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Detection of taste thresholds at different growth stages of broilers

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ABSTRACT

The sense of taste has a key role in nutrient sensing and food intake in poultry. A standardized and simple method for the determination of tastant-detection thresholds is required for chemosensory research in poultry as well poultry feed formulation. The goal of the study was to evaluate the effect of aging on the behavioural taste sensitivities of broiler chickens in order to improve the efficiency of feeding through correct feed selection and ration preparation. It especially aimed to establish the threshold concentrations of five different taste components (sweet, sour, bitter, salt, and umami). Total of 15 feeding trials for broiler chicks of various ages were performed. For each taste quality, the powdered flavor active ingredients for sweet, sour, bitter, salty, and umami were selected. The actual drinking volume of water and taste solution was identified. Because the p values were less than 0.05, the concentrations of sucrose (100 mM), citric acid (50 mM), sodium chloride (20 mM), caffeine (10 mM), and mono-sodium glutamate (MSG) (100 mM) were significant. Taken together, it may be concluded that the taste active chemical sensitivity was very "concentration-dependent" manner for the aforementioned concentrations and that younger chickens have a greater sense of taste than older birds.

Introduction

Elucidation of the taste sense of chickens is important not only for the development of chicken feedstuffs but also to help clarify the evolution of the taste sense among animals. Taste is an important factor in guiding nutritive choices and motivating feed intake. Recent studies of chicken taste systems have revealed that chickens have many taste buds in the oral cavity by using a new chicken taste bud marker, vimentin, and whole-mount tissues from the oral epithelial sheet (Venkatesan et al. 2016 and Rajapaksha et al. 2016), and that chickens can detect some taste qualities such as fat, bitter, and umami via these taste receptors (Hirose et al. 2015; Swamura et al. 2015 and Yoshida et al. 2015). Furthermore, a few researchers showed that taste cues have been linked to food acceptance and avoidance, as well as feed or liquid intake, in different animals (Gentle, 1972). Knowledge regarding taste bud development, regulation and taste response to different stimuli will help to improve the feed efficiency, thereby increasing the productivity. The present study mainly focused on the identification of the threshold level of different taste active compounds at different growth stages of broiler chicken. Because, the understanding of this parameter is important for studying potential effects on chicken feeding behavior. By using this finding, there is a chance of improving feeding efficiency of the chickens by proper feed selection and preparation of a ration that will reduce feed wastage. Dey et al. (2018) reported that baby chicks are more sensitive to bitterness than older chicks and they proved their findings using both *in-vitro* and *in-vivo* experiments. There will be less wastage of feed if we manufacture formulate ration

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based on the bird's taste preferences and ages of birds. This judgment may be made by understanding the varied taste active chemical threshold levels and maintaining these threshold levels throughout feed formulation while selecting ingredients for feed formulation. This information will aid in the formulation of starter, grower, and finisher rations, as well as the right selection of feed ingredients based on the amount of taste active threshold. Taste threshold levels will serve as a guideline for selecting certain ingredients for inclusion in rations, as well as for nutritional manipulation. There is a prospect of introducing novel poultry feeds that have never been used before. Feed costs are the most significant cost of producing broilers; if this can be achieved, production costs will be much reduced, and the broiler chicken business will benefit greatly. Therefore, the present research has undertaken to identify the thresholds of different taste active compounds at growth stages of broiler chickens.

Materials and Methods

Experimental Birds

A total number of 16 Day old as hatched Cobb 500 broiler chicks were used in this study. The chicks were placed in a box brooder maintained one chick in each compartment. Two separate disposable plastic cups placed in each pan for feed and water supply. Feed was supplied *ad-libitum* to the broilers throughout the experimental period but water supply was restricted for 10 mins. Chicks were trained from day 1 to 6 to drink for a short period of time. The drinking test had done at day 7 to 10. All other necessary bird's husbandry practiced was done accordingly.

Taste active compounds

Five basic taste active compounds such as sucrose, citric acid, sodium chloride, caffeine and monosodium glutamate (MSG) were used the representative of sweet, sour, salt, bitter and umami taste respectively. The chemicals were purchased from a reputed company maintained highest purity of use. Each of the taste active compounds was used three different concentrations in the behavioral drinking test. Table 1 showed the taste active compounds and their concentration used. In this study, sucrose at the concentration of 10 mM, 50 mM, and 100 mM solutions were prepared for sweet taste; citric acid of 10 mM, 30 mM and 50 mM solutions were prepared for sour taste; sodium chloride of 5 mM, 10 mM, 20 mM solutions were prepared for salty taste; caffeine 2 mM, 5 mM, 10 mM solutions were prepared for bitter taste; and MSG 20 mM, 50mM and 100 mM were prepared as umami taste qualities and tested individually.

Experimental procedure

One-cup drinking tests were conducted with two different ages of birds based on our previous report (Dey et al. 2017) with slight modifications. Briefly, the behavioral test took place over 10 consecutive days, where the first six days were considered to be a training period for the chicks and days 7-10 were considered as the experimental period. The chicks were kept together for the first two days to allow them to overcome psychological stress and then separated into individual pens (30 × 30cm). Commercial broiler feed was fed to the chicks as *ad-libitum* basis throughout the experimental period (Kazi Farms Group, Bangladesh). On the first day, the chicks were supplied normal tap water for 24 h and then water was restricted only 10 mins in twice daily (09.30 to 09.40 and 16.00 to 16.10) to train them in drinking for a short period of time. Over the experimental period at day 7-10, the chicks were supplied either water or test solutions (sucrose, citric acid, sodium chloride, caffeine and MSG)) for 10 mins as did in the training period. The water and test solutions were given on a randomized basis over the experimental period. To compensate for the evaporation loss from the cup in the 10 mins of exposure, control tap water was set in a brooder box, and the amount of evaporation was subtracted from the volume of water or test solution intake.

Data Analysis

The data were expressed as means ± SE. Statistical analysis was done using the paired *t*-test and un-paired *t*-test and differences with *p*-values < 0.05 were considered to be significant.

Results and Discussion

Thresholds of taste active compounds

Taste threshold is the minimum concentration at which taste sensitivity to a particular substance or food can be perceived. It was previously reported that (Rajpaksha 2016), there are five fundamentals taste qualities like as sweet, sour, bitter, salty, and umami and chicken can detect all those taste qualities using their taste buds. The response of birds (including chickens) to each group of taste stimuli for primary taste qualities were also reported by (Roura et al. 2013). The taste thresholds of broiler chickens were determined using three different concentrations. Kare and Mason (1986) showed that birds are much more sensitive to flavors in water than in feed. This sensitivity to flavors in water may be due to the fact that birds consume almost twice as much water as feed. To detect the taste perception in chicken, many behavioral experiments have focused on intake feed and water. Dey et al.

(2011) showed that the feed intake was slightly decreased when the layer-type chicken diet contained 20g/kg neem leaves (bitter plant leaves). The thresholds levels of the taste active compounds at different growth stages of chickens were presented in Table 1. In this study, in the 10-minutes drinking experiment, day old chicks showed aversive behavior in100 mM sucrose; 50 mM citric acid; 20 mM sodium chloride; 5 mM, and

Table 1: Threshold concentration for five basic taste types

Taste Type	Taste compound	Threshold concentration		p-value
		DOC	21 Day	
Sweet	Sucrose	100 mM	No aversion	**<0.003**
Sour	Citric Acid	50 mM	No aversion	**<0.013**
Bitter	Caffeine	5 mM	No aversion	**<0.01**
Salt	Sodium Chloride	20 mM	No aversion	**<0.043** **<0.023**
Umami	Mono Sodium Glutamate	50 mM	No aversion	**<0.05** **<0.006**

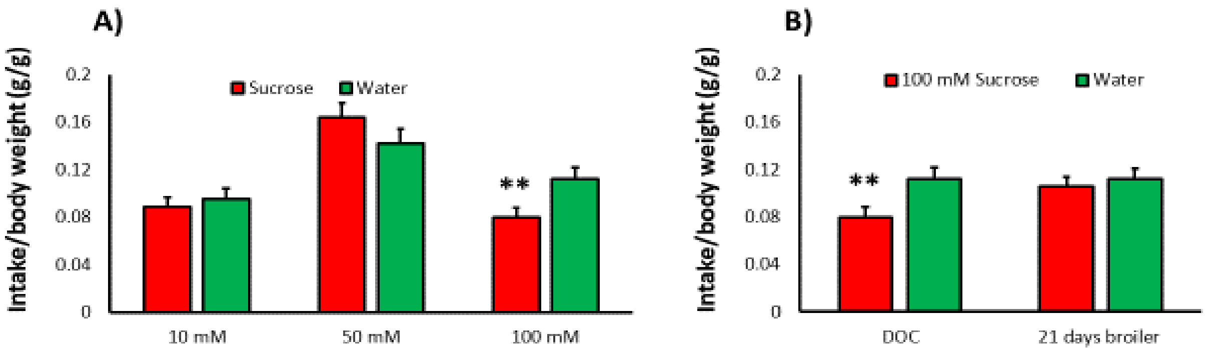

Figure 1: Drinking experiments of 3 different concentrations of Sucrose in broilers.

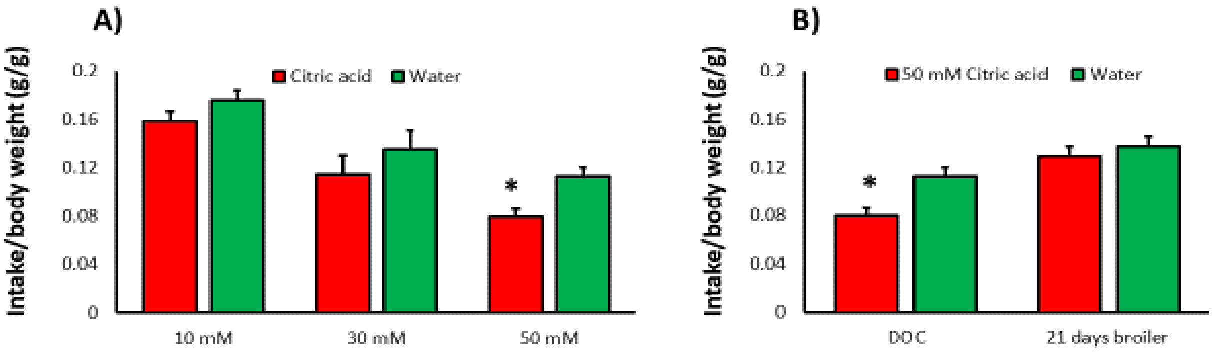

Figure 2: Drinking experiments of 3 different concentrations of Citric acid in broilers.

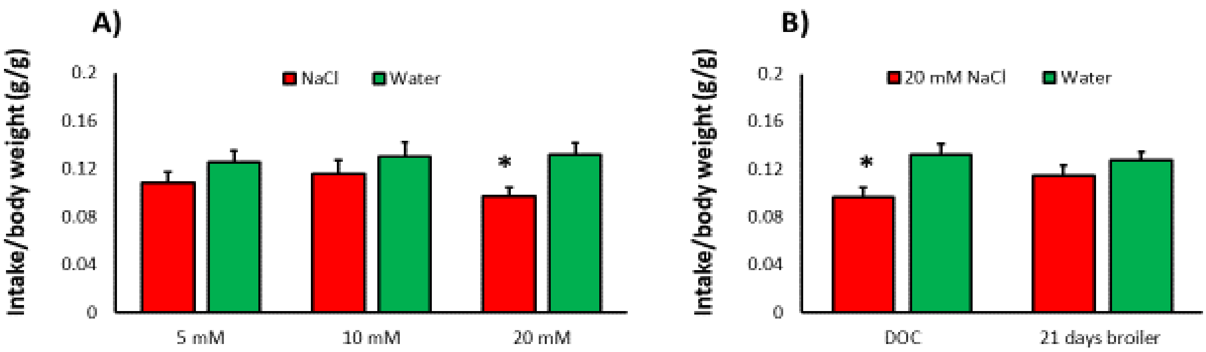

Figure 3: Drinking experiments of three different concentration of Sodium chloride in broilers.

10 mM caffeine; 50 mM, and 100 mM mono sodium glutamate solutions compared to normal tap water. In the 3-week-old broilers, none of the dosages tested evoked any aversions.

Sensitivity and thresholds for sweet compounds

Several *in-vivo* studies in chicken have demonstrated a behavioral response (either preference or rejection) to different sugars (Gentle, 1972; Roura et al. 2013). Whereas glucose and fructose are mostly rejected, sucrose shows mixed responses (both aversion and preference), depending on the concentration tested. Sucrose was chosen in this study for sweet taste-threshold detection tests in broiler type chickens. Three different concentrations were tested: 10 mM, 50 mM and 100 mM (Figure 1).

The intake of 10 mM and 50 mM sucrose solutions was not statistically different compared to normal tap water (A). But the chicks showed a significant ($p=0.003$) aversive behavior in case of the highest concentration of sucrose (100 mM) compared to water in the 10 minutes drinking experiment (C). When studying sweet perception in chickens, the absence of 1 monomer (T1R2) of the heterodimeric sweet-taste receptor (T1R2/T1R3) must be considered (Lagerstrom et al. 2006; Shi and Zhang, 2006). Our results showed that lower concentration (10 mM) has no significant effect of chicken drinking but the increment in concentrations chicken showed significant preferences for 50 mM. Interestingly, the highest concentration tested here (100mM) chicken showed significant ($p<0.003$) aversive behavior. The findings of this study agree with the observations of Gentle, 1972. On the other hand, the younger chicks showed significant ($p<0.003$) aversive behavior than older chicks at the highest concentration (100mM) of sucrose tested here (Figure 1) which aggress with the findings of Dey et al. 2018.

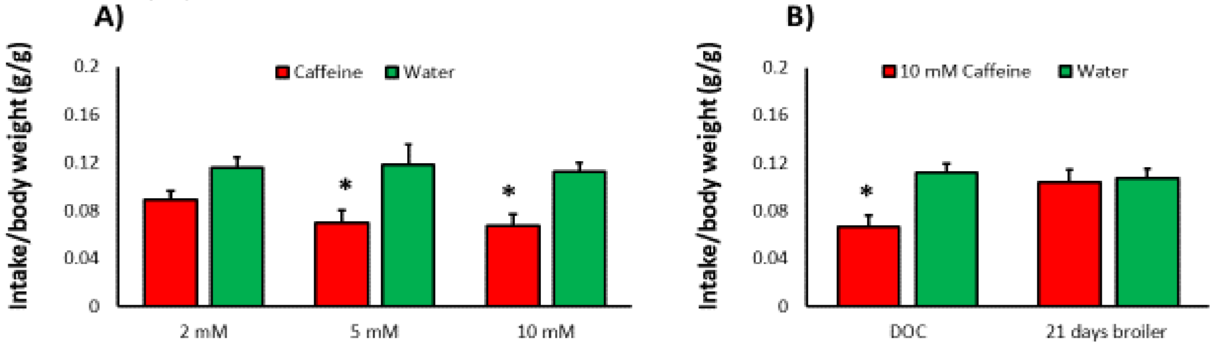

Figure 4: Drinking experiments of three different concentrations of Caffeine in broilers.

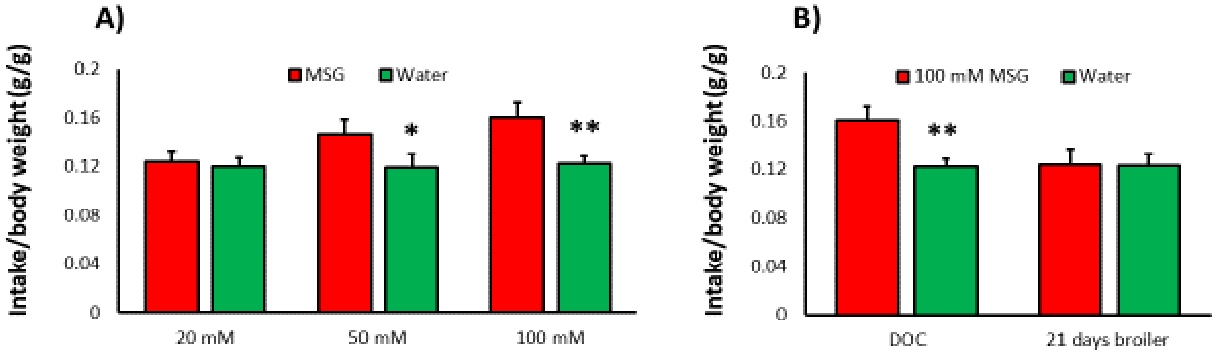

Figure 5: Drinking experiments of three different concentrations of MSG in broilers.

Sensitivity and thresholds of sour taste

For sour flavor taste 50 mM citric acid solution was used which showed slight aversion in case of younger birds. Compatible with the behavioral taste (Engelmann et al. 1960) also reported that sensitivity to acid changes with avian species and with age. In case of 3-week-old birds there was no aversion behavior was observed using the same concentrations of the taste active compounds. Kare and Mason (1986) reported that high concentration of salty taste becomes unpleasant and elicits aversion, whereas low concentrations are usually attractive, particularly after sodium depletion and it was also established that, it is easier to detect some flavors at low concentrations compared with other flavors. A 100 mM sucrose solution showed quite impressive aversion in case of younger broiler birds compared with other doses. However, in earlier it was reported by Kare and Mason (1986) that chickens in fact does not prefer sweet water rather they prefer water in cold and slightly acid in taste than sweet.

Sensitivity and thresholds of salty taste

Kare and Mason (1986) reported that salty high concentration becomes unpleasant and elicits aversion, whereas low concentrations are usually attractive, particularly after sodium depletion and it was also established that, it is easier to detect some flavors at low concentrations compared with other flavors. In this experiment the day-old chicks showed a significant ($p<0.01$) aversive behavior in case of the highest concentration of sodium chloride (20 mM).

Sensitivity and thresholds of bitter taste

Bitter taste is considered a warning signal against the consumption of poisons. Several compounds have been shown to activate chickens' bitter-taste receptors (Behrens et al. 2014). The natural bitter molecule caffeine has been tested in chicken and its consumption, behavioral responses was recorded accordingly. The intake of 2 mM caffeine solution was not statistically different compared to normal tap water. But the chicks showed a significant ($p<0.05$) & ($p<0.05$) aversive behavior in case of the highest concentration of caffeine 5 mM ,10 mM compared to water in the 10 minutes drinking experiment. Previously, with another experiment Dey et al. 2016 showed that chicken can tolerate the bitterness of caffeine up to 3mM. Our experiment determined the caffeine-detection threshold in broiler to be 5 mM. Behrens et al. (2014) showed that caffeine, coumarin and parthenolide were strong agonists for chicken bitter taste receptors.

Sensitivity and thresholds of umami taste

It was found that day-old chicks drank significantly less solution than water, with the exception of 100 mM MSG solution. The 100 mM monosodium glutamate solution aversion rate was higher in older birds. Chicks showed a significant ($p<0.05$) aversive behavior in case of the highest concentration of MSG (100 mM) and (50 mM). The outcome of the 21-days-old birds was statistically indistinguishable from that of normal tap water. It implies that young chicks have better taste than mature birds. Younger broiler chickens had larger aversions to all five basic flavor active compounds than older broiler chickens.

Younger broiler chickens had larger aversions to all five basic flavor active compounds than older broiler chickens. As a result, it is possible that young chicks are more flavor sensitive than adult birds. For each taste, threshold level has been identified. So, from the above discussions it is revealed that birds sensed taste and they have a gustatory system like other mammals. The avian taste system is well developed but differs significantly with different species. The basic tastes of sweet, salty and sour have different thresholds, or concentration levels, at which they can be detected. During this study, it was found that, younger broiler chickens are more sensitive to all five basic tastes active chemicals than older broiler chickens. Juvenile chickens are more taste-sensitive than older birds, according to research. In this research, different taste-active natural compounds have been identified which may be useful for broilers.

Conclusion

In conclusion, we have shown that younger chicks have greater aversion to bitter compounds than that of older chicks. The taste threshold levels of five basic (sweet, bitter, umami, sour, salty) taste active compounds were also measured in this study. One of the key challenges in the poultry industry is the availability and cost of feed ingredients. With these considerations, feed millers can cut-off feed costs by using unconventional feed ingredients during ration formulation based on this research findings and thus helps to formulate cost-effective rations. The findings of this study are also help us to widen the scope of taste research in other avian species.

Author's contribution

Bapon Dey: Planned the research, critically evaluate the manuscript and coordinate the whole research. Shuvosree Sarker: Conducted the research and prepared the draft manuscript. Anita Roy: Assisted the research and manuscript preparation. Rukhsana Amin Runa: Critically evaluate the manuscript.

Conflict of interest statement

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Data Availability

All the necessary data used in this research will be made available as per the authorization of the authors.

Ethical Approval

The research has been conducted as the ethical principles of the institution.

Consent to participate

The authors provide full consent to participate as per need.

Consent for publication

All the author has fully agreed to publish this research in Bangladesh Journal of Animal Science.

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