

Hulless Barley (*Hordeum vulgare L.*) with Altered Starch Traits: Rumen Degradation Kinetics

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Key words: amylose and amylopectin ratio, beta-glucan, hulless barley, rumen degradation
and intestinal digestion

Abstract:

The objective of this study was to determine the effect of new hulless barley lines (zero-amylose waxy, CDC Fibar; 5%-amylose waxy, CDC Rattan; normal-amylose, CDC McGwire and high-amylose, HB08302) on rumen degradation kinetics and in vitro intestinal nutrient digestion with CDC Copeland included as a hulled control. Three dry Holstein cows fitted with rumen cannula were used for measuring rumen degradation of barley varieties. The estimation of intestinal digestion was determined by a modification of the three-step in vitro procedure described by Calsamiglia and Stern with duplicate of each in situ residue. Among the hulless barley lines, CDC Rattan was greater ($P < 0.05$) in effectively degradable starch (EDST: 461 g/kg DM) but reduced ($P < 0.05$) in rumen undegradable protein (RUP: 55g/kg DM) while CDC Fibar was greater ($P < 0.05$) in effectively degradable crude protein (EDCP: 90 g/kg DM) and total digestible protein (TDP: 147 g/kg DM) than other hulless barley lines. CDC McGwire showed greater ($P < 0.05$) in total digestible bypass starch (TDST: 590 g/kg DM), effectively degradable CHO (EDCHO: 581 g/kg DM) and total digestible CHO (TDCHO: 600 g/kg DM) than other hulless barley lines but no significant difference compared to CDC Copeland ($P > 0.05$). HB08302 was greater ($P < 0.05$) in rumen bypass starch (BST: 218 g/kg DM vs. 146 g/kg DM and 155 g/kg DM) and effective degradable NDF (EDNDF: 74 g/kg DM vs. 49 g/kg DM and 52 g/kg DM) than CDC Fibar and CDC Rattan. HB08302 was also greater in total digestible NDF (TDNDF: 93 g/kg DM vs. 62 g/kg DM and 67 g/kg DM) and intestinal digestible rumen bypass starch (IDBST: 180 g/kg DM vs. 122 g/kg DM and 130 g/kg DM) compared to CDC Fibar and CDC McGwire. HB08302 also showed greater ($P < 0.05$) in bypass CHO (BCHO: 179 g/kg DM) and intestinal digestible bypass CHO (IDBCHO: 31 g/kg DM) than other hulless barley lines. Amylose and amylopectin were significantly correlated ($P < 0.001$) to EDCP ($r = -0.71$, $r = 0.64$) and TDP ($r = -0.85$; $r = 0.77$), while amylose, ratio of amylose and amylopectin were positively correlated ($P < 0.01$) to EDNDF, TDNDF, BST, IDBST and TDCHO ($P < 0.05$). BCP, IDP, TDP, BNDF were positively correlated to beta-glucan levels ($P < 0.001$) while EDST, TDST, EDCHO and TDCHO were negatively correlated to beta-glucan levels in hulless barley lines ($P < 0.01$). In conclusion hulless barley lines with altered carbohydrate traits have the potential to increase

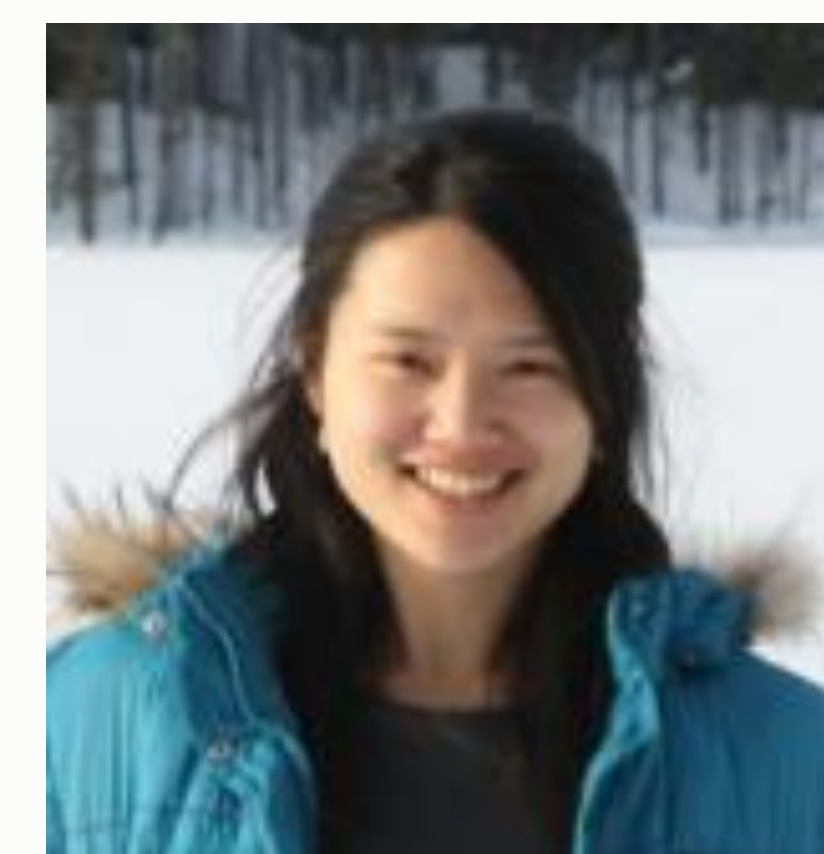
rumen and intestinal nutrient availability to ruminants. Altered beta-glucan levels had a greater effect on rumen carbohydrates and crude protein degradation than altered starch traits.

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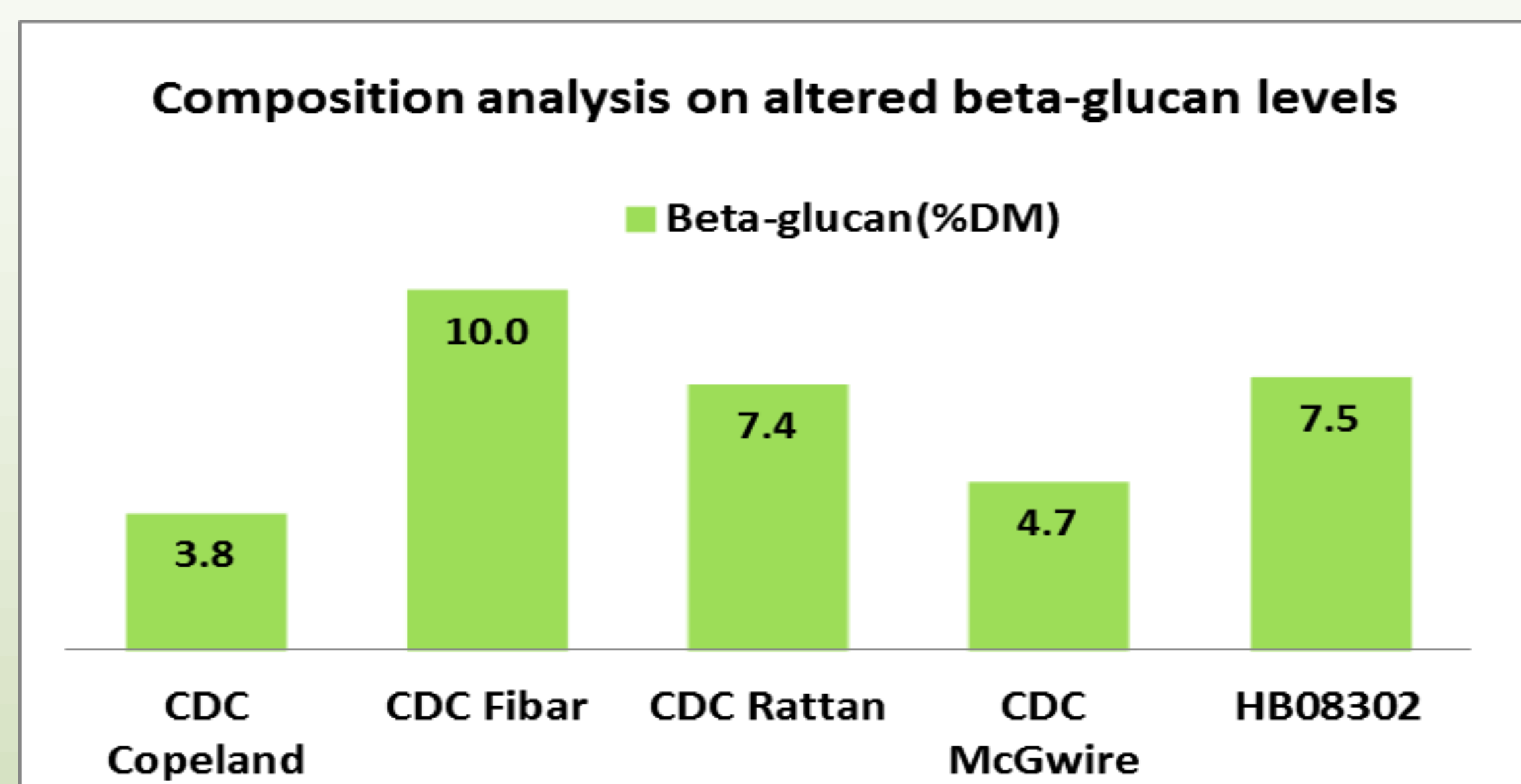
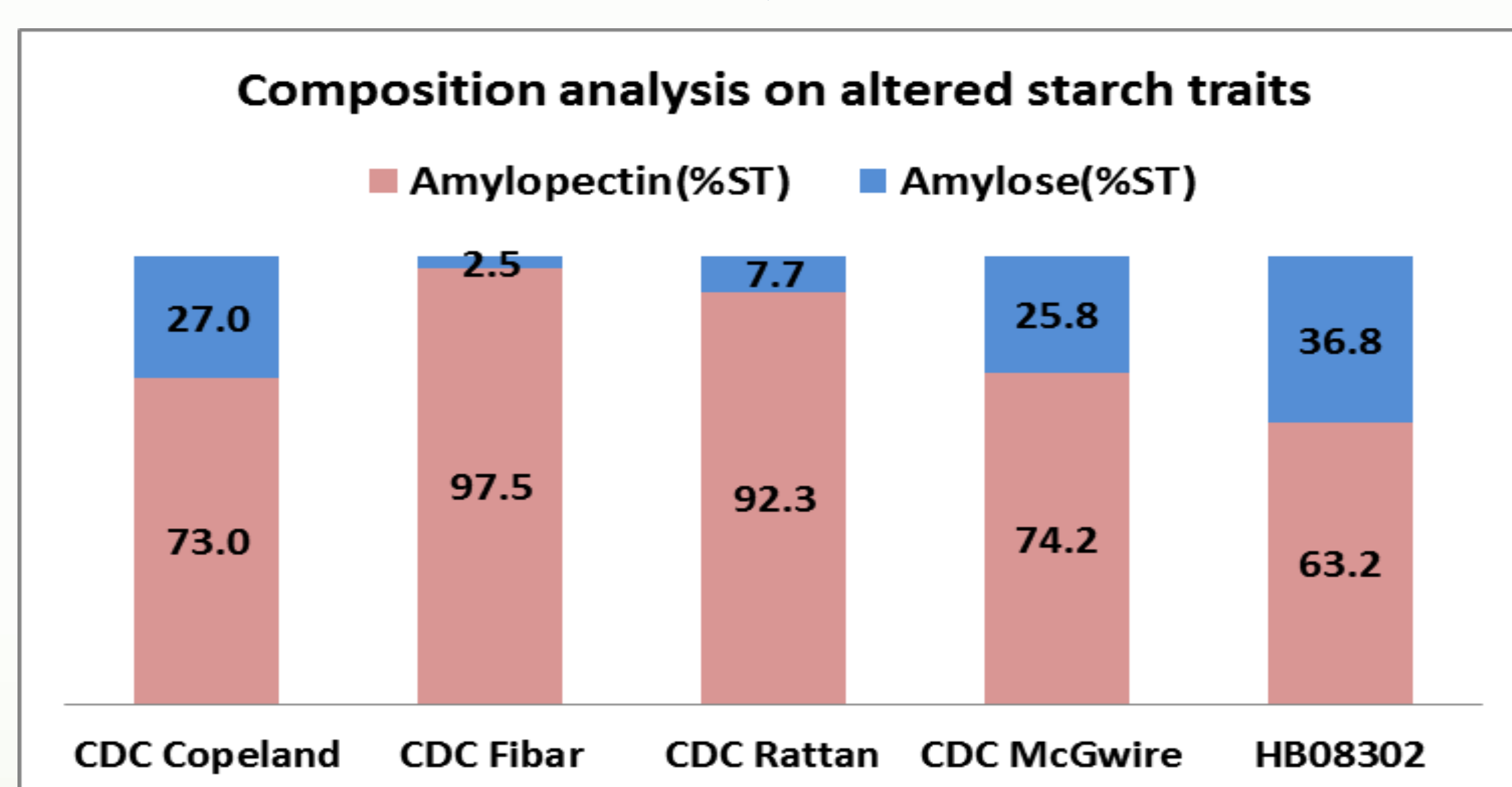
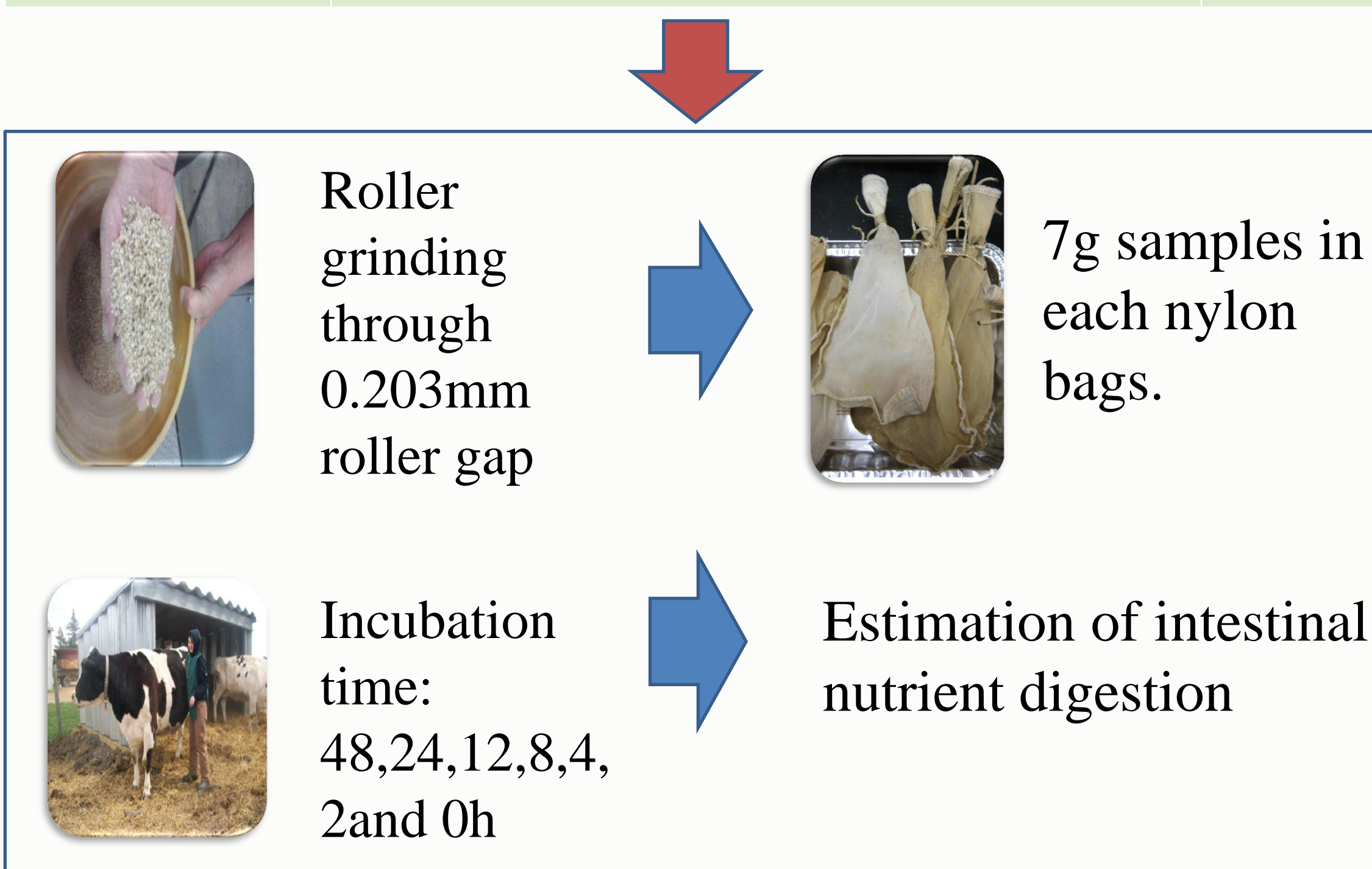
Introduction

- Hulless barley contained higher energy value and better nutrient availability with its reduced fiber and increased starch content compared to hull cultivars.
- Four hulless barley breeding lines varied in amylose and beta-glucan content were used to determine the difference on carbohydrate utilization and availability in ruminants with hulled barley as reference check.

Materials and Methods

Table 1: Breeding targets of four newly developed CDC hulless barleys and CDC hulled barley (control)

Items	Hulless Barley				
	CDC Copeland	CDC Fibar	CDC Rattan	CDC McGwire	HB 08302
Amylose (% in starch)	25-29	0	5	25	40
Amylopectin (% in starch)	71-75	100	95	75	60
Beta-glucan (% in DM)	3.5-4	Very High	High	High	High
Sample year	2008,2009,2010				09-10



Objectives

Compare hulled barley (CDC Copeland) with three newly developed hulless barley cultivars (zero-amylose waxy, CDC Fibar; waxy, CDC Rattan; and high-amylose, HB08302) and normal starch hulless barley cultivar (CDC McGwire) in terms of nutrient availability for dairy cattle.

Conclusion

Hulless barley lines with altered carbohydrate traits have the potential to increase rumen and intestinal nutrient availability to ruminants. Altered beta-glucan levels had a greater effect on rumen carbohydrates and crude protein degradation than altered starch traits.

Results

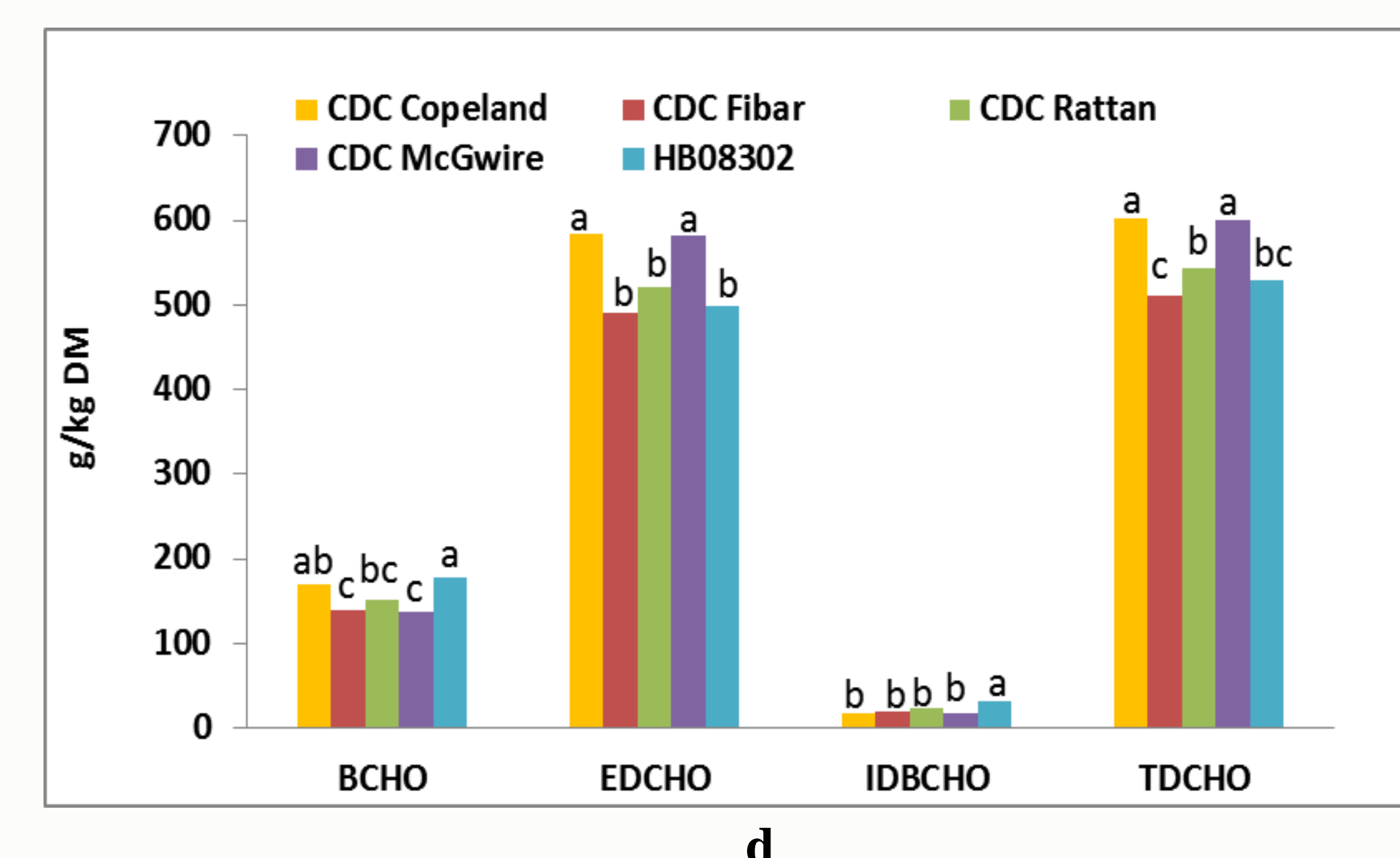
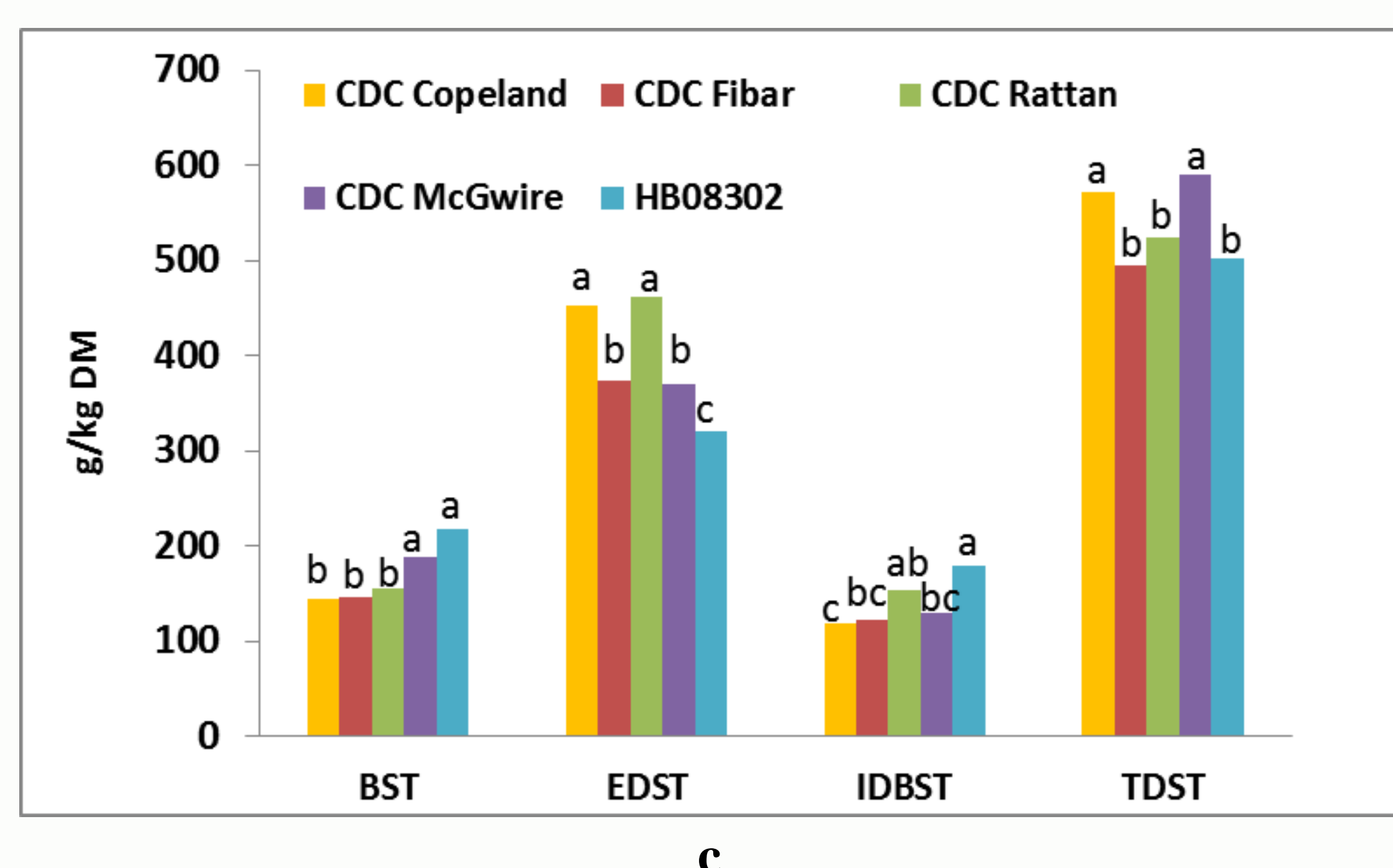
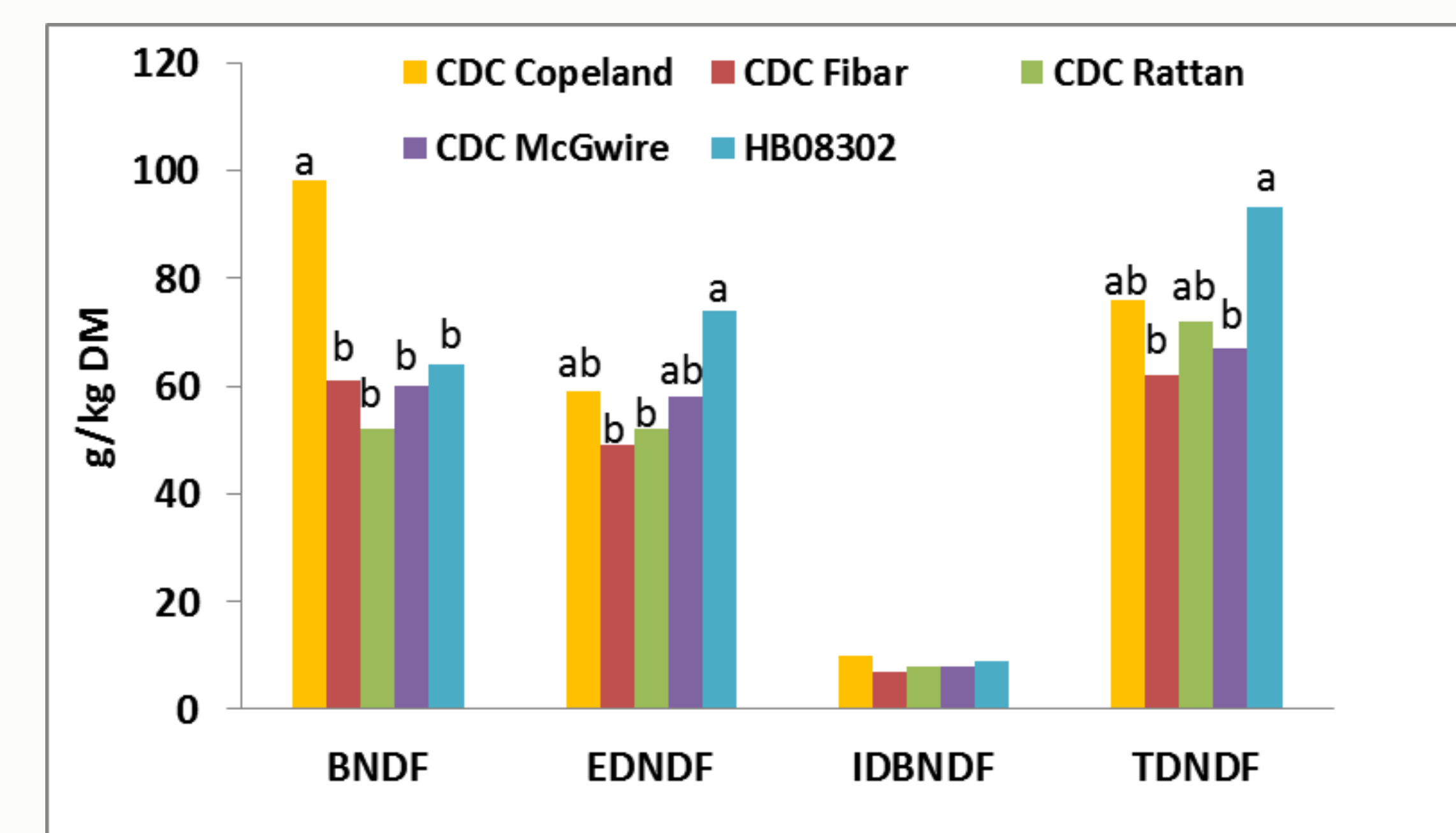
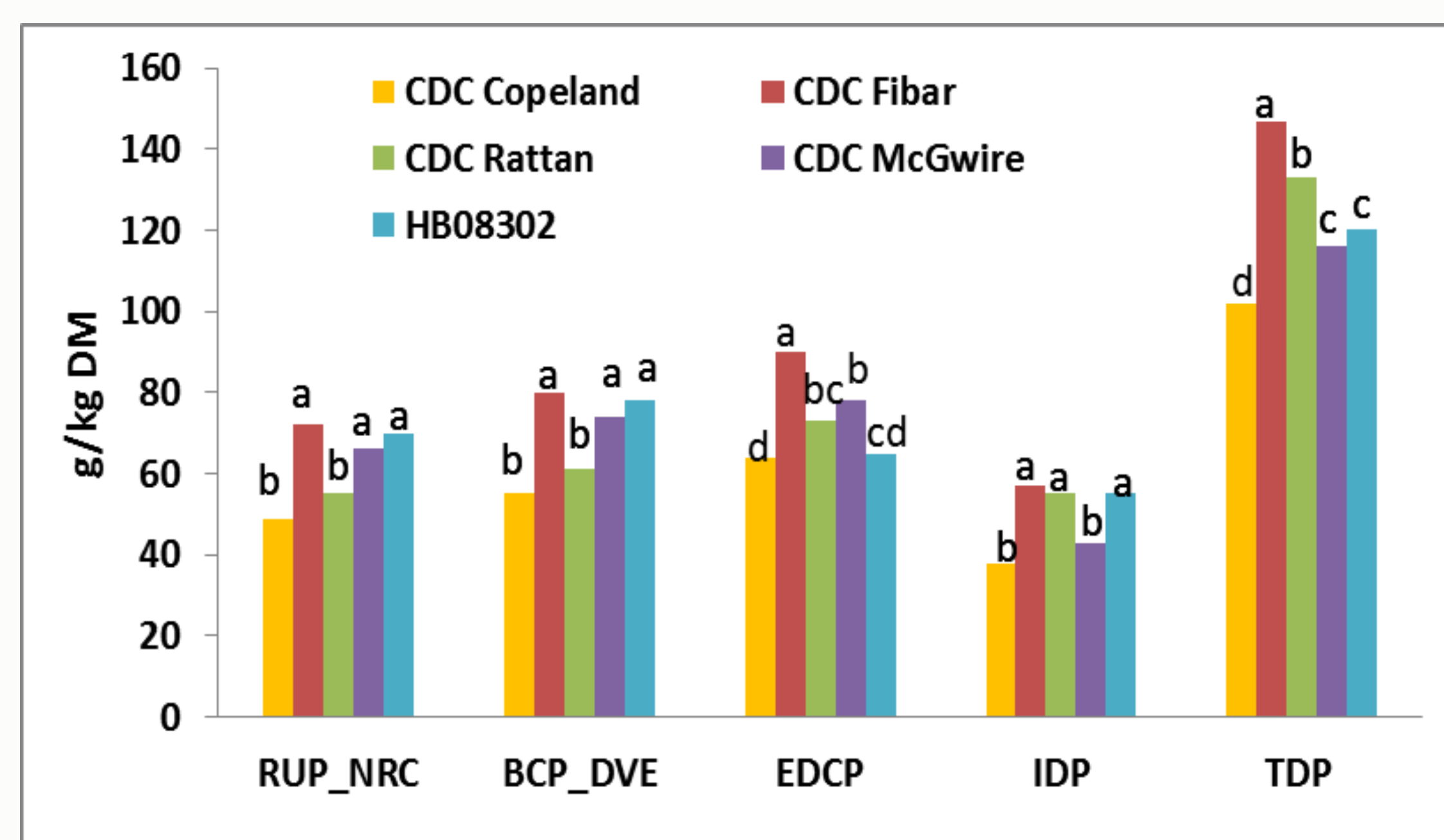


Figure 1: Rumen bypass(B), effective degradable(ED), intestinal digestible(ID) and total digestible(TD) crude protein(a), neutral detergent fiber(b), starch(c) and carbohydrate(d)

Table 2: Correlation analysis between altered carbohydrate traits [amylose level, amylopectin level, ratio of amylose to amylopectin (Ay:Ap) and beta-glucan level] and rumen degradation, intestinal digestion of CP, NDF, Starch and CHO

Items	Altered Starch Traits			
	Amylose (%DM)	Amylopectin(%DM)	Ay:Ap	Beta-glucan (%DM)
-----Spearman Correlation R value -----				
In situ rumen CP degradation and intestinal CP digestion (g/kg DM)				
BCP_DVE	-0.25	0.08	-0.28	0.63***
RUP_NRC	-0.25	0.08	-0.28	0.63***
EDCP	-0.71***	0.64***	-0.70	0.37+
IDP	-0.39+	0.27	-0.41+	0.76***
TDP	-0.85***	0.77***	-0.84***	0.74***
In situ rumen NDF degradation and intestinal NDF digestion (g/kg DM)				
BNDF	-0.25	0.19	-0.25	0.44*
EDNDF	0.54**	-0.28	0.54**	-0.20
IDBNDF	0.16	-0.10	0.15	-0.05
TDNDF	0.58**	-0.45*	0.58**	-0.17
In situ rumen Starch degradation and intestinal starch digestion (g/kg DM)				
BST	0.53*	-0.41+	0.51*	0.11
EDST	-0.07	0.18	-0.04	-0.60**
IDBST	0.53*	-0.37+	0.51*	0.08
TDST	0.38+	-0.13	0.40+	-0.79***
In situ rumen CHO degradation and intestinal CHO digestion (g/kg DM)				
BCHO	0.37+	-0.41+	0.35	0.13
EDCHO	0.32	-0.07	0.34	-0.80***
IDBCHO	0.39+	-0.45*	0.36+	0.11
TDCHO	0.54**	-0.29	0.56**	-0.89***

Note: + for P<0.10; * for P<0.05, ** for P<0.01, *** for P<0.001

Acknowledgements

