UNIVERSITI PUTRA MALAYSIA

EFFECT OF FORAGE TO CONCENTRATE RATIO AND NUTRIENT INTAKE ON MILK PRODUCTION IN DAIRY BUFFALOES: A META-ANALYSIS STUDY

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FPV 2021 13

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A project paper submitted to

Faculty of Veterinary Medicine, Universiti Putra Malaysia

In partial fulfillment of the requirement of the

DEGREE OF DOCTOR OF VETERINARY MEDICINE

Universiti Putra Malaysia

Serdang, Selangor Darul Ehsan.

DECEMBER 2021

ACKNOWLEDGEMENTS

This project would not be done without the meticulous guidance from the supervisory committee, my beloved supervisors Associate Prof. Dr. Hasliza binti Abu Hassim and Prof. Dr. Md Zuki bin Abu Bakar; research team Dr. Agung Irawan, Dr. Adib Norma Respati, Mr. Amirul Faiz bin Mohd Azmi and Mr. Muhamad Affan bin Ab Azid.

I would also like to express my gratitude for my FYP teammates, Hafizin Mu'izz, Izreen Edriana and Baqir Irfani who helped me a lot even when they were busy working with their own projects.

Special thanks to my friends Haikal, Alya, Husaini, El and the rest of DVM22 for your direct help and emotional support throughout this study.

Last but not least, my family members Zulkifli, Samsilah, Munierah, Afiefah, Sofeyyah, Wardah, Baby, Sim, Elvis and Pichu for everything.

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ABSTRAK

Abstrak daripada kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999 – Projek Tahun Akhir.

KESAN RATIO FORAJ – KONSENTRAT DAN PENGAMBILAN NUTRIEN TERHADAP PRODUKSI SUSU DALAM KERBAU TENUSU: SATU KAJIAN META-ANALISIS

Oleh

Syakirah binti Zulkifli

2021

Penyelia: Prof. Dr. Md Zuki bin Abu Bakar

Kerbau adalah pengeluar susu kedua terbesar di dunia, dan sama seperti haiwan tenusu yang lain, kedua faktor intrinsik dan dan ekstrinsik sedang dikaji untuk meningkatkan kuantiti susu yang dihasilkan tanpa menjejaskan kualiti komposisi susu. Kajian yang telah dijalankan menunjukkan bahawa pengurusan pemberian makanan memainkan peranan dalam memberi kesan kepada kualiti susu, dan begitu juga dengan pengambilan nutrien. Pelbagai kajian juga telah membuktikan bahawa pemberian diet yang tinggi dalam kandungan protein dan tenaga akan memberi kesan positif terhadap produksi kuantiti susu tersebut. Oleh itu, objektif kajian ini adalah untuk mengkaji dan menganalisis hubungan antara kesan ratio foraj – konsentrat serta pengambilan nutrien terhadap produksi susu

dalam kerbau tenusu menggunakan kaedah meta-analisis. Sebanyak 20 kajian yang telah dilaporkan telah dianalisis untuk mengkaji kesan ratio foraj – konsentrat dan pengambilan nutrien terhadap jumlah dan komposisi susu. Ratio foraj – konsentrat dan pengambilan bahan kering makanan yang merupakan pembolehubah dimanipulasi dalam projek ini telah dibahagikan kepada tiga kumpulan: rendah, sederhana dan tinggi. Pembolehubah bergerak balas pula, iaitu hasil susu, juga dibahagikan kepada tiga kumpulan: rendah, sederhana dan tinggi. Satu analisis statistikal telah dilakukan melalui analisis kategorikal menggunakan perisian SAS online. Hasil daripada analisis kategorikal tersebut menunjukkan bahawa ratio foraj – konsentrat tidak dapat dibuktikan untuk memberi kesan kepada hasil dan komposisi susu ($p>0.05$) namun, pengambilan bahan kering makanan dan protein kasar terbukti memberi kesan kepada hasil susu. Kebolehubahan dalam hasil ini boleh disebabkan oleh pelbagai faktor seperti baka, kesihatan umum dan faktor luaran yang memberi kesan kepada produksi susu. Kajian lebih mendalam dengan saiz sampel yang lebih besar dan durasi kajian yang lebih panjang adalah disyorkan.

Kata kunci: *kerbau, tenusu, susu, foraj, konsentrat*

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfillment of the course VPD 4999 – Final Year Project.

EFFECT OF FORAGE TO CONCENTRATE RATIO AND NUTRIENT INTAKE ON MILK PRODUCTION OF DAIRY BUFFALOES: A META-ANALYSIS STUDY

by

Syakirah binti Zulkifli

2021

Supervisor: Prof. Dr. Md Zuki bin Abu Bakar

Buffaloes are the second largest milk producers in the world, and as with other dairy animals, both intrinsic and extrinsic factors are studied to increase the milk yield without compromising the milk composition quality. Studies have shown that feeding

management does play a role in influencing milk quality as well as nutrient intake. Various studies also demonstrated that administration of high protein and energy level diet will have a positive effect on the quantitative production of the milk. Thus, the aim of this study was to investigate and analyse the relationship between effect of forage to concentrate ratio and nutrient intake on milk production in dairy buffalo using meta-analysis study. A total of 20 reported studies were analysed in this study to investigate the effect of forage to concentrate ratio and nutrient intake on milk yield and composition. Forage to concentrate ratio and dry matter intake which were the manipulated variables in this study were divided into three groups: low, medium and high. The responding variable, the milk yield, was also divided into three groups: low, medium and high. A statistical analysis was carried out through categorical analysis via SAS online statistical software. Results from the categorical analysis showed that forage and concentrate could not be proven to influence milk yield and composition ($p>0.05$) but dry matter intake and crude protein intake do affect milk yield. These variabilities could be contributed by various factors such as breed, general health and environmental factors affecting the milk production. Further research with improvements in terms of sample size and length of study is recommended.

Keywords: *dairy, buffalo, milk, forage, concentrate*

1.0 INTRODUCTION

1.1 Background of the study

Milk is a major source of dietary energy, protein and fat, contributing on average 134 kcal of energy/person/day, 8g of protein/person/day and 7.3g of fat/person/day in 2009 (FAO, 2013). In East, Southeast Asia, and South Asia, milk consumption is increasing faster than meat consumption (FAO, 2013). In the study of milk, usually it is divided into physical properties, evaluation of quality, and nutrient composition. Physical properties of milk that have been studied and analysed between species include viscosity, specific gravity, and freezing point. Milk contains more water than any other element, with the rest of the composition being total solids (TS). TS includes fats, proteins, sugars, vitamins and minerals. When fat is excluded from the TS component, the rest is known as solids-non-fat (SNF).

Buffaloes are the second largest milk producers in the world, however there is still a huge gap between buffalo milk and cow milk produced annually (IDF, 2009). They are favored due to efficient utilization of low-quality, high-roughage diet (Larsson, 2009), have good resistance to parasites, quick and easy calf growth, as well as good quality and rich milk (El-Shibiny, 2011). In addition, their milk has been recorded to be higher in level of fat, lactose, protein, ash, casein, vitamins A and C as compared to cow milk (Laxminaryana and Dastur, 1968).

Forage to concentrate ratio plays a significant role in nutrition and feeding strategies. This is because different buffalo breeds have different genotypes, physiological needs, as well as function and production. Some buffaloes have dual-purpose use (draught and meat) while others have triple-purpose use (draught, meat and milk). Thus, research is always needed to

study nutrient utilisation and allocation to support changes in live weight and body composition, thus maximizing production (Devendra. C, 1989).

1.2 Overall objective of the study

To assess the effect of feed to concentrate ratio and nutrient intake on milk production using meta-analysis study.

1.3 Justification of the study

Even though dairy buffaloes are the second largest milk producers in the world, buffalo milk has not been as widely studied as compared to dairy cow milk. This reduces the full potential of buffalo milk to be commercialized and produced on a larger scale. A better understanding of how feed affects the milk yield and composition will have a positive economic impact for the industry.

1.4 Hypotheses of the study

Ho: Forage to concentrate ratio and nutrient intake affect milk production in dairy buffalo

Ha: Forage to concentrate ratio and nutrient intake do not affect milk production in dairy buffalo.

2.0 MATERIALS AND METHODS

2.1 Literature search and selection criteria

A literature search was conducted using the online scientific platforms of Google Scholar, Science Direct and Scopus to search for studies of the milk production in dairy buffaloes with varying diets. The key words 'dairy', 'buffalo', 'milk', 'concentrate' and 'forage' were used in the screening process of the articles. To be eligible for inclusion in the present meta-analysis, papers were selected following the protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as a systematic and reproducible method. Accordingly, studies were selected based on the following inclusion criteria: (a) published in English, (b) contained information on the ratio of forage and concentrate feed, (c) involved lactating dairy buffaloes, and (d) reported the amount of milk yield as well as the composition of the milk produced.

A flowchart explaining the process of study selection based on PRISMA protocol is provided in Figure 1. Briefly, a total of 1445 peer-reviewed research articles were identified based on the title of the papers. According to the criteria aforementioned, 1381 articles were excluded and 64 articles were selected. After carefully reviewing the full texts, contents and variables, we also excluded a further 44 studies for the following reasons: (i) the variable did not meet the minimum criteria needed to run the meta-analysis, (ii) incomplete information on the parameters studied, (iii) did not involve the target animal species which is buffalos and other species such as cows, (v) repeatedly published articles on different online platforms and (vi) not published in a peer-reviewed journal. Finally, 20 studies with 20 experiments with 59 different forage to ratio concentrate supplementation were integrated in the database and used for the meta-analysis.

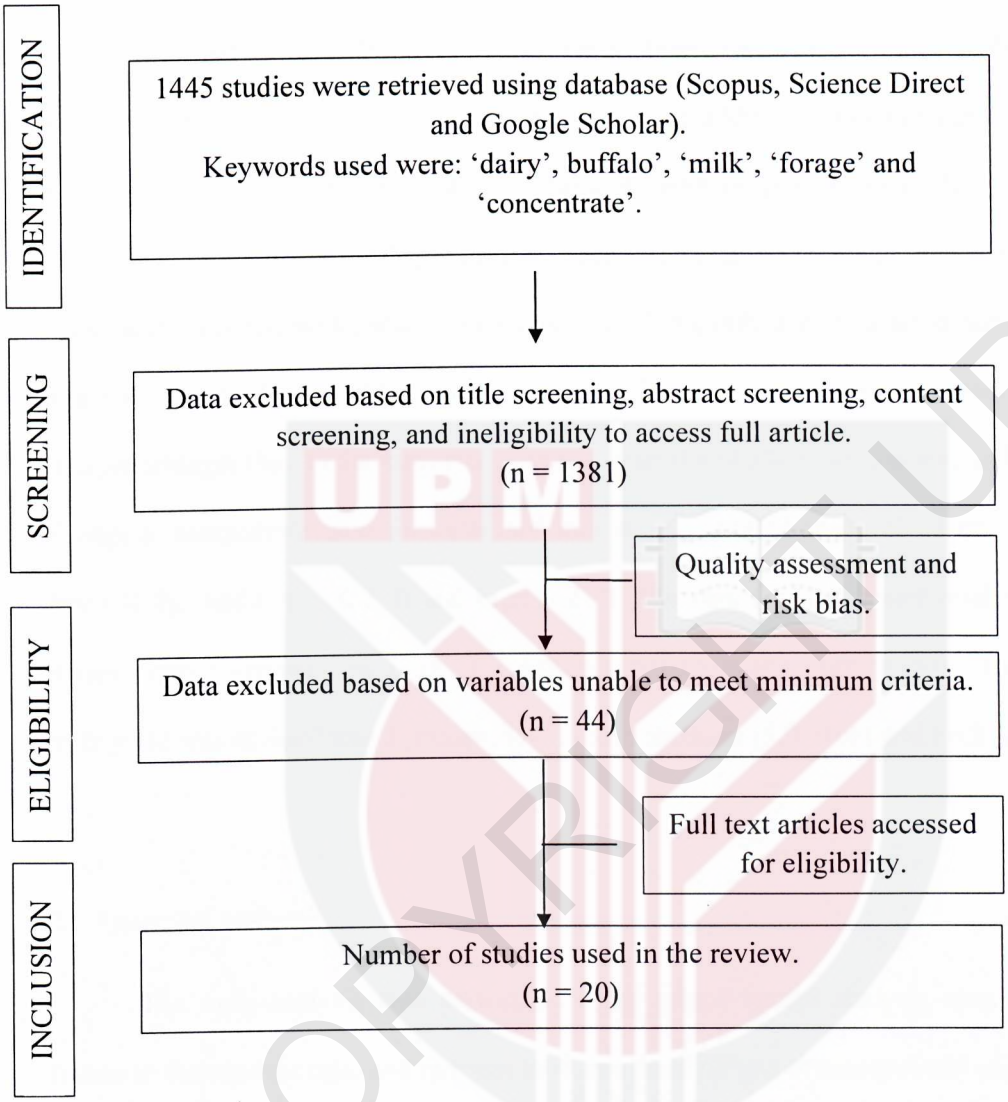


Figure 1: Flowchart explaining process of study selection based on PRISMA protocol.

2.2 Database development

Information on authors, number of replications, year and period of study, ratio of forage, roughage/silage and concentrate for each feed, additive/supplement given (if any), nutrient composition of feed, nutrient intake, as well as productive performance were recorded in a Microsoft Excel spreadsheet. Response variables included in the dataset were milk yield, milk fat, milk protein, milk total solid (TS), milk ash, milk solid non-fat (SNF) and milk lactose. Milk yield was recorded in kg/d while the rest were recorded/converted into percentages (%), as the same unit of measurement will allow calculations and analyses. Forage to concentrate ratio for each feed mix was calculated and divided into 3 groups; low (<1.0), medium (1.0-2.0) and high (>2.0). The data for dry matter intake was also divided into 3 groups; low (<10.0), medium (10.0-15.0) and high (>15.0). The data for milk yield was divided into 3 groups; low (<5.0), medium (5.0-10.0) and high (>10.0).

2.3 Statistical analysis

The meta-analysis was performed using mixed model analysis considering the forage to concentrate ratio and nutrient intake as fixed effects or manipulated variables, the milk yield and properties as responding variables and the different studies as random effects. The analysis was conducted following the PROC MIXED procedure of SAS (SAS STUDIO 3.8, University Edition, 2018). As indicated in Table 1, each experiment contained at least 2 different total mixed rations (TMR) with varying percentages of forage to concentrate ratio (CF Ratio). Next, certain parameters were chosen from the manipulated variables list: forage to concentrate ratio (CF ratio), concentrate level (concentrate), dry

matter nutrient intake (NIDMI) and crude protein intake (NICP). Another set of parameters were chosen from the responding variables list: Milk yield (Myield), milk fat (Mfat), milk protein (Mprotein), milk lactose (Mlac) and milk ash (Mash).

Then, the first coding analysis which provide a mechanism to obtain statistical inferences for the covariance parameters was done using the following code:

proc mixed data=group2 cl covtest;

class study;

weight animal;

model [responding variable]=[manipulated variable][manipulated

variable[manipulated variable]/solution;*

random study;

run;

The second coding analysis which provide a mechanism to obtain statistical inferences for interaction between the parameters was done using the following code:

proc mixed data=group2 cl covtest;

class study breed;

weight animal;

model [responding variable]=[manipulated variable] [manipulated variable]

*[manipulated variable] [manipulated variable] *breed/solution;*

random study;

The third coding analysis which provide a mechanism to obtain a categorical analysis for the parameters was done using the following code:

proc mixed data=group2 cl covtest method=type3;

class study [manipulated variable] Group;

weight animal;

model [responding variable]=[manipulated variable]Group;

random study;

lsmeans [manipulated variable]Group/pdiff cl adjust=tukey;

run;

Initially, regression analysis was scheduled to be done, however due to time constraint this analysis method was not done.

Table 1 : Studies included in the meta-analysis.

Reference	Year	Study	Exp	CF Ratio	CF Group	NID MI	NIDMI Group	NICP	NICP Group	Milk Yield (kg/d)	Milk Yield Group
M. Verna et al.	1993	13	4	7	high	17.2	high	.	.	10.49	high
M. Verna et al.	1993	13	4	3	high	19.2	high	.	.	10.4	high
M. Verna et al.	1993	13	4	1.67	medium	18.2	high	.	.	11.24	high
M. Verna et al.	1993	13	4	1	low	18.2	high	.	.	11.25	high
Salzano. A et al.	2000	14	80	1.27	medium	.	.	.	.	9.8	medium
Salzano. A et al.	2000	14	80	2.23	high	.	.	.	.	9.7	medium
F. Bovera et al.	2002	1	24	1.61	medium	.	.	.	.	8.57	medium
F. Bovera et al.	2002	1	24	1.67	medium	.	.	.	.	8.24	medium
S. Bartocci, S. Terramoccia, C. Tripaldi	2006	4	14	0.92	low	16.37	high	2.59	high	11.66	high
S. Bartocci, S. Terramoccia, C. Tripaldi	2006	4	14	1.22	medium	16.53	high	2.39	high	9.42	medium
A.K. Tyagi et al.	2006	9	18	0.72	low	10.3	medium	.	.	7.2	medium
A.K. Tyagi et al.	2006	9	18	3	high	11.8	medium	.	.	7.4	medium
A.K. Tyagi et al.	2006	9	18	0	low	12.6	medium	.	.	7.8	medium
M. Eslami, M. Mashyekhee, H. M. Kasiri	2007	12	8	0.82	low	.	.	.	.	5.2	medium
M. Eslami, M. Mashyekhee, H. M. Kasiri	2007	12	8	0.82	low	.	.	.	.	4.9	low
M. Eslami, M. Mashyekhee, H. M. Kasiri	2007	12	8	0.82	low	.	.	.	.	5.4	medium
M. Eslami, M. Mashyekhee, H. M. Kasiri	2007	12	8	0.82	low	.	.	.	.	5.8	medium

S. Bartocci and S. Terramoccia	2010	3	16	1.13	medium	17.23	high	3.09	high	11.89	high
S. Bartocci and S. Terramoccia	2010	3	16	1.13	medium	17.29	high	2.69	high	10.9	high
I. Begum, et al.	2010	11	12	0.33	low	16.35	high	2.04	high	10.14	high
I. Begum, et al.	2010	11	12	0.33	low	16.31	high	2.03	high	10.75	high
I. Begum, et al.	2010	11	12	0.33	low	16.73	high	2.09	high	11.8	high
S. M. Kholif et al.	2011	6	21	1.66	medium	.	.	.	.	7.8	medium
S. M. Kholif et al.	2011	6	21	1.66	medium	.	.	.	.	8.91	medium
S. M. Kholif et al.	2011	6	21	1.66	medium	.	.	.	.	8.24	medium
R. Amit et al	2012	20	15	1.5	medium	.	.	.	.	5.47	medium
R. Amit et al	2012	20	15	1.5	medium	.	.	.	.	6.14	medium
R. Amit et al	2012	20	15	1.5	medium	.	.	.	.	7.27	medium
A. E. M. Mahmoud and H.M. Ebeid	2014	7	12	1	low	.	.	.	.	9.44	medium
A. E. M. Mahmoud and H.M. Ebeid	2014	7	12	1	low	.	.	.	.	10.29	high
Sakai. T, et al.	2015	5	4	4	high	10.3	medium	0.762	low	2.75	low
Sakai. T, et al.	2015	5	4	4	high	10.8	medium	0.764	low	2.65	low
Sakai. T, et al.	2015	5	4	1.5	medium	12.8	medium	1.193	medium	3.33	low
A. Kholif et al	2016	16	21	1.5	medium	13.4	medium	2.17	high	7.26	medium
A. Kholif et al	2016	16	21	1.5	medium	14	medium	2.27	high	7.91	medium
A. Kholif et al	2016	16	21	1.5	medium	14	medium	2.27	high	7.59	medium
M.S. Mahesh, S.S. Thakur	2017	8	18	2.13	high	14.6	medium	.	.	8.78	medium
M.S. Mahesh, S.S. Thakur	2017	8	18	2.13	high	14.8	medium	.	.	9.55	medium
M.S. Mahesh, S.S. Thakur	2017	8	18	2.13	high	15.1	high	.	.	9.88	medium
SA Hossain, et al.	2017	10	28	2.23	high	15.36	high	1.72	medium	8.46	medium
SA Hossain, et al.	2017	10	28	4	high	15.43	high	1.65	medium	8.71	medium
Hansen. H. H et al	2017	17	24	3.08	high	10.46	medium	1.31	medium	6.8	medium
Hansen. H. H et al	2017	17	24	3.08	high	9.96	low	1.25	medium	6.4	medium

Hansen. H. H et al	2017	17	24	3.08	high	10.72	medium	1.35	medium	7.2	medium
Hansen. H. H et al	2017	17	24	3.08	high	11.6	medium	1.46	medium	8.4	medium
Hifzulrahman et al	2019	19	12	1.5	medium	15.6	high	.	.	7.56	medium
Hifzulrahman et al	2019	19	12	1.5	medium	15.1	high	.	.	8.09	medium
Hifzulrahman et al	2019	19	12	1.5	medium	15.9	high	.	.	8.35	medium
Hifzulrahman et al	2019	19	12	1.5	medium	15.7	high	.	.	8.02	medium
E. Eldahshan et al.	2020	2	18	2.33	high	15.8	high	.	.	8.37	medium
E. Eldahshan et al.	2020	2	18	2.33	high	15.65	high	.	.	8.25	medium
E. Eldahshan et al.	2020	2	18	2.33	high	15.7	high	.	.	8.04	medium
de Moura Lima, E. et al.	2021	15	5	0	low	18.19	high	1.89	medium	7.15	medium
de Moura Lima, E. et al.	2021	15	5	3.55	high	16.23	high	1.69	medium	8.03	medium
de Moura Lima, E. et al.	2021	15	5	1.27	medium	14.8	medium	1.52	medium	8.21	medium
de Moura Lima, E. et al.	2021	15	5	0.52	low	14.78	medium	1.4	medium	7.48	medium
Singla. A et al	2021	18	10	1.63	medium	11.2	medium	.	.	7.24	medium
Singla. A et al	2021	18	10	1.63	medium	11.1	medium	.	.	8.25	medium

Table 2 : Descriptive statistics of the database used in the meta-analysis.

Response variables	Unit	n	Mean	SD	Min	Max
roughage/silage	%	21	53.98	15	33	75.5
forage	%	45	53.68	22.08	10	100
concentrate	%	59	40.4	17.02	0	100
cf ratio	.	58	1.81	1.17	0	7
Nutrient Composition						
OM	g/kg DM	24	896.16	17.89	857.1	925.3
CP	g/kg DM	38	162.13	35.94	107.1	226
EE	g/kg DM	38	40.67	19.11	15	105.5
CF	g/kg DM	19	177.15	70.59	47.1	298.2
NDF	g/kg DM	29	393.39	133.37	201	911
ADF	g/kg DM	26	259.73	100.83	131	664
ADL	g/kg DM	10	38.63	9.28	27	57.6
NFC	g/kg DM	15	330.27	81.61	153	533
ME	Mcal/kg DM	15	5.89	9.23	1.75	35.5
Nutrient Intake						
DMI	kg/d	42	14.6	2.55	9.96	19.2
OM	kg/d	7	13.68	1.59	12	16.59
NDF	kg/d	13	6.15	0.68	5.19	7.34
ADF	kg/d	6	3.63	0.52	3.1	4.4
CP	kg/d	23	1.81	0.6	0.762	3.09
EE	kg/d	3	119.51	82.16	5.2	0.52
Productive Performance						
BWG	g/d	9	89.84	151.46	-0.18	416
Milk Yield	kg/d	59	8.16	2.07	2.65	11.89
Milk Fat	%	57	7.46	1.01	5.8	9.8

Milk Protein	%	51	4.13	0.32	3.41	4.71
Milk Total Solid	%	27	17.17	1.23	14.7	19.45
Milk Ash	%	21	0.86	0.15	0.67	1.22
Milk Solid Non Fat	%	25	9.53	0.59	7.6	10.9
Milk Lactose	%	32	4.91	0.47	4.17	6

3.0 RESULTS

3.1 Description of the database included in the meta-analysis

In this present meta-analysis, 59 data with varying forage to concentrate ratio from 20 studies were compared. Each data represents different dietary rations. The studies included are presented in Table 1 and the descriptive statistics are provided in Table 2. Out of 59 data, the forage to concentrate ratio for high, medium and low were 19, 24 and 16 respectively. However, only 42 data for nutrient intake (DMI) were available, with high, medium and low being 23, 18 and 1 respectively. On the other hand, 23 data were recorded for nutrient intake (crude protein), with the classification for high, medium and low being 10, 11 and 2.

3.2 Effect of forage to ratio concentrate on milk yield and composition

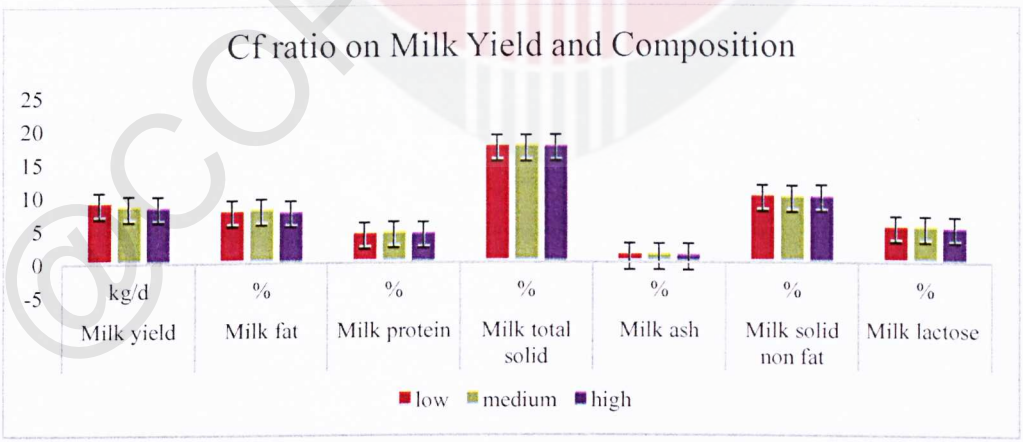
From the categorical analysis done, it was found that there is no obvious trend for the effect of forage to concentrate ratio on milk yield and composition as shown in Table 3 and Figure 2. However, the data tabulated for these parameters were deemed as non-significant ($p > 0.05$). Therefore, this data is deemed not strong enough to support the hypothesis.

Table 3 : Effect of forage to concentrate ratio on milk yield and composition.

Effect of cf ratio on Milk Yield and Composition

Response variables	Unit	n	low	medium	high	p-value
Milk yield	kg/d	58	8.75	8.23	8.13	0.3328
Milk fat	%	56	7.48	7.71	7.39	0.124
Milk protein	%	50	4.06	4.21	4.18	0.2229
Milk total solid	%	27	17.16	17.17	17.20	0.9965
Milk ash	%	21	0.88	0.87	0.85	0.8252
Milk solid non fat	%	25	9.70	9.59	9.67	0.8072
Milk lactose	%	31	5.00	4.98	4.87	0.3473

Figure 2 : Bar graph showing the effect of forage to concentrate ratio (low to high) on milk yield and composition.



3.3 Effect of dry matter intake (NIDMI) on milk yield and composition

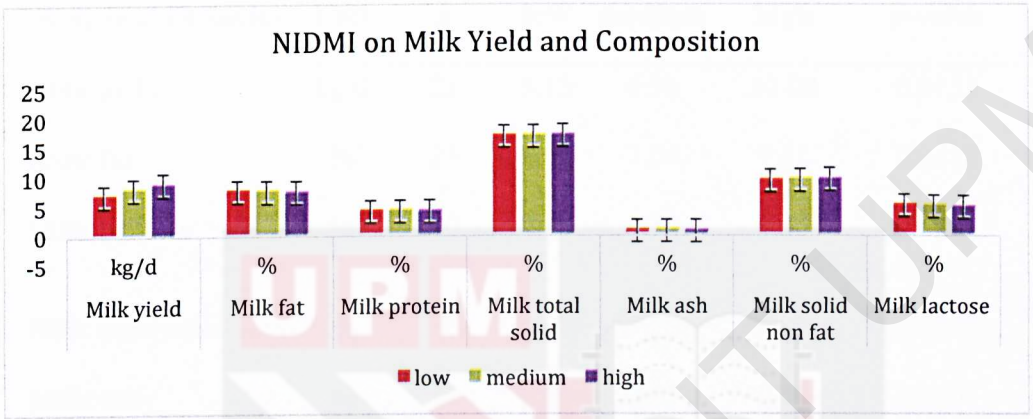
From the categorical analysis done, it was found that the higher the dry matter intake, the higher the milk yield (Table 4). The data for this analysis was considered significant ($p < 0.05$). However, similar results were not seen for the rest of the milk composition. But this data cannot be compared to the milk yield finding as it was considered non-significant ($p > 0.05$).

Table 4 : Effect of dry matter intake (NIDMI) on milk yield and composition.

Effect of dry matter intake on Milk Yield and Composition

Response variables	Unit	n	low	medium	high	p-value
Milk yield	kg/d	42	6.91	7.99	8.87	0.0288
Milk fat	%	42	7.69	7.58	7.50	0.8802
Milk protein	%	39	4.17	4.20	4.22	0.9125
Milk total solid	%	18	17.01	17.03	17.20	0.7483
Milk ash	%	13	0.78	0.79	0.78	0.7754
Milk solid non fat	%	16	9.35	9.46	9.67	0.4085
Milk lactose	%	26	5.21	5.01	4.92	0.2656

Figure 3 : Bar graph showing the effect of dry matter nutrient intake (low to high) on milk yield and composition.



3.4 Effect of crude protein intake (NICP) on milk yield and composition

From the categorical analysis done, it was found that the higher the crude protein intake, the higher the milk yield, milk fat and milk total solid (Table 5 and Figure 4). These findings were considered significant ($p < 0.05$). This strongly suggests that crude protein intake affect milk yield, milk fat as well as milk total solid composition.

Table 5: Effect of crude protein intake (NICP) on milk yield and composition.

Effect of NICP on Milk Yield and Composition						
Response variables	**Unit**	**n**	**low**	**medium**	**high**	**p-value**
Milk yield	kg/d	23	5.15	6.96	10.08	0.0135
Milk fat	%	23	6.30	7.04	7.41	0.0418
Milk protein	%	20	4.18	4.28	4.35	0.6292
Milk total solid	%	9	14.80	15.100	16.56	0.0015
Milk ash	%	6	0.83	0.77	0.75	0.2301
Milk solid non fat	%	11	9.030	9.49	9.57	0.1501
Milk lactose	%	10	4.79	4.75	4.65	0.2572

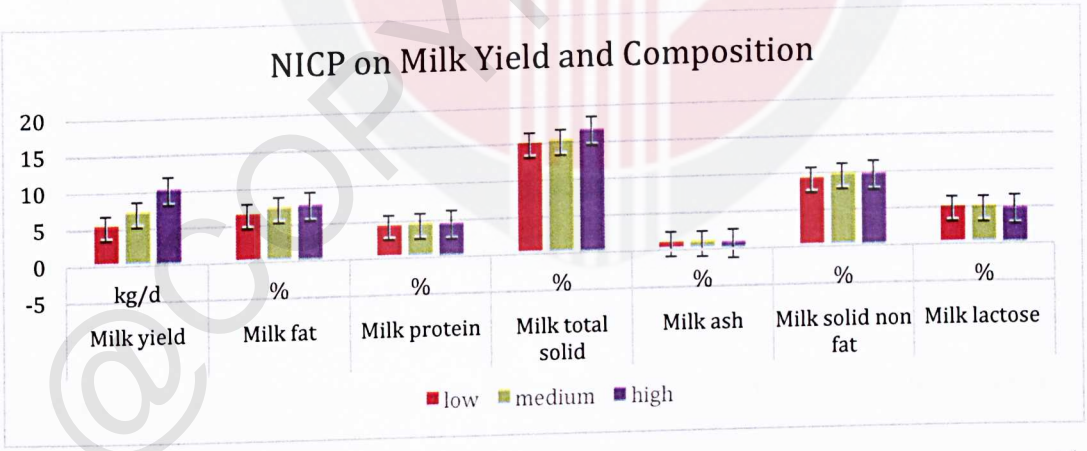


Figure 4 : Bar graph showing the effect of crude protein nutrient intake (low to high) on milk yield and composition.

4.0 DISCUSSION

4.1 Comparison with previous findings

When looking into studies centered around the big question of whether concentrate play a big role in affecting milk yield, studies with differing results were found. For instance, a study by Gaafar *et al.* (2009) concluded that lactating buffaloes fed ration consisting of 40% concentrate and 60% roughages on DM basis (berseem hay and rice straw) with 15g baker's yeast supplementation/head/day showed the best results concerning milk yield, feed conversion and economic efficiency. In contrast, another study by Purcell (2016) stated that concentrate feeding method had no effect on the performance of high-yielding cows in early to mid lactation, when all the cows were offered the same amount of concentrate in addition to a basal diet offered *ad libitum*. The difference in the findings could be attributed to the statement that concentrate is not the only factor affecting milk yield.

4.2 Factors affecting milk yield

Aside from concentrate, other factors that affect milk yield and composition are breed, farming system or environment as well as forage quality. Momin *et al.* (2016) stated that in terms of breed, river types buffalo's performance was superior to other breeds. The parameters used in this study was live weight, daily milk yield, lactation length and lactation production. The same study also outlined that in terms of farming system or environment, semi-intensive farming system was superior to other systems, when comparing the live weight and daily milk yield. Another study by Uzun. *et al.* (2018) concluded that inclusion of fresh sorghum in a buffalo TMR with at least 26.5% on a DM

basis is able to modify the fatty acid composition of buffalo mozzarella cheese. In short, all these factors coexist and interact with each other, thus affecting the overall milk results.

4.3 Significance of buffalo milk production performance studies

Studies concerning buffalo milk production are significant for buffalo milk plays an important role in human nutrition, particularly in developing countries such as India and Pakistan. Aside from that, in comparison with cow milk, buffalo milk is richer in almost all the main milk nutrients. It is also important as some milk products are specialties of buffalo milk such as mozzarella cheese and ghee (Mohamed Abd El-Salam and El-Shibiny, 2011). Individuals with cow milk allergies are capable of tolerating buffalo milk, in certain cases (Sheehan and Phipatanakul, 2009). Therefore, it might also be a dairy alternative for individuals with cow milk allergies, thus creating its own niche market.

4.4 Role of concentrate in milk production

Production of milk, just like any other biological activity, requires energy and thus supplementation with feed concentrates that generally are low-fiber and high-energy when compared to forages serves this purpose. Lawrence *et al.* (2015) reported that by increasing the total amount of concentrate offered, cows had higher TDMI and energy intake, which resulted in increased milk production and reduced negative energy balance and body condition score loss. This is a common trend in dairy production, where concentrates are most often fed to raise energy level as well as to compensate for other deficiencies in the total mixed ration. Increasing the concentrate feed input in diets based on grass silage (Agnew *et al.,* 1996) and maize silage (Fitzgerald and Murphy, 1999) has a positive effect on milk production and BCS loss (Delaby *et al.,* 2009), otherwise known as a response to

concentrate (Bargo *et al.,* 2003). However, animals respond differently to concentrate supplementation due to variation within the herd, which is caused by differences in stage of lactation, parity, and genotype (Horan *et al.,* 2005).

4.5 Role of forage in milk production

Stokes (2002) outlined the important points regarding the role of forage in milk production. The points mentioned were to provide a highly fermentable diet that supports high intakes, promotes consistent ruminal fermentation and to prevent metabolic upsets if requirements are not met. Metabolic upsets can cause losses as they lead to milk production losses, treatment costs and if the condition does not improve, culling or total loss of the livestock. Therefore, while concentrate provides most of the energy source for milk production, forage is just as important in ensuring the nutrients can be absorbed and utilized aside from maintaining general health of the animal.

5.0 CONCLUSION

In conclusion, this meta-analysis review study did not prove or support the hypothesis that forage to concentrate ratio affect milk yield and composition. This is highly likely due to the limited sample size. However, this study did prove that nutrient intake affects milk composition, which means the hypothesis for this statement is accepted.

6.0 RECOMMENDATION

Improvements for future studies on this matter should be implemented as it is an economically significant field of study and can potentially further support the dairy buffalo milk market.

Related studies should also be done, such as evaluation of the type of concentrate or forage used in a particular ration against a specific buffalo breed. Different types of forage and concentrate, even when given in similar ratio will have different quality and nutritional content and thus, might bear different production results. In addition, if there are enough studies using this method done amongst different species, a follow-up study can be done to see if varying breeds digest or utilize different types of concentrate similarly or differently. From there, the best possible combination of forage and concentrate types and ratio can be constructed specifically for a particular breed.

Next, studying the type of concentrate versus the amount of concentrate. Learning issues regarding this study would be how a higher quality concentrate, when offered in a lower amount would fare against a lower quality concentrate offered in a higher amount. This study

can also help to further prove the significance of quality versus quantity in forming mixed rations.

Nutrient utilization studies are also significant for this area of research in order to understand whether nutrient intake and nutrient utilization will both increase linearly. For instance, if the concentrate input is increased, thus increasing the crude protein intake, and how much of the crude protein is actually being utilized by the buffalo or animal could be determined. If the nutrient utilization plateau after a certain amount of nutrient intake increment, then further addition in terms of quantity would be deemed wasteful.

Lastly, the practicality of the application for the findings should also be studied. For example, the link between the cost increase to modify pre-existing feed rations and the profit made by the increased production. This is vital because realistically, the feed cost would have to be increased in order to increase the production. However, if the production increment is not significant enough to cover the increase in feed rations cost it would lead to economical loss which would not justify the changes made.

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