kinect camera. *J. Dairy Sci.* 99(9):7714-25.
- Sarah E. Dickinson, Michelle F. Elmore, Lisa Kriese-Anderson, Joshua B. Elmore, Bailey N. Walker, Paul W. Dyce, Soren P. Rodning and Fernando H. Biase (2019) Evaluation of age, weaning weight, body condition score, and reproductive tract score in pre-selected beef heifers relative to reproductive potential .Dickinson et al. *Journal of Animal Science and Biotechnology* (2019) 10:18
- Schroder, U.J. and R. Staufenbiel (2006) Invited Review: Methods to determine body fat reserve in the dairy cow with an special regard to ultrasonographic measurement of back fat thickness. *J. Dairy Sci.* 89:1-14.
- Sebastiano Battiato, Giovanni Maria Farinella, Giuseppe Claudio Guarnera, Giovanni Puglisi, Giuseppe Azzaro, and Margherita Caccamo (2010) Assessment of Cow's Body Condition Score Through Statistical Shape Analysis and Regression Machines. *JMLR: Workshop and Conference Proceedings* 11 (2010) 66–73
- Shelly, A.N. (2016) Incorporating Machine Vision in Precision Dairy Farming Technologies (Ph.D. Thesis) University of Kentucky. <https://doi.org/10.13023/ETD.2016.147>.
- Shirley John E. (1993) Body condition scoring: A management tool. Issue 2 *Dairy Research* (1984-2014) Article 32

- Song X., E. A. M. Bokkers, S. van Mourik, P. W. G. Groot Koerkamp, and P. P. J. van der Tol. (2018) Automated body condition scoring of dairy cows using 3-dimensional feature extraction from multiple body regions. *J. Dairy Sci.* 102:1–15 <https://doi.org/10.3168/jds.15238>
- Sun Yukun,¹ Huo Pengju, Wang Yujie, Cui Ziqi, Li Yang, Dai Baishen, Li Runze, and Zhang Yonggen (2019) Automatic monitoring system for individual dairy cows based on a deep learning framework that provides identification via body parts and estimation of body condition score. *J. Dairy Sci.* 102:10140–10151
- Thi Thi Zin, Pann Thinzar Seint, Pyke Tin, Yoichiro Horii and Ikuo Kobayashi. (2020) Body Condition Score Estimation Based on Regression Analysis Using a 3D Camera. *Sensors* 2020, 20, 3705; doi:10.3390/s20133705
- Thi Thi Zin, Pyke Tin, Ikuo Kobayashi, Yoichiro Horii. (2018) An Automatic Estimation of Dairy Cow Body Condition Score Using Analytic Geometric Image Features 2018 IEEE 7th global conference on consumer electronics
- Wangchuk Kesang, Jigme Wangdi & Mindu Mindu. (2017) Comparison and reliability of techniques to estimate live cattle body weight. *JOURNAL OF APPLIED ANIMAL RESEARCH*, 2017
- Wayne Kellogg (1914) *Body Condition Scoring With Dairy Cattle*. Agriculture and Natural Resources.
- Wildman, E., Jones, G., Wagner, P. and L. Boman (1982) A dairy cow body condition scoring system and its relationship to selected production characteristics. *J. Dairy Sci.* 65: 495-501.
- Wissal Souissi and Rachid Bouraoui (2019) Relationship between Body Condition Score, Milk Yield, Reproduction, and Biochemical Parameters in Dairy

Cow. Lactation in Farm Animals - Biology, Physiological Basis,
Nutritional Requirements

Yan. T., D. Patterson, C. Mayne, R. Agnew and M. Porter (2009) Prediction of empty body weight and composition from live weight and other live animal measurements in lactation dairy cows. *J. Agric. Sci.* 147: 241-252.

VITA

The author, **Wankhade Tejas Sunil**, was born on 11th June, 1993 at Dist. Amravati, Maharashtra State, India. He passed his Secondary School Certificate (S.S.C) examination in year 2009 from DnyanmataHighschool, Amravati. He passed his Higher Secondary School Certificate (H.S.S.C) examination in year 2011.

Being interested in the field of Veterinary Science, he was admitted to Nagpur veterinary Collage, Nagpur and successfully completed B.V.Sc. and A.H. degree course. He was activity engaged in extracurricular activities like N.S.S., Vaccination camps. He joined Department of Livestock Production and Management for his Post graduation at Nagpur veterinary college (MAFSU, Nagpur).

He believes that he will use his knowledge in a constructive manner for veterinary profession.

Thesis Abstract

- a) Title of thesis : **“DEVELOPMENT OF DECISION SUPPORT SYSTEM FOR BODY CONDITION SCORE (BCS) IN COWS THROUGH ARTIFICIAL INTELLIGENCE (AI)”**
- b) Full Name of Student : **WANKHADE TEJAS SUNIL**
- c) Name & Address of Advisor/ Guide : **Dr. S. S. CHOPADE**
Professor & Head,
Department of Livestock Production and Management
- d) Degree to be awarded : **Master of Veterinary Science**
- e) Year of award of degree : **2021**
- f) Major subject : **LIVESTOCK PRODUCTION AND MANAGEMENT**
- g) Total number of pages in the thesis : **42**
- h) Number of words in the thesis abstract : **295**
- i) Signature of student :
- j) Signature, Name & Address of forwarding authority :

**Associate Dean,
Nagpur Veterinary College,
Nagpur**

ABSTRACT

The research entitled “Development of Decision Support System for Body Condition Score (BCS) in Cows through Artificial Intelligence (AI)” was carried out to develop a system that models the body shape of a cow from the back and lateral view images and then assesses the BCS with observed angle features in score estimation. The

farmers may take help of these angle features to decide the score of the animal on his mobile phone via developed mobile application (*BCS App*).

The cows with BCS 1+ and 3- are weak, very thin, under conditioned and emaciated with very poor body constitution due to insufficient energy supply and shortage of protein reserves in body. It is very essential to increase body reserves (energy & protein) to maintain health and production of cow, while feeding the cows with low score. Thin, weak and emaciated heifers could not reach puberty at proper age as they are unable to grow rapidly enough to attain required body weight.

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Feeding of low quality roughage to weak or very poor conditioned cows may not supply enough energy or protein, hence, cows with BCS 1+ and 3- should be fed main nutrients from supplements such as molasses, grain, urea or vegetable protein meals. Feed high quality forage with high energy content and reduce the quantity of straw in ration. Grain feeding increases total energy intake and improves rate of gain of cows. Reduction of energy intake, correction of crude protein level of ration is the measure for over-conditioned cows (3.5 to 4+ score) during mid-lactation and late lactation. Do not put on diet; instead reduce the energy content of the diet of fat cows during dry period in late lactation. Two weeks prior to calving cows with 3.75+ body condition score are more prone to decreased feed intake, weight loss, fatty liver, ketosis, calving and reproductive problems.

The body condition of heifers should be maintained at 3- to 3+ to avoid greater fat infiltration in the mammary glands at puberty so that they will produce to their full genetic potential at first calving. To maintain body condition of heifers in recommended range, it is important to feed balance ration with adequate amount of energy, protein, vitamins and minerals

प्रबंध सारांश

अ. प्रबंधाचे शिर्षक	“कृत्रिम बुद्धिमत्ता द्वारे शरीर स्थिती स्कोअरसाठी निर्णय समर्थन प्रणालीचा विकास”
ब. विद्यार्थ्यांचे पुर्ण नाव	: तेजस सुनील वानखडे
क. मार्गदर्शकाचे नाव आणि पत्ता	: डॉ. एस.एस. चोपडे सहयोगी प्राध्यापक पशुउत्पादन व व्यवस्थापन विभाग, नागपूर पशुवैद्यकीय महाविद्यालय नागपूर
ड. प्रदान करण्यात येणारी पदवी	: पशुवैद्यकीय पदव्युत्तर पदवी
इ. पदवी प्रदान करण्याचे वर्ष	: २०२१
फ. मुख्य विषय	: पशुउत्पादन व व्यवस्थापन
ग. प्रबंधातील एकूण पृष्ठ	: ४२
ह. सारांशातील एकूण शब्द	: ३००
ई. विद्यार्थ्यांची सही	:
ज. अग्रेषित करणार्या अधिकार्याची सही, नांव आणि पत्ता	:

सहयोगी अधिष्ठाता
नागपूर पशुवैद्यकीय महाविद्यालय,
नागपूर

सारांश

“कृत्रिम बुद्धिमत्ता च्या माध्यमातून गायींमध्ये शरीर स्थिती स्थिती गुण (बीसीएस) साठी विकास समर्थन प्रणालीचा विकास” हे संशोधन एका गायीच्या शरीराच्या आकाराचे मागील आणि बाजूकडील दृश्य प्रतिमांकडून मॉडेल बनविणारी प्रणाली विकसित

करण्यासाठी केले गेले आणि त्यानंतर मूल्यांकन बीसीएस स्कोअर अनुमानात निरीक्षित कोन वैशिष्ट्यांसह. विकसीत मोबाईल एप्लिकेशन (बीसीएस) (एप) च्या माध्यमातून शेतकरी त्याच्या मोबाईल फोनवर जनावरांची संख्या निश्चित करण्यासाठी या अँगल वैशिष्ट्यांची मदत घेऊ शकतात.

अपुरा उर्जा पुरवठा आणि शरीरात प्रथिने साठ्याच्या कमतरतेमुळे बीसीएस 1 + आणि 3 - असलेल्या गायी कमकुवत, अगदी पातळ, कंडिशन व अत्यंत शरीर संवेदनशीलतेने मुक्त झाल्या आहेत. गायींचे कमी गुण देताना, गाईचे आरोग्य व उत्पादन टिकवून ठेवण्यासाठी शरीर साठा (ऊर्जा व प्रथिने) वाढवणे खूप आवश्यक आहे. पातळ, कमकुवत आणि विस्मयकारक हेफर्स योग्य वयात तारुण्यापर्यंत पोहोचू शकले नाहीत कारण शरीराचे आवश्यक वजन कमी करण्यासाठी ते पुरेसे वेगाने वाढू शकत नाहीत.

चरबीयुक्त गाय चयापचयातील समस्या आणि संसर्गास अतिसंवेदनशील असते आणि त्यास वासराला आणि नंतर त्रास होण्याची अधिक शक्यता असते. स्तनपान करवण्याच्या शेवटच्या 3 - 4 महिन्यांत जास्त कंडिशनिंग सुरू होते, जेव्हा दुधाचे उत्पादन कमी होते, परंतु त्यानुसार आहारातील उर्जा आणि एकूण पौष्टिक पातळी कमी केली गेली नाहीत. चरबीचे स्थूल हेफर्स याना पैदासी करिता अडचणी निर्माण होऊ शकतात तसेच त्यांना कष्टदायक प्रसूती होऊ शकते शिवाय त्यानंतर त्या दूध सुद्धा कमी देऊ शकतात

कमकुवत किंवा अत्यंत गरीब वातानुकूलित गायींना कमी दर्जाचे रफेजेस खाऊन पुरेशी उर्जा किंवा प्रथिने मिळू शकत नाहीत, म्हणूनच, बीसीएस 1+ आणि 3- असलेल्या गायींना गुळ, धान्य, युरिया किंवा वनस्पती प्रथिने खुराक यासारख्या पूरक आहारातून मुख्य पोषक आहार द्यावे. उच्च उर्जा सामग्रीसह उच्च प्रतीचे चारा खायला द्या आणि रेशनमध्ये पेंढाचे प्रमाण कमी करा. धान्य आहारात एकूण उर्जा वाढते आणि गायींच्या वाढीचे प्रमाण सुधारते. उर्जा सेवन कमी करणे, रेशनच्या कूड प्रोटीन पातळीत सुधारणा करणे हे मध्यम स्तनपान व उशीरा दुग्धपान दरम्यान ओव्हर कंडिशंड गायींसाठी (3.5 to 4+ स्कोअर) उपाय आहे. आहार घालू नका; त्याऐवजी उशीरा स्तनपान करवण्याच्या कोरड्या कालावधीत चरबी गायींच्या आहाराची उर्जा सामग्री कमी करा. फीडचे सेवन,

वजन कमी होणे, चरबी यकृत, केटोसिस, बछडे आणि प्रजनन समस्या कमी होण्याची शक्यता जास्त आहे.

पौगंडावस्थेतील स्तन ग्रंथींमध्ये जास्त चरबी घुसळण टाळण्यासाठी हेफर्सच्या शरीराची स्थिती 3- ते 3+ पर्यंत राखली पाहिजे जेणेकरून ते पहिल्या वेतनाच्या वेळी त्यांच्या पूर्ण अनुवांशिक संभाव्यतेसाठी तयार होतील. शिफारस केलेल्या रेंजमध्ये हेफर्सची शरीराची स्थिती राखण्यासाठी, शिल्लक रेशन पुरेसे ऊर्जा, प्रथिने, जीवनसत्त्वे आणि खनिजयुक्त आहार देणे आवश्यक आहे.