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Prerequisites for Diet Selection in Poultry

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Abstract
Individual birds in a flock of poultry have the ability to select from various feed ingredients offered and make up their own diet according to their actual needs and production capacity. For this, animals must be able to differentiate between foods with different nutrient compositions by vision, taste, olfaction and texture, moreover, they need to be taught to associate the sensory properties of foods with their yields of nutrients. Birds can improve the balance between their nutrient requirements and their nutrient intake if they are taught to select an appropriate diet.

Key words: Diet selection, poultry, sensory differences, learning

Tavukçulukta Seçmeli Yemlemenin Ön Koşulları

Özet
Kanatlı hayvanlara çeşitli yem hammaddeleri sunulduğunda, sürüdeki bireyler bunlardan belli düzeylerde seçerek üretim kapasiteleri ve gerçek ihtiyaçlarına göre kendi rasyonlarını yapma kabiliyetine sahiptirler. Bunun için, farklı besin içerikleri ihtiva eden yem hammaddeleri hayvanlar tarafından görünüş, tad, koku ve yapı özellikleriyle ayırt edilebilmeli, dahası, yem hammaddeleri duyusal özellikleri ile bunlara ait besin içeriklerini hayvanların ilişkilendirip öğrenmesine ihtiyaç vardır. Eğer hayvanlar uygun rasyonu seçmeyi öğrenirse, besin maddesi ihtiyaçları ile besin maddesi alımları arasındaki dengeyi iyileştirebilirler.

Anahtar sözcükler: Yem seçimi, kanatlı hayvan, duyusal farklılıklar, öğrenme

Introduction

Poultry can be managed under different feeding systems, depending on the husbandry skills and the feed available. Under natural conditions, animals face many foodstuffs and as not all of these are balanced nutritionally, animals need to be able to select appropriate amounts of each food, in order to ingest an adequate diet. In the case of hens, Kempster (1916) and Rugg (1925) found evidence for diet selection. They observed that hens, given a choice between foods could balance their own diets and produce more eggs than those fed a single food. Most experiments (e.g. by Funk, 1932; Graham, 1932; Forbes and Shariatmadari, 1994; Delezie et al., 2009; Kim, 2014) demonstrate that broilers and laying hens are able to select an adequate diet from a choice of two foods which are individually inadequate (e.g. one food is higher in protein content than required and the other one is lower). However, Ahmed (1984) showed that broilers selected a nutritionally balanced diet from as many as nine different foodstuffs. This

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Araştırmacının Doktora Tezinden Yararlanılmıştır.

diet provided nutrients in similar proportions to those normally recommended by NRC, (1994). Similarly, when Banta (1932) gave Rhode Island Red yearling hens access to 13 feedstuffs, the birds did not eat at random but they selected a diet similar to the recommendation at that time, and their performance was satisfactory.

Chickens were domesticated from a wild progenitor by natural selection for making the best possible use of the resources available to them. However, against all this background, there are many examples of birds that appear not to be making appropriate choices. These instances can often be explained by shortcomings in the experimental design or a failure to meet the necessary principles and conditions set by the choice-feeding paradigm. The need to adhere to these conditions in order to demonstrate successful diet selection might represent limitations in the implementation of the choice-feeding system to commercial practice. The present paper therefore concentrates on prerequisites for successful diet selection.

Sensory Discrimination

For animals in order to differentiate between foods to compose an appropriate diet, sensory cues are very important. These can be, for instance, colour, smell, the taste or texture of the food. Birds rely primarily on their vision to identify foods, but they also use their sense of taste and "post-ingestional" factors and, possibly, both olfaction and temperature when making the correct choice of food (Gentle, 1972; Forbes, J. M. 2010). With the use of sensory cues it is possible to envisage a learned appetite for an essential nutrient, thus if the hens can be taught an appetite then this can be used in a choice-feeding situation to improve the balance between their nutrient requirements and intake.

Vision: In common with most birds, both young and mature chickens have an acute sense of vision, therefore the look of the food is a very strong signal for them (Kilham et al., 1968). The most important parameters are shape, size and colour.

Newly hatched chickens have an innate preference for round objects (Frantz, 1957) and for solidity: they peck more at a solid hemisphere than at a flat disk, whether real or not, on a photograph (Dawkins, 1968). In contrast, the preference for size is learnt by experience. Hogan-Warburg and Hogan (1981) observed that young chicks, given a mixture of feed and sand, learn to ingest primarily feed but still ingest some sand. They suggest that an increase in feed ingestion is probably the result of an association between the visual-tactile-gustatory stimuli from the feed and the positive long-term effects of the feed ingestion. In addition, chickens' preference for feed particle size has also been demonstrated. Portella et al., (1988) noted that feed particles were selected by broilers according to size. When offered one large and one small corn seed, chickens selected the larger seed (Frantz, 1957; Schreck et al., 1963; Dawkins, 1968; Van Prooije, 1978).

Moreover, as chickens age, their preferred particle size increases. When a mixture of particles of different sizes were offered to broilers, larger than 1.18 mm particles were selected by all ages of birds, while at 8 and 16 days old they favoured particles between 1.18 and 2.36 mm, and as they aged they preferred particles larger than 2.36 mm (Portella et al., 1988). The importance of preference for size on food consumption was demonstrated by Schreck et al., (1963). Reducing the size of the feed granules was associated with decreased body weight and even with increasing mortality.

It has been established that turkeys have an overall preference for green followed by red, yellow, blue and white in that order (Cooper, 1971). The literatures on the colour preference of chickens agree that they like natural, reddish colours. Hess and Gogel (1954) found that chickens prefer light-coloured foods, particularly pink, while Van Prooije (1978) concluded that chickens prefer yellow-white seed, followed by yellow, orange and finally orange-red. The red, red-blue and blue seeds were only chosen in exceptional circumstances (severe hunger). Kennedy (1980) also observed that adult chickens show a preference for red and natural coloured diets over black and green. Studies by Hess and Gogel (1956) showed that when chickens could pick at dots of various colours, they picked the most at colours from the orange and the blue region of the colour spectrum. An explanation for what induces colour preference is offered by Kennedy (1980). He demonstrated that the colour of the food offered just after hatching determined the later colour preference of hatchling chicks. In addition, Hurnik et al., (1971) observed that the preferred food colour is not necessarily the preferred trough colour. The order of preference by adult White Leghorn hens for the feeder was red 29%, blue 27%, green 23% and yellow 21%, therefore red seems to be the most preferred feeder colour.

Responses to different patterns were also investigated (Hurnik et al., 1971), and the highest food intake was observed with the most complex pattern (blue, green, yellow and red), with green/yellow next whereas yellow alone resulted in the lowest intake.

Using transparent drinkers Wilcoxon et al., (1971) showed that colour can be a cue for drink as well. This observation was confirmed and applied by Cadirci et al., (2009) who fed laying hens with food deficient in methionine and offered drinking water with or without added methionine. The researchers demonstrated that layers fed methionine deficient diet were able to select for water supplemented with methionine in favour to pure water by using colour cue. The hens did not compensate methionine deficiency by drinking treated water when colour cue was not used. When, however, water bottles were coloured differently according to whether the water contained methionine or not, and the birds had learned the difference between the two, they balanced their diet for methionine, even when the position of the bottles was reversed.

However, as chickens usually spend very little time in contact with the visual properties of water, taste of the drink seems to have an importance, although colour cues are also noticed and attended to (Gillette et al., 1980).

Thus it appears that colour is a property which may be particularly useful in feeding practice. For instance by using coloured food or feeder or cage, food consumption could be increased (Hurnik et al., 1971, 1974), and also trace amounts of nutrient supplementation can be associated with colour cue (Kutlu and Forbes, 1993). However, it has been indicated that visual cues are not always necessary. For example, when a calcium-deficient diet is offered with calcite, the cues are obvious. But when the choice is between two mash diets differing only in the presence or absence of calcium, the cues are more subtle. The addition of calcium carbonate results in a paler diet, probably with a different taste. But if white flour is added to the deficient diet to give the same visual aspect, birds still exhibit a significantly greater preference for the calcium-enriched diet (Hughes and Wood-Gush, 1971a).

Taste: The sense of taste helps animals to select among feeds, to choose that which is palatable and to avoid those that are unpalatable or toxic. It also encourages the ingestion of nutrients. It has been demonstrated that chickens have taste buds (Lindermaier and Kare, 1959; Saito, 1966; Gentle, 1971a), and that they have a good sense of taste (Kare *et al*., 1957; Kare and Medway, 1959; Kare and Pick, 1960; Gentle, 1971a, 1972). The ability to taste, however, is not uniformly present in all chickens. Williamson (1964) found significant sex differences indicating a genetic difference in the ability of chicks to taste ferric chloride, and Gentle (1972) reported that some of them are 'taste blind'.

Taste plays a major role in the initial selection of feed and possibly in the motivation to eat (Gentle, 1971b). Therefore many flavours have been studied to improve feed consumption, weight gain and feed conversion (Berkhoudt, 1985). It has been shown (Jacobs and Scott, 1957; Williamson, 1964; Yang and Kare, 1968; Kare and Mason, 1986; Forbes, 2010) that birds can differentiate between the taste qualities of sweet, salt, sour and bitter. They have very strong preferences for some flavours; e.g. they will not drink solutions of saccharin, salt or quinine (El Boushy and Van der Poel, 1994), but like citric acid (Balog and Millar, 1989). Interestingly, in common with most avian species tested, chickens do not avidly select sugar solutions, when fed on an energy-balanced diet (Jukes, 1938; Kare and Medwat, 1959; Kare and Pick, 1960; Kare and Rogers, 1976). It has also been shown that even an unpleasant flavour, such as lactate in the case of a calcium source, can assist chickens in making the appropriate choice. But if the diet containing calcium is made less palatable by the addition of quinine, the aversion is so strong that the diet will be rejected even if the bird is deficient in calcium (Hughes and Wood-Gush, 1971b).

Changes in taste preferences of chickens readily occur following experimental manipulation (Gentle, 1975). They also quickly become accustomed to aversive chemicals such as dimethyl anthraniline, and many times the natural concentration of bitter tasting substances in the food is required to depress food intake over long periods, compared with the amount which is selected against when choice is given (Kare and Pick, 1960).

Olfaction: Smell takes place in the olfactory organ, which consists of the nostrils, the taste buds which lie in the olfactory epithelium, and the olfactory bulbs in the brain (Bang, 1971). That birds lack the behaviour of sniffing indicates that they need moving air to effect contact between odour stimuli and receptors. Many birds have a well developed olfactory system; pigeons, for instance, use olfactory cues for navigation over long distances (Kare and Mason, 1986). There is no direct evidence for chickens using this olfaction in food selection, but Tucker (1965) has shown by electrical recording from the olfactory nerves - innervating the nasal cavity of birds- that they respond to amyl acetate. Chickens therefore appear to have a functional olfactory system and it seems likely that it is used. In addition, it has been suggested that they may regulate their behaviour in response to olfactory factors (Jones and Gentle, 1985).

Texture of food: The texture of food partly means a visual effect, partly a factor in the palatability of the food. The effects of the shape of the food (round/solid/granulated) have been mentioned above. When the food is swallowed, the texture is sensed by the mouth/tongue. Forbes (2007) proposed that texture is a dynamic feature, as foods give changing sensations during grinding and swallowing. Not only the texture of the food changes but also its temperature, and as metabolic processes already begins in the mouth, its taste and smell change too. Hyde and Witherly (1993) proposed that all these changes during a meal, or even a swallow, have a big impact on a food's palatability. Thus Forbes (2007) suggests that texture should be considered as an additional cue in characterising a food, in conjunction with its sight, smell and taste. Pelleted forages are usually eaten more than the same ingredients in unpelleted form (Heaney et al., 1963). Although much of this increment is attributable to the reduction in particle size associated with pelleting, some improvement in palatability is also related (Van Niekerk et al., 1973).

Experience and nutritional needs: The experience and nutritional needs of the animal can alter its natural preferences and thus food consumption. Researches in recent years have made it clear that animals learn to associate the sensory properties of foods with the metabolic consequences of eating those foods. They are sensitive to a number of nutrients and can make appropriate choices, according to how they feel. Therefore, for instance, if a food is deficient or imbalanced for one or more essential nutrients, the animal is malnourished and feels ill. This influences how much it eats.

Colour has been shown to be a strong cue for learned aversions (e.g. Martin et al., 1977) and preferences (e.g. Kutlu and Forbes, 1993) in birds. Although chickens prefer light-coloured foods, particularly pink, preferences for other colours can be induced simply by prior exposure to them (Hess and Gogel, 1954; Taylor et al., 1969). Thus, for example, Capretta (1969) has managed to increase the birds' consumption of red-coloured food. Also, the innate preference of newly hatched chickens for round objects can be increased or decreased (Frantz, 1957).

Memories of grinding pressures and the number of swallows help to recall how much food to eat for satiety (Miller and Teastes, 1986). Memorable foods (additional cues, e.g.; sight, smell, taste, colour) are more easily learned with regard to their eventual metabolic properties, compared with bland foods. Adding spices to foods enhances palatability, even if not at the first exposure, by making the food subsequently more identifiable.

Post-ingestional effects also add to the animal's experience in choosing food. Capretta (1961) found that preferences for different coloured foods could be altered by noxious stimulation of the crop. Flavours, though initially able to influence intake and preference, soon lose this ability (Balog and Millar, 1989) if the birds learn that there is no nutritional implication of the different flavours.

The nutritional state of the birds can also change the preference behaviour. Kare and Maller (1967) observed that although chickens do not naturally exhibit a marked preference for a sucrose solution, when fed on a diet low in energy their sucrose intake increased to balance the calorie intake. When a calorie-enriched diet was again given, the consumption of sucrose was not reduced.

The Role of Learning in Diet Selection by Poultry

Birds quickly learn to associate the sensory properties of a food with the metabolic consequences of eating it. The fowl, for example, often initially rejects the unfamiliar feed by recognition. This is because the chicks are not fed directly by the parents, therefore there is an elaborate system of innate behavioural patterns that protect the birds from ingesting noxious diets. However, new experiences or the influence of conspecifics subsequently modify these innate reflexes thus allowing the birds to exploit a variety of valuable feed sources. Therefore, not merely innate preferences/aversions, but also the bird's own experience and social factors play an important role when selecting from a choice of foods.

Prior experience: Only a limited number of experiments have been carried out to study the feeding behaviour of chickens on choice feeding, i.e. when they have the opportunity for diet selection. It is now understood that chickens are capable of rapidly modifying their feeding behaviour by experience. When their preferred grains were stuck to the floor, newly hatched feral, commercial layer and broiler chickens quickly learned to avoid them (Adret-Hausberger and Cumming, 1985). However, previous observations (Dun, 1977) showed that introducing choice feeding to laying birds previously given complete foods causes a 5% decrease in rate of lay over the next four weeks. Also, the sudden change from one feeding system to another largely reduced the birds' feed intake and growth performance (Scholtyssek, 1982). These, and additional observations (Kennedy, 1980; Mastika and Cumming, 1987; Covasa and Forbes, 1993b) have made it clear that the characteristics of the previous diet affect feed intake and performance of choice-fed birds. Therefore, prior experience is very important for birds on choice feeding (Cumming, 1987), and it is necessary for birds to be given the opportunity to learn the difference between the two (or more) feeds on offer and hence to learn their nutritional characteristics. Mastika and Cumming (1981) noted that once imprinted, chickens can be introduced to choice feeding at any age. This observation implies that imprinted chickens have an effective memory for food type. It appears that for chickens the optimum age for imprinting is the second week after hatching (Covasa and Forbes, 1993a). Cumming (1987) noted that, whatever the age of introduction to the whole grain, chickens need a learning period of at least seven to ten days. In summary, training the birds by accustoming them to whole grains at an early age improves their ability to select foods to meet nutrient requirements at later stages of growth.

Training: In many cases birds will learn about two foods if they are introduced simultaneously but they may learn more quickly if each food is given in turn for a few days. During the learning period, an alternating method can be used if the birds are to distinguish between, for instance, the properties of different types of mash (Shariatmadari and Forbes, 1993). However, Forbes and Covasa (1995) noted that the same method in case of choice feeding and the use of whole grains is not useful because, although there are obvious visual differences between the foods offered, the digestive tract of birds fed whole grains has to adapt and it undergoes physical changes in order to facilitate digestion. Moreover, the bird can avoid eating grain by learning when to eat in relation to the time of day (Pinchasov et al., 1985) and wait until the normal food is on offer (Rose et al., 1994). In addition, Covasa and Forbes (1994b) reported that choice-fed birds exhibit better dietary selection than those fed alternately.

Social interactions: Animals living together in a group tend to copy from each other and they are more likely to learn about foods when they are in groups than in individual cages. There is also usually a leader that guides the others to the desired food. To peck at food, newly hatched chickens need to be stimulated by the sight and sound of the hen pecking (Savory et al., 1978), i.e. social facilitation plays an important role in the initiation of pecking (Strobel and McDonald, 1974). Also, visual cues are important in the synchronisation of feeding in individually caged birds (Hughes, 1971). Joshua and Mueller (1979) found that within five days of being given a choice between a calcium-deficient food and calcite, broilers consumed enough calcium when kept in groups, however, individual caging inhibited this ability even when there was visual contact between the birds. When the birds were then caged individually after learning to eat calcium in a group, they took an adequate amount of calcium. Similar observations were made by Covasa and Forbes (1994c) who compared wheat consumption of pairs of birds to that of single-caged birds, and found a significant improvement despite the fact that individually caged birds could see each other.

It has been suggested (Mastika, 1987) that for the best result in selection, birds need to be in groups of at least eight. A larger number of birds seem to make no further difference in diet selection (Rose et al., 1986). It is now commonly accepted that group-housed animals are more successful in selecting a diet that meets their requirements than those caged singly (McDonald et al., 1963; Adret-Hausberger and Cumming, 1987).

As learning is influenced by the presence and behaviour of conspecifics (Nicol and Pope, 1993), it seems likely that the process of learning could be accelerated by using experienced birds as 'teachers' (Mastika and Cumming, 1987). However, Covasa and Forbes, (1994a) demonstrated that simply putting birds together encourages wheat intake, therefore it is not necessary to use experienced birds as teachers.

Conclusion

Free-choice feeding might have great commercial potential for the free-range poultry production. This review aimed to highlight some of the factors important in the process of diet selection by poultry. These factors must be taken into account when practicing free-choice feeding. If given the appropriate conditions for animals, diet-selection methodology can provide a very powerful tool for nutritional and behavioural scientists.

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