Animal Feed Science and Technology 209 (2015) 16–29

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Review

Starch digestion in broiler chickens fed cereal diets

F. Zaefarian*, M.R. Abdollahi, V. Ravindran

Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11 222, Palmerston North 4442, New Zealand

ARTICLE INFO

Article history:
Received 23 March 2015
Received in revised form 17 July 2015
Accepted 18 July 2015

Keywords:
Starch
Digestion
Cereals
Feed processing
Broiler chickens

ABSTRACT

Starch, comprising up to 70–80% of most cereal grains, is the primary source of energy in poultry diets. Although it is generally believed that starch is well digested by poultry, low total tract and ileal starch digestibility has been reported in some studies. The structure and composition of starch granules, their interaction with protein matrix, and their availability after feed processing play important roles in the digestion of starch. There is clear evidence that starch digestion is highly correlated with its structural location within feedstuffs and components associated with starch granule. Viscous non-starch polysaccharides and feed technology practices such as pelleting, whole grain feeding and inclusion of fibrous materials also have significant influence on starch digestibility. The aim of this review is to focus on factors affecting the digestion and absorption processes of starch in poultry. The effects of components associated with starch granule, soluble and insoluble dietary fibre, anti-nutrients and feed processing on starch digestion are also reviewed.

Contents

* Corresponding author. Tel.: +64 6 356 9099.
E-mail address: F.Zaefarian@massey.ac.nz (F. Zaefarian).

http://dx.doi.org/10.1016/j.anifeedsci.2015.07.020
0377-8401/

1. Introduction

Starch is the main source of energy in poultry diets, comprising approximately 40% of the diet and contributing to more than half the metabolisable energy intake (Svihus, 2011). Variations in starch digestion therefore have a strong influence on the energy value of poultry diets. Despite this, starch digestion has not received much attention until recently because of starch digestion is seldom a problem in poultry fed maize-based diets. Several studies indicate that starch in maize is almost completely digested in broiler chickens (Table 1). Chickens are also able to increase the secretion of pancreatic α-amylase with increasing amounts of starch ingestion (Moran, 1985). However, evidence is accumulating to suggest that starch is not fully digested in poultry and that there is considerable variation among cereal species and cultivars within species. Thus consideration of the factors that could lower total tract or ileal starch digestibility is of critical relevance in practical feed formulations. Factors contributing to the variability in starch digestibility, including starch granule structure, anti-nutritional factors and cell wall structure, are reviewed herein. The influence of feed technology practices such as pelleting and thermal treatments, whole grain feeding, inclusion of structural components in the diet and feed particle size are also discussed.

2. Starch structure and classification

Starch accumulates in granules in the endosperm and consists of two different glucose polymers, namely amylose and amylopectin. Structure of these polymers and differences between amylose and amylopectin has been described in many studies (Heijnen, 1997; Oates, 1997; French, 1984; Gallant et al., 1992; Hizukuri et al., 1997; Buleon et al., 1998; Imberty et al., 1991). The negative relationship between amylose to amylopectin ratio and starch digestion rate is well recognised (Topping et al., 1997; Åkerberg et al., 1998; Bednar et al., 2001; Saito et al., 2001; Abdel-Aal et al., 2002). Raw starches high in amylopectin have been shown to be digested more quickly than those high in amylose (Svihus et al., 2005). The starch

Table 1
Starch digestibility of cereals in poultry.

Grain type	Age (day)	Starch digestibility		Reference
		Ileal	Total tract	
Maize	14	0.98	–	Yutste et al. (1991)
	35	0.97	–	Camden et al. (2001)
	24	–	0.94–0.96	Maisonnier et al. (2001)
	29	0.97	0.97	Weurding et al. (2001)
	21	0.98–0.99	–	Abdollahi et al. (2013b)
Wheat	42		0.93[a]	Rogel et al. (1987a)
	14	0.98	–	Yutste et al. (1991)
	24	–	0.82–0.87	Maisonnier et al. (2001)
	21	0.79	–	Svihus (2001)
	21	0.79	–	Svihus and Hetland (2001)
	29	0.94	0.94	Weurding et al. (2001)
	24	0.97	–	Hetland et al. (2002)
	38	0.94	–	Hetland et al. (2002)
	33	0.97	–	Hetland et al. (2003)
	24	–	0.94–0.97	Svihus et al. (2004)
	25	0.95–0.98	–	Svihus et al. (2004)
	24	–	0.89–0.96	Carré et al. (2005)
	21	0.81–0.83	–	Zimonja and Svihus (2009)
	21	0.81–0.98	–	Abdollahi et al. (2011)
	21	0.92–0.98	–	Abdollahi et al. (2013a)
Sorghum	29	0.95	0.95	Weurding et al. (2001)
	27	0.87–0.91	–	Selle et al. (2012)
	21	0.93–0.96	–	Abdollahi et al. (2014)
	28	0.86–0.89[b]	–	Selle et al. (2014)
	28	0.84–0.91[c]	–	Selle et al. (2014)
Barley	19	0.89[d]	–	Hesselman and Aman (1986)
	19	0.85[e]	–	Hesselman and Aman (1986)
	21	0.96	–	Svihus (2001)
	29	0.98	0.98	Weurding et al. (2001)
Oat	21	0.99	–	Svihus (2001)
	21	0.96–0.97	–	Zimonja and Svihus (2009)

[a] Mean total starch digestibility of 38 wheat varieties grown in Australia.
[b] White sorghum.
[c] Red sorghum.
[d] Low viscous barley.
[e] High viscous barley.