Characterization of dietary protein in *Brassica carinata* meal when used as a protein supplement for beef cattle consuming a forage-based diet

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ABSTRACT

A novel oilseed crop, *Brassica carinata* has the capacity of producing high-quality jet biofuel, with a protein-dense meal (~40% crude protein; CP) obtained as a byproduct of oil extraction. Characterization of the meal protein is limited; therefore, the objective of this experiment was to determine ruminal and post-ruminal digestibility of protein from *B. carinata*. Eight ruminally-cannulated Angus crossbred steers (473 ± 119 kg) were used in a duplicated 4 × 4 Latin square design, in which in situ ruminal and post-ruminal degradability of nutrients were evaluated. The three-step in vitro procedure was used to compare CP and amino acid degradation in *B. carinata* meal pellets (**BCM**) with that of cottonseed meal (**CSM**), dry distillers grains with solubles (**DDGS**), and soybean meal (**SBM**). In situ bags were ruminally incubated for 0 to 96 h, with the undegraded supplement remaining after 16 h subjected to serial in vitro enzymatic solutions. Data were analyzed using the MIXED procedure of SAS. Ruminal rate of degradation of dry matter, organic matter, and CP was greatest ($P < 0.01$) for SBM. Rumen degradable protein (RDP) content did not differ ($P = 0.20$) between CSM and DDGS but was decreased ($P < 0.01$) compared with SBM and BCM, which did not differ ($P = 0.99$). Compared with DDGS, SBM had greater ($P < 0.01$) intestinal digestibility of rumen undegradable protein (RUP). Intestinally absorbable digestible protein was greatest ($P < 0.01$) for CSM, with SBM and BCM having the least. Total tract digestibility of CP (TTDP) was greater ($P < 0.01$) for SBM compared with CSM and DDGS. The contribution of RUP to intestinally absorbable amino acids was 7.2 g of lysine and 3.1 g of methionine per kilogram of CP in BCM. The evaluation of *Brassica carinata* meal as protein supplemented for cattle consuming a forage-based diet resulted in 71.8% RDP and 97.1% TTDP, demonstrating its viability as a high-quality protein supplement.

INTRODUCTION

- As a non-food oilseed crop, *Brassica carinata* possesses a favorable very long chain fatty acid composition for conversion to biofuel and has been successfully utilized as a 100% drop-in jet biofuel
- The meal obtained as a byproduct of oil extraction would be considered waste, yet the protein-dense meal (~40% crude protein; CP) of carinata has the potential to be utilized as a protein supplement in beef cattle operations
- Utilization of the plant, oil from the seed, and residual meal promotes the use of carinata as a renewable, and potentially sustainable, resource

OBJECTIVE

To characterize the ruminal fractionation of dietary protein, and subsequent post-ruminal degradation of dietary protein in *B. carinata* meal compared with protein supplements common to the southeastern U.S., and to determine the amino acid profile of carinata upon ruminal and post-ruminal degradation

MATERIALS AND METHODS

- Duplicated 4 × 4 Latin square design conducted over four consecutive 28-d periods
- Eight ruminally cannulated Angus crossbred steers (473 ± 119 kg initial BW), randomly allocated to 8 pens
- Within each period steers were randomly assigned to one of four treatments:
  - **BCM** - 1.39 kg/d *B. carinata* meal pellets
  - **CSM** - 1.62 kg/d cottonseed meal
  - **DDGS** - 2.15 kg/d dry distillers grains plus solubles
  - **SBM** - 1.17 kg/d soybean meal
    - Ad libitum access to bahiagrass hay (*Paspalum notatum*) and water
    - BCM provided at 0.3% of initial BW
    - Treatments were calculated to be isonitrogenous based on total nitrogen provided by supplementation of 1.39 kg/d of BCM
- 14-d adaptation to facilities, hay, and treatments
- Ruminal in situ degradability procedure (incubated in rumen of supplement-specific adapted steer)
  - 0, 3, 6, 9, 12, **16**, 24, 48, 72, and 96 h
- Modified Three-step in vitro procedure utilizing **16** h in situ residue
  - Analysis of crude protein and determination of BCM amino acid profile

Table 1. Analyzed chemical and nutrient composition (DM basis) of hay and protein supplements fed to ruminally-cannulated Angus crossbred steers

		Treatment			
Item, % DM	**Bahiagrass hay**	**BCM**	**CSM**	**DDGS**	**SBM**
DM, % as fed	94.0	89.8	88.9	86.3	90.7
CP	7.2	43.3	49.2	32.8	52.9
NFC	--	21.7	13.2	20.2	28.7
aNDF	71.4	23.5	28.6	30.7	10.2
ADF	41.8	12.8	18.7	14.3	8.4
TDN	56	80	67	83	79
S	0.35	1.75	--	--	--

RESULTS

Table 2. Ruminal in situ kinetics of dry matter, organic matter, and crude protein in protein supplements fed to ruminally cannulated Angus crossbred beef steers consuming a forage-based diet

		Treatment					*P*-value
	Item	**BCM**	**CSM**	**DDGS**	**SBM**	**SEM**	**TRT**
DM	K_d, % h^{-1}	6.61^{b}	2.85^{c}	5.16^{bc}	10.87^{a}	0.929	< 0.001
	T0, h	0.53^{b}	2.87^{a}	1.20^{ab}	2.52^{a}	0.530	0.0094
	SF, %	42.97^{b}	32.25^{c}	48.81^{a}	40.70^{b}	1.580	< 0.001
	D, %	54.74^{ab}	59.78^{a}	45.83^{b}	59.11^{a}	3.223	0.0086
	Undeg, %	2.38	7.98	5.36	0.12	3.063	0.2049
OM	K_d, % h^{-1}	6.71^{b}	2.54^{c}	5.31^{bc}	11.27^{a}	0.888	< 0.001
	T0, h	0.99^{ab}	2.64^{a}	0.78^{b}	2.68^{a}	0.613	0.0096
	SF, %	7.49	5.28	5.96	2.33	1.608	0.0674
	D, %	92.48	94.68	93.95	97.65	1.604	0.0636
	Undeg, %	0.03^{ab}	0.04^{ab}	0.09^{a}	0.01^{b}	0.017	0.0287
CP	K_d, % h^{-1}	**7.59^{b}**	3.86^{c}	4.68^{bc}	11.50^{a}	0.877	< 0.001
	T0, h	**0.87^{b}**	8.89^{a}	3.44^{ab}	2.80^{b}	1.779	0.0066
	SF, %	**22.10^{a}**	0.24^{d}	15.66^{b}	7.78^{c}	1.929	< 0.001
	D, %	**76.80^{bc}**	98.70^{a}	74.67^{c}	88.60^{ab}	3.771	< 0.001
	Undeg, %	**0.69**	1.06	9.67	3.94	3.876	0.2409

K_d = degradation rate of D; T0 = lag time; SF = soluble fraction; D = potentially degradable fraction; Undeg = undegradable fraction

Additional information and figures.

Table 3. Apparent total tract digestibility of essential amino acids (AA) of *B. carinata* meal pellets and contribution of rumen undegradable protein (RUP) to intestinally absorbable essential amino acids (IAAA)

	AA digestibility		
Essential AA composition	**In situ 16 h residue (%)**	**Post-ruminal digestion residue (%)**	**Contribution of RUP to IAAA (g/kg CP)**
Lysine	80.92	91.55	7.16
Methionine	81.56	94.84	3.09

SUMMARY and CONCLUSION

- *Brassica carinata* meal performed similarly to SBM in RDP, RUP, IADP, and TTDP
- The contribution of RUP to IAAA was 7.16 g of Lysine and 3.09 g of Methionine per kg of CP in *B. carinata*

The evaluation of *Brassica carinata* meal as protein supplemented for cattle consuming a forage-based diet, resulted in a protein fraction comprised of 71.8% RDP, and a total tract digestibility of dietary protein of 97%, thus indicating its viability as a high-value protein supplement for beef cattle

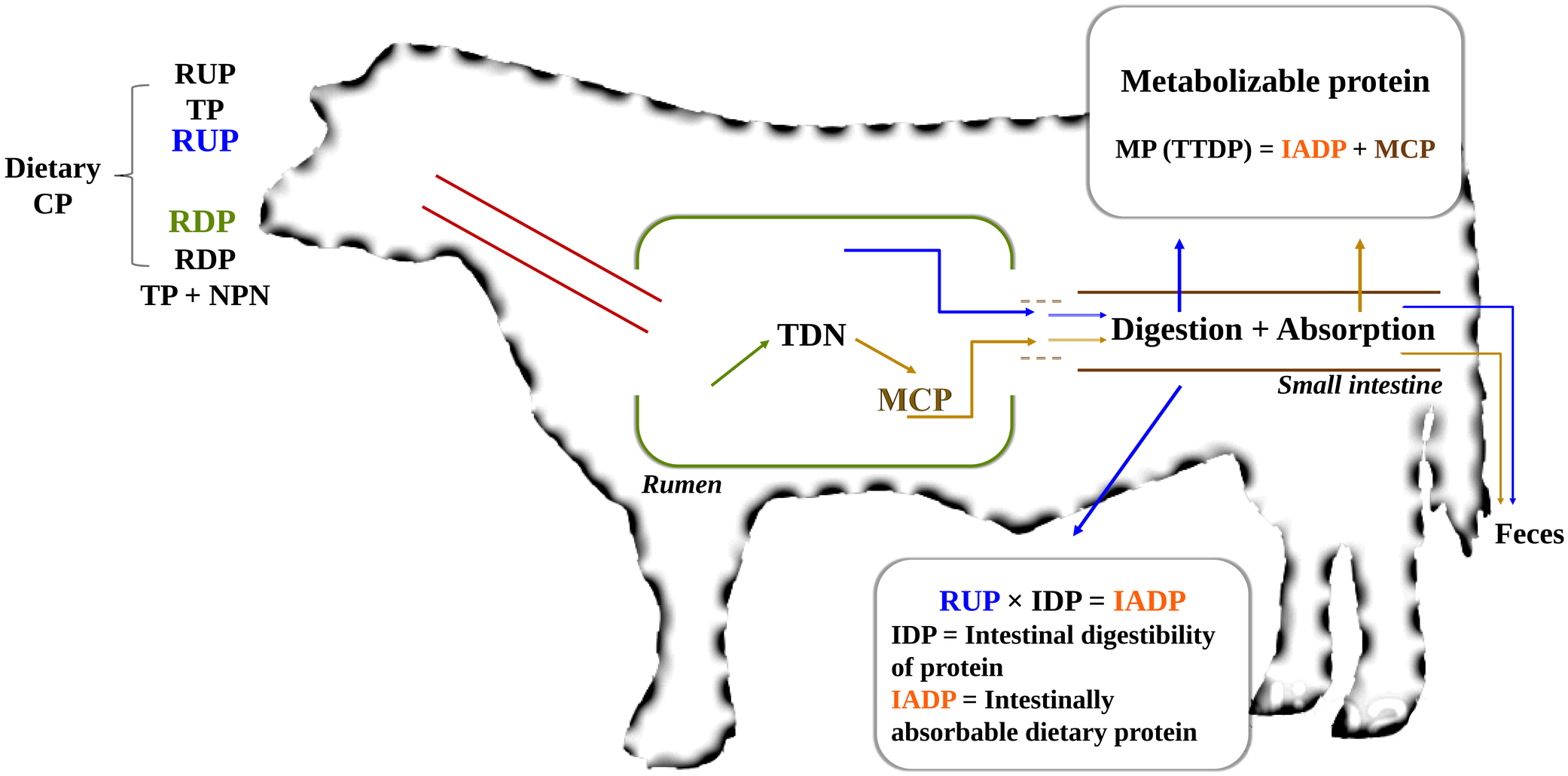
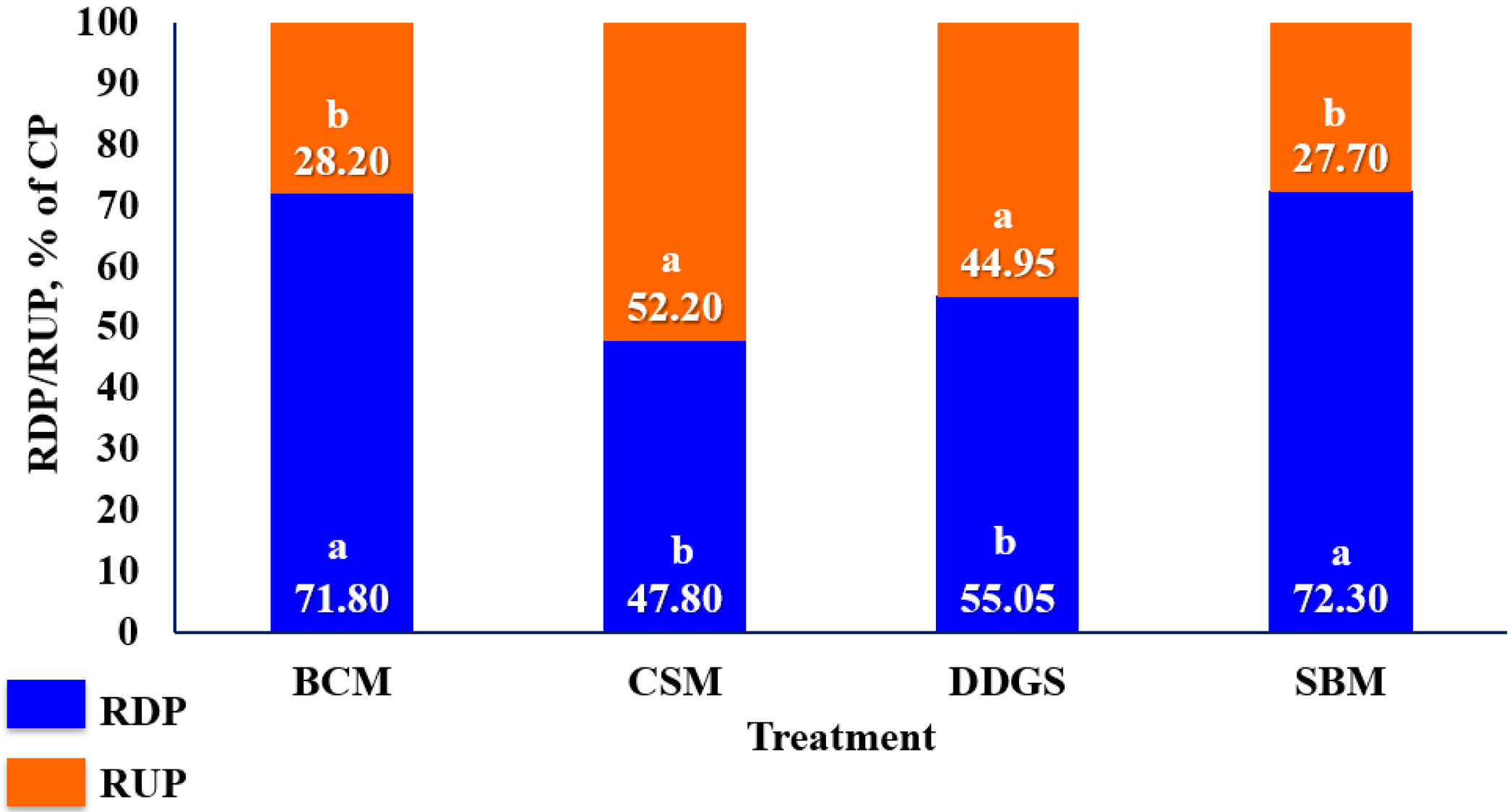
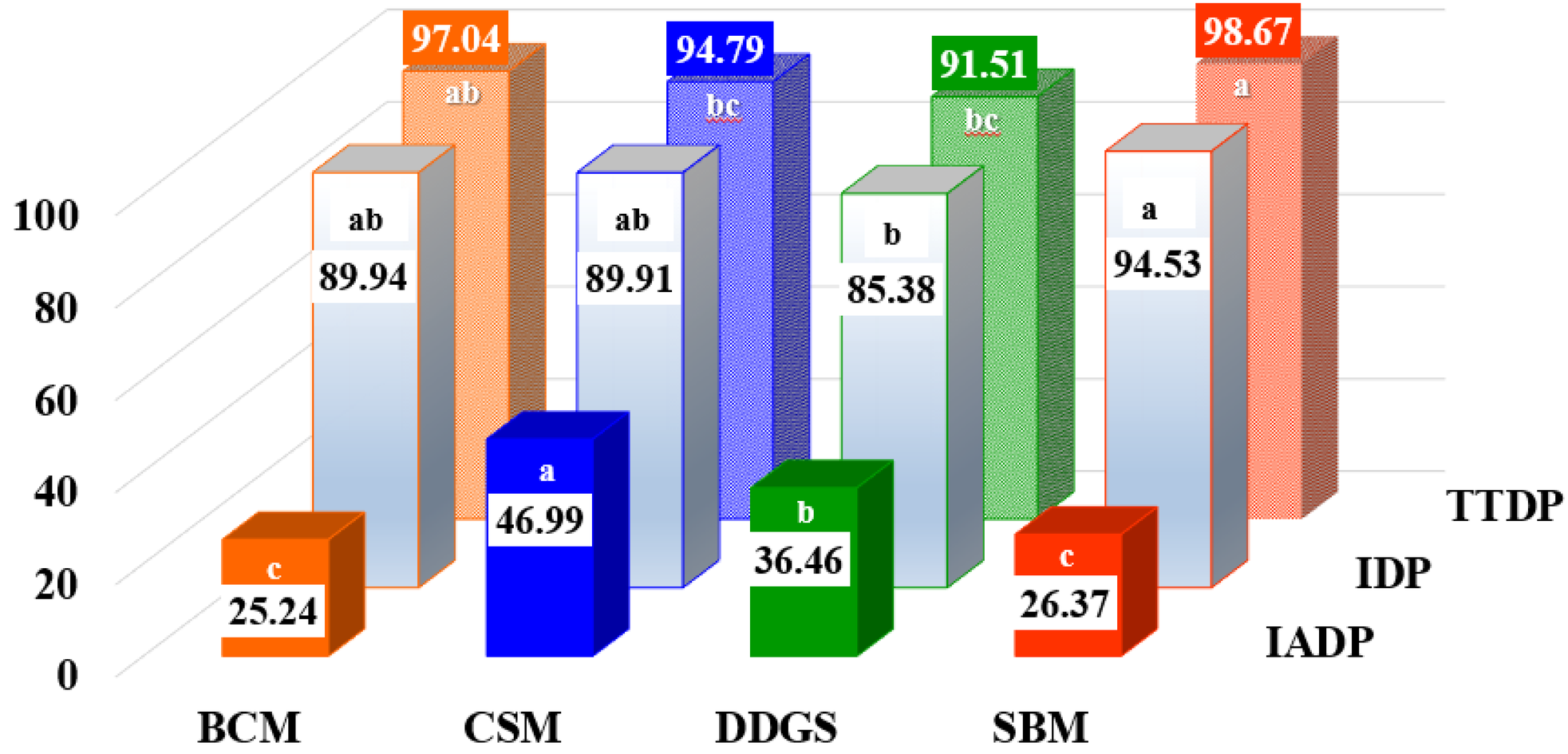

Dietary CP
RUP
TP
RUP
RDP
RDP
TP + NPN
Metabolizable protein
MP (TTDP) = IADP + MCP
TDN
MCP
Digestion + Absorption
Small intestine
Rumen
Feces
RUP × IDP = IADP
IDP = Intestinal digestibility of protein
IADP = Intestinally absorbable dietary protein

Figure 1. Ruminal fractionation of protein supplements fed to ruminally cannulated Angus crossbred beef steers consuming a forage-based diet



Treatment effect, $P < 0.01$; SEM 3.29 [a,b]Means with different letters differ, $P < 0.05$

Figure 2. Intestinally absorbable dietary protein (IADP), intestinally digestible protein (IDP), and total-tract digestibility of protein (TTDP) of supplements fed to ruminally cannulated Angus crossbred beef steers consuming a forage-based diet



[a,b,c] Means with different letters differ, $P < 0.05$

Treatment effect, $P < 0.01$
IADP, SEM 2.847; IDP, SEM 2.194; TTDP, SEM 0.958