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In vitro gas and volatile fatty acids production profiles of barley and maize and their soluble and washout fractions after feed processing

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Abstract

In vitro fermentation characteristics of soluble, washout, and non-washout fractions separated from barley and maize and their technologically processed (i.e., pressure toasting, pelleting and their combination) products were measured. The aim was to establish whether the soluble equaled the washout fraction, whether these fractions are rapidly and completely fermented, and whether their fermentation characteristics are the same. A simple fractionation method was developed to separate the whole grain into a soluble fraction, a washout fraction, an insoluble washout fraction, and a non-washout fraction. Proximate analysis of the different fractions revealed in the soluble fraction a large (>400 g kg^{-1} DM) residual organic matter component of unknown origin, while the insoluble washout fraction contained between 800 and 900 g starch/kg DM. Fermentation characteristics of all fractions as well as the whole grain were measured for 72 h using gas and volatile fatty acids (VFA) production in vitro. After fractionation, gas and VFA production profiles of the fractions with different chemical compositions were found to be different. Based on gas production profiles it was shown that the

Abbreviations: VFA, volatile fatty acids; BCR, ratio of the sum of the branched-chain volatile fatty acid plus valeric to the sum of acetic, propionic and butyric acids (in units of acetic acid equivalent); NGR, ratio of non-glucogenic to glucogenic fatty acids; SWF, soluble washout fraction; ISWF, insoluble washout fraction; TWF, recombined total washout fraction; NWF, non-washout fraction; WHO, whole grain after grinding; FOM, fermented organic matter

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soluble fraction was easily fermentable and was fermented faster than the insoluble washout and the non-washout fraction. Differences were however much smaller than anticipated, which would suggest that the extent of fermentation of washout fractions in the rumen is incomplete. The maximum gas and VFA production from the soluble fraction was always lower than that of the insoluble washout, and the non-washout fraction. The combination of pressure toasting and pelleting reduced fermentability both in terms of gas and VFA production compared with the other treatments.

Keywords: Barley; Maize; Cumulative gas production; Feed fractionation; Feed processing; Fermentability; Pelleting; Pressure toasting; Rumen; Volatile fatty acids

1. Introduction

The nutritive value of grains is most often evaluated in terms of its in situ degradability and in vitro organic matter digestibility. These values are calculated assuming that the fermentation of degradable components is complete, which means that the cell contents, which are assumed to be soluble, are also assumed to be 100% degradable. However, in recent years, research results (De Boever et al., 1995, 1997; Lopez et al., 1994; Madsen et al., 1995) have questioned, at least for crude protein, if all washouts from nylon bags are really soluble, and further, whether they are also readily and completely fermented in the rumen. The question has been raised whether it might be necessary to separate the washout fraction (W) into a soluble washout fraction (SWF) and an insoluble washout fraction (ISWF) and to correct for the loss of particles.

A similar situation may exist for starch. A difference between SWF and ISWF could be caused by a difference in particle size after grinding, because fine grinding ruptures more cell walls and releases more soluble nutrients or nutrients small enough to be washed out than coarse grinding (De Boever et al., 1997). The difference between W and SWF could consist of a rapidly fermented starch fraction, which is lost from the bags before it is fermented, though a loss of undegraded particles is also a possible explanation (Dewhurst et al., 1995). In summary, microbial degradation of feed nutrients and their end-products in terms of volatile fatty acids (VFA), microbial protein synthesised in rumen fermentation, ammonia (NH_3), and fermentation gases, could easily be over- or underestimated due to the assumption that W is equal to SWF in situ and the assumption that W is rapidly and completely degraded. Such problems cannot be solved with nylon bag incubation studies.

Feed processing (i.e., grinding, pelleting, extrusion, pressure toasting, etc.) may substantially alter the rumen degradation characteristics of starch in compound feeds for dairy cows (Tamminga et al., 1990; Nocek and Tamminga, 1991; Goelema, 1999). The actual rate and extent of fermentation can be estimated from the gas and volatile fatty acids produced during incubation, as measured using the cumulative gas production technique (Theodorou et al., 1994).

The objective of this study was two-fold. First it explored a new physical method of separating feeds in different fractions, that was supposed to mimic the washout procedure with nylon bags, and which could then demonstrate different fermentation characteristics between the non-washout (NW), washout (W), and soluble washout fractions (SWF), using the cumulative gas production technique, including also following the dynamics of volatile