Interaction between nutrition and cannibalism in laying hens

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Summary

Cannibalism remains an important problem for the poultry industry around the world because its occurrence affects the welfare of birds and causes economic losses to poultry producers. With an increasing pressure of public opinion and from various regulatory authorities, some of the traditional methods of controlling cannibalism in chickens such as beak–trimming are under scrutiny. Numerous alternatives to beak–trimming have been tested, including putting goggles on the birds, using low light intensity in the layer house, or keeping birds in individual cages, but these measures are very costly. If the current production system without beak–trimming is continued, behavioural and nutritional approaches must be taken to alleviate cannibalism problems. This paper discusses the occurrence and prevention of cannibalism in chickens, focussing on dietary strategies using various types of fibre to prevent and stop cannibalism, and the possible mechanisms underlying its effects.

Keywords: cannibalism, feather pecking, insoluble fibre, non–starch polysaccharides, laying hen

Introduction

Cannibalism in poultry, the behaviour exhibited when a bird starts pecking and tearing off the skin or underlying tissues of another bird, is undoubtedly the major cause of mortality in cage–housed hens not beak–trimmed in the absence of a clinical outbreak. It results in great economic losses for poultry producers and causes animal welfare problems because it results in high mortality (Kato *et al.* 1991) and morbidity due to injuries or stress to pecked birds (Allen and Perry 1975; Barnett *et al.* 1997; Huber and Wechsler 1998). Production suffers because of a direct loss of birds to cannibalism as well as a reduced rate of lay (Johnsen *et al.* 1998). Although cannibalism is usually associated with feather pecking, it more often arises independently from that behaviour in a form known as 'vent peck' (Allen and Perry 1975) which is the most common pecking in laying hens and appears to be initiated when a minor partial prolapse of the uterus occurs after the onset of lay (Savory 1995). Feather pecking, an abnormal behaviour, which consists of pecking the feathers of other birds (van Hierden *et al.* 2002), can range from gentle pecks known also as 'allopreening' (Vestergaard *et al.* 1993) to severe feather pulling (Savory 1995; Bilcik and Keeling 1999). Deterioration of plumage due to feather pulling will become an attractive target for further feather pecking (McAdie and Keeling 2000), and when a wound is present in such a circumstance the action will change to cannibalism. Gentle pecks can become more severe and lead to cannibalism (Vestergaard *et al.* 1993).

The outbreak of cannibalism has been associated with a number of factors. Unsatisfactory housing conditions such as in a wire floor system (Baum 1995; Johnsen *et al.* 1998) or cages (Tablante *et al.* 2000) have been shown to promote its occurrence. Increasing group size and stocking density increases the frequency of aggressive pecks (Bilsing *et al.* 1992; Savory *et al.* 1999; Bilcik and Keeling 2000), resulting in a greater feather damage (Appleby *et al.* 2002) and leading to cannibalism. Blokhuis (1986) and Vestergaard (1994) suggested that the occurrence of feather pecking is a result of frustration due to the lack of opportunity for ground pecking because of crowding, which also restricts dust–bathing (Vestergaard 1994). It is questionable whether those conditions are involved in the occurrence of cannibalism in turkeys because they do not exhibit behaviours commonly observed in other poultry species such as dust–bathing, and ground–scratching while feeding (Sherwin and Kelland 1998). Bright light is another management factor associated with the occurrence of cannibalism. A comparison of low and high intensity light (3 vs 30 lux), Kjaer and Vestergaard (1999) showed that severe pecks were 2–3 times more frequent under 30 lux and were associated with increased mortality. Hartini *et al.* (2002) also observed that birds reared under bright light (60 lux) tended to exhibit aggressive behaviour (pecking and cannibalizing) from as early as 5 weeks of age, while

those reared under dim light (5 lux) remained calm.

Whilst management practices are extremely important in the prevention of cannibalism in poultry, conditions such as light intensity and multiple–bird cages are difficult to change in many countries where the main production system uses battery cages in open–sided housing. In these situations, dietary manipulations to minimise cannibalism become highly attractive; these will be discussed later.

Prevention of cannibalism using the traditional methods

The most commonly used method to reduce the incidence of injuries and deaths associated with feather pecking and cannibalism is beak–trimming, a process where about one–third of the upper and lower mandible of a bird is cut off (Blokhuis *et al.* 1989). This process can result in chronic pain to the bird (Gentle 1986; Struwe *et al.* 1992) and is often criticized on welfare grounds despite its significant contribution to reducing cannibalism mortality (Kuo *et al.* 1991). Thus, the focus of recent research has been on minimising the incidence of feather pecking and cannibalistic behaviour of birds largely through bird management and husbandry. These studies indicate that birds reared in floor pens with access to sand (Vestergaard and Lisborg 1993; Johnsen *et al.* 1998; Larsen *et al.* 2000), or wood shavings (Baum 1992), or whole grains (Blokhuis *et al.* 1992) exhibited less pecking and cannibalistic behaviour, perhaps because the birds used sand or wood shavings or grains as dust–bathing substrate. This supports the hypothesis that feather pecking is actually redirected ground pecking. Blokhuis *et al.* (1989) reported that the experience of birds during rearing influences the development of pecking preferences during the laying period. Indeed, Kjaer and Vestergaard (1999) found that non–aggressive behaviour that developed in birds reared in dim light persisted throughout the laying period. The results from Hartini *et al*. (2002), in part, support this finding, although the authors found an increase in mortality rate when birds had just been moved from dim to bright light. It was suggested that a sudden change of environment from dim to bright light might stress the birds. When birds are stressed there is more likely to be an onset of pecking (El *et al.* 2000). Another possible management strategy for reducing cannibalism in birds is the use of genetic selection. For example, birds selected on the basis of a low propensity to feather peck have a low incidence of feather pecking and cannibalism (Kjaer and Sorensen 1997; Blokhuis and Wiepkema 1998). Cuthbertson (1980) and Muir and Craig (1998) agreed that by genetic selection, strain of laying hens with low pecking behaviour could be developed without reducing productivity. The finding of Korte *et al.* (1999) that high– and low–feather pecking birds have different activities in terms of coping style highlights the feasibility of reducing the occurrence of cannibalism by genetic selection. However, selection based on behavioural traits is highly complex and it requires a multi–factorial approach taking into account production and environmental parameters on a long–term basis.

Nutritional interventions

The possibility of preventing cannibalism through dietary manipulation was investigated in the 1940s and 1950s. For example, Bearse *et al.* (1940) and Scott *et al.* (1954) found that inclusion of oat hulls in diets decreased the incidence and severity of feather pecking and showed superior feather conditions. No other studies had been made on the role of nutrition in feather pecking and cannibalism until recently, when several dietary deficiencies have been found to be related to feather pecking and/or cannibalism (Cain *et al.* 1984; Cooke 1992; Ambrosen and Petersen 1997). Low levels of dietary protein (Cain *et al.* 1984; Ambrosen and Petersen 1997), of tryptophan (Shea *et al.* 1990; Savory *et al.* 1999), and of lysine, methionine, and threonine (Ambrosen and Petersen 1997) have been reported to cause aggressive pecking and cannibalism in birds. Diets deficient in phosphorus and sodium have also been linked with the outbreak of cannibalism in chickens (Cooke 1992; Cumming *et al.* 1995). Of particular significance are the findings of Esmail (1997) that addition of oat hulls to a layer diet reduced the incidence of feather pecking and cannibalism in a dose–response manner. Recent research by Hartini *et al*. (2002) also found that insoluble dietary fibre was very effective in reducing cannibalism mortality.

Protein and animo acids

Birds consuming diets deficient in protein are often poorly feathered, and an inferior plumage condition can lead to feather pecking and/or cannibalism (Hughes and Duncan 1972; Barnett *et al.* 1997). Cain *et al.* (1984) found that feather pecking in growing pheasants was reduced with dietary protein levels greater than 19%. Ambrosen and Petersen (1997), on the other hand, found no significant effect on the onset of cannibalism or plumage conditions in hens with 15.2% or more protein in the diet. It is suggested that an increase in cannibalism when diets low in protein are offered might be due to an imbalance in amino acids, and increasing protein level would tend to overcome deficiencies in some crucial amino acids. However, when Curtis and Marsh (1993) increased the dietary protein level from 14.5% to 18% by changing the ratio of plant to animal protein feeds, cannibalism mortality increased. They suggested that changes in protein sources might influence the flavour and palatability of the feed, decreasing feed intake and exacerbating the outbreak of cannibalism. March *et al.* (1975) also reported that substituting soybean meal with rapeseed meal as the main protein source for laying hens impaired production efficiency and induced cannibalism. However, recent findings by

several workers (Savory *et al.* 1999; McKeegan *et al.* 2001) demonstrated that different dietary protein sources (plant, animal, mainly semi–purified) had no effect on pecking damage in laying hens. This highlights the difficulty in drawing conclusions on whether protein is a predisposing factor for cannibalism because when protein sources are changed, the amount of fibre and anti–nutrients present in the diet will also change.

Fibre

The connection between cannibalism and fibre in poultry comes from the evidence that birds fed oats do not cannibalise each other (Bearse *et al*. 1940; Scott *et al*. 1954). This has some support from a study by Wahlstrøm *et al.* (1998) who compared the behaviour of birds given a diet based on wheat with that of birds given a diet based on oats. For the wheat and oats diets respectively, total mortalities were 18.4% and 13.4% and deaths from cannibalism were 13.0% and 8.7%.

Oats contain 20–25% non–starch polysaccharides (NSP), with 85–90% being insoluble. The fibre components of poultry diets consist primarily of NSP, which are the main constituents of plant cell walls (Fincher and Stone 1986). In poultry nutrition, however, the focus of research is on the anti–nutritive effect of soluble fibre and little attention has been paid to the roles of insoluble fibre. In an experiment using 1440 ISA Brown laying hens not beak–trimmed, we investigated the effect of diets containing a high level (c. 20%) of insoluble NSP on cannibalism mortality during the pre–lay period (17–20 weeks of age) and early–lay period (21–24 weeks of age). The high fibre diet was more preventative of cannibalism than a commercial diet; mortality was respectively 13.2% vs 3.9% for the pre–lay period and 28.9% vs 14.3% for the early–lay period. When the diets were crossed over, the cannibalism mortality in the flock fed the commercial diet significantly decreased within a week of switching to the high fibre diet (Table 1). The insoluble fibre source used in this experiment was a wheat by–product (millrun) containing approximately 2/3 bran and 1/3 pollard. The barley diet was used as a source of soluble fibre as it contains a considerable amount of β–glucan. Furthermore, an enzyme β–glucanase at 300 g/kg diet) was used in the barley diet to test if depolymerisation of the polysaccharide would lead to different outcomes for their effect on cannibalism. A confounding factor in this experiment was that the barley diet contained as much insoluble NSP as the millrun diet (11.2% vs 11.6%); it also contained 2.1% soluble NSP, which was largely degraded when the enzyme was added to the diet. Thus, the expected difference between the effect of soluble and insoluble fibre on cannibalism was not demonstrated in this study.

Other fibre sources including rice hulls and oat hulls are being tested and are showing a similar effectiveness in controlling cannibalism (Hartini *et al.* 2003). The mechanisms by which high insoluble fibre diets reduce cannibalism in laying hens are not known but a number of hypotheses have been proposed. Firstly, it seems that birds require structural components of feed in the gizzard to regulate downstream digestion of nutrients (Hetland and Choct 2003). This is because the modern, highly refined diet that lacks fibre may bypass the crop and the gizzard, leading to a high volume of nutrients, such as starch, entering the small intestine in a short span of time to overwhelm digestive capacity of the bird. This may cause discomfort to the bird which, in turn, could be manifest as behavioural changes including cannibalism. Secondly, the transit rate of digesta may play an important role in the outbreak of cannibalism. Since only a limited digestion of insoluble fibre occurs in birds, the side effects will be a more bulky digesta and a shorter residence time of digesta in the gut (Hetland and Choct 2003). The bulking effect of fibre is related to its ability to hold a large amount of water and bacterial mass in its matrix. In our recent study, the rate of feed passage in birds fed wheat, barley and millrun diets was measured using an alkane marker, $C_{36}H_{72}$ (Choct *et al*. 2002). The maximum excretion of the marker from birds fed the millrun diet occurred during a very short time, about 3–4 h after dosing, but occurred during a considerably longer time (3–5 h after dosing) for those fed the wheat diet (Figure 1). As mentioned earlier, birds fed millrun and barley diets had a lower mortality due to cannibalism than those fed wheat diets (Hartini *et al*. 2002).

Table 1 Feed intake, egg production and mortality of laying hens fed diets differing in fibre content (Hartini *et al.* 2002).

		Mortality (%)		Early–lay	
Diets	**NSP level %**	**Pre–lay**	**Early–lay**	**Feed intake (g/d)**	**Rate of lay (%)**
Wheat	7.2	13.2[b]	28.9[b]	100.6[a]	61.2
Millrun	12.2	3.9[a]	14.3[a]	101.4[a]	64.1
Barley	13.3	5.8[a]	15.9[a]	108.9[b]	63.2
Barley + enzyme	8.9	4.1[a]	17.8[a]	107.8[b]	62.4
P value	<0.01	<0.01	<0.01	<0.01	NS

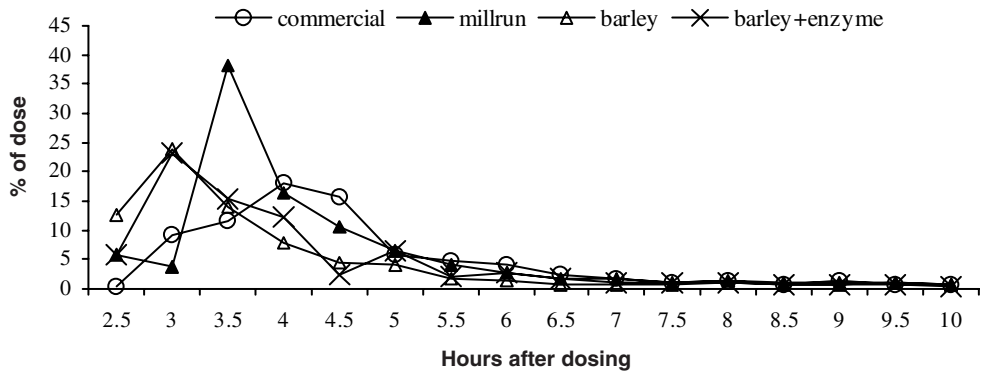

Figure 1 Alkane excretion per 30 minute sampling period expressed as a percentage of the total dose administered during an 8 h complete collection digestion trial (Choct *et al.* 2002).

It is postulated that a faster rate of digesta passage will stimulate birds to eat more due to increased need for 'gut fill'. In addition, inclusion of insoluble fibre such as oat hulls reduces energy concentration and birds compensate for this by increasing their feed consumption (Hetland and Svihus 2001). Such a condition may induce birds to spend more time eating and less in pecking each other (Hughes and Black 1977). There is also evidence that birds fed mash diets spend a longer time feeding in order to obtain an adequate amount of energy compared with those fed pellets, and these birds exhibit less pecking behaviour (Aerni *et al.* 2000; Hartini *et al*. 2003). This seems to support the hypothesis that the bird's drive for energy is an important factor in reducing cannibalism. However, when birds were given a diet containing 4% sand they ate more, and hence spent longer time feeding to compensate for the energy dilution, without any reduction in cannibalism mortality (Hartini *et al.* 2003). It is possible that the bird requires fibre to maintain proper functioning of its gizzard, and hence its 'normal' physiological activities.

Conclusion and recommendation

An adequate amount of insoluble fibre in the diet appears to be important for minimising the outbreak of cannibalism in chickens. Millrun, oat hulls, rice hulls and lucerne meal are effective sources of fibre in this regard. The mechanisms are probably related to (1) the physical properties of fibre in modulating the function of the gizzard, giving birds a 'calm feeling', and (2) increased rate of digesta passage which, in turn, increases the appearance of hunger and results in birds spending more time eating and consequently less time pecking. It is therefore recommended that in order to reduce the occurrence of cannibalism, laying hens should be fed diets containing a high–insoluble fibre, or fed their diet in mash form which increases their feeding time. A possibility that there is a link between gut microbial status and the outbreak of cannibalism warrants a further study.

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