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Quantification and comparison of microplastics in broiler and household chickens

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Abstract - Microplastics (MPs) in poultry may be harmful to the environment, animals, and human health. Hence, the present study was an attempt to investigate the MPs in broiler and household chickens in the coastal areas of the Ampara district in Sri Lanka. Broiler (n=8) and household chickens (n=8) were purchased, representing different commercial farms and households. The contents of crops and gizzards were separated and put into 10% KOH in the conical flask and left for digestion for 36 hours, to which, NaCl (3:1) solution was added and the mixture was left undisturbed for 24 hours for density separation. The MPs on the surface of the solution were separated into container. The solution was filtered using the sieve sizes of 425, 250, 150, 75 µm. The filter papers were dried in the desiccator and the weight of MPs was obtained. The data were analyzed statistically using a two-sample t- test. The results showed that the mean weight of MPs in the household chickens (0.450 ± 0.073mg) was significantly higher ($p<0.05$) than in the broiler chickens (0.129 ± 0.060mg). The quantity of larger size MPs (425 µm) was higher in broiler chickens than the sizes of 250µm, 150µm, and 75 µm while the quantity of various sizes of MPs in the household chickens were similar. The weight of 425µm MPs found in the gizzard was higher than the crop in broiler chickens while 250µm, 150µm, and 75µm seem to be similar in weight. It is concluded that the microplastics contaminated both crops and gizzards of both broiler and household chickens, further, the MPs contamination was at a higher level in the household chickens than the broiler chickens in terms of weight.

Keywords- Crop, Gizzard, MP contamination, Size of microplastics, Food chain

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1. Introduction

Microplastics (MP) are well-known pollutants of global concern in the ecosystems, defined as any synthetic polymeric matrix or solid particle, with regular or irregular shape and with size ranging from 1 µm to 5 mm and the primary or secondary manufacturing origin, that are insoluble in water (Frias and Nash, 2019). They are made up of hydrogen and carbon atoms joined in polymer strands. Primary microplastics are released into the environment by product use, spills, or washing. One example of this is the micro-beads used in personal care products. Weathering of bigger plastics produces secondary microplastics. These micro-plastics compromise energy reserves and bio-accumulate along the food chain, posing eco-toxicological concerns in aquatic ecosystems (Akdogan et al., 2019).

The sources, pathways, and distribution of microplastics in the environment are multifaceted, with their prevalence in the food chain posing significant environmental and health concerns (Sharma and Vidyarthi, 2024). Microplastics can enter the terrestrial environment through different pathways, including landfills (Geyer et al., 2017), atmospheric fallout (Evangeliou et al., 2020), and from different agricultural practices, for example, the use of plastic mulching (Büks & Kaupenjohann, 2020; Crossman et al., 2020). According to Baho et al. (2021), Agroecosystems are major entry routes for microplastics to the terrestrial environment. Baho et al. (2021) further stated that microplastics within the terrestrial ecosystem may increase ecological surprises i.e., last for centuries by being a persistent global pollutant, interact with the abiotic environment in a complex manner, impact terrestrial organisms directly or indirectly and interact with other contaminants and can facilitate their transport.

The exposure, ingestion, and accumulation of microplastics in poultry is becoming an important concern about animal health and food safety. Previous studies identified the pathways microplastics can enter poultry birds. Sharma and Vidyarthi (2024) categorized routes of microplastics entering poultry into three groups i.e., 1. physical (farm building, food types, knife and other meat processing equipment, packaging materials, handling container and vehicle), 2. chemical (food preservatives, additives and pesticides, meat preservatives, contaminated water) and 3. biological (bacteria, viruses, parasites, fungus in poultry farm, meat processing plant, transportation, and distribution units). Lwanga et al. (2017) found that chickens take up plastics mainly from the plastic residues on the soil surface. Ingestion of MPs in poultry birds may lead to disruption of normal digestive function, gastrointestinal blockages, impaired nutrient absorption, inflammation, and compromising overall health (Sharma and Vidyarthi, 2024). Microplastics from the environment through the food chain again enter into the environment while circulating through the food chain; they may cause damage to animals, humans, and the environment.

According to Bilal et al. (2023), mean MP particles in crop and gizzard were 17.8 ±12.1 and 33.25 ±17.8 respectively with an abundance (63%) of large particles (300–500µm) in Pakistan in poultry chickens. Lwanga et al. (2017) found that gizzards contained 10.2±13.8 MP particles while crops contained no MP particles in poultry in rural home gardens in Southeastern Mexico. Therefore, by consuming eggs, meat and other poultry-derived foods, humans can ingest microplastics found in poultry products (Sharma and Vidyarthi, 2024). Thus, the poultry chickens contaminated with MPs may be harmful not only to environment and animals but to human beings health. The quantification of MPs in poultry chickens in local context will be helpful to take further actions in relation to issues arising from them. Hence, the present study was an attempt to investigate and compare the MPs in broiler and village chickens in the coastal areas of the Ampara district in Sri Lanka.

2. Methodology

Study area

Chicken samples were collected from several locations i.e., Irakkamam, Ashraf Town, Palamunai, Akkarapaththu, and Oluvil areas of the Ampara district. These diverse locations provided representation of the region, which was crucial for the accuracy and validity of the study. Broiler chickens (n=8), one chicken from each commercial farm located in Irakkamam and Akkarapaththu, and two from two farms located in Ashraf Town were purchased. Household chickens (n=8) were purchased from household located in Palamunei, Irakkamam and Oluvil (two household from Oluvil) and two household chickens from each location were purchased (Figure 1 and Figure 2). The sample size was limited having the ethical consideration involved in slaughtering the poultry birds and also having the sample size used in the previous studies (Lwanga et al., 2017; Bilal et al., 2023).

Figure 1. *Broiler*

Figure 2. *Household chicken*

Slaughtering of chickens and separation of crop and gizzard

The chickens were slaughtered following the Halal method, ensuring adherence to specific religious and ethical guidelines. After slaughtering, the crops and gizzards were isolated and categorized according to their respective farms, this procedure was adopted because previous research investigated microplastics in the crop and gizzard organs (Lwanga et al. (2017).

Digestion of the organ's content

The content of crops and gizzards were separated and placed into conical flasks separately and labeled to ensure the accurate tracking and comparison of microplastic concentrations between different organs and farms. The separated organ's content was put in 10% KOH for 36 hours for digestion. They were left in a water bath for 36 hours, where the temperature required for digestion and other factors were provided. In some cases, some undigested parts had to be left for more time to digest (Bilal et al., 2023).

Density separation

After the digestion was completed, NaCl 3:1 ratio solution was added into the conical flask and mixed with a stirrer for about 20 minutes. The well-mixed mixture was kept undisturbed for about 24 hours for density separation. The portion containing the micro-plastics on the surface of the solution was carefully separated into another container. The solution with MPs was filtered using the sieves with the sizes of 425, 250, 150, and 75 µm. Then the filter papers were dried in the desiccator and the weight of MPs was obtained (Bilal et al., 2023).

Data analysis

The final data of microplastics obtained from broiler and household chickens were analyzed using a two-sample t-test, a statistical method designed to compare the means of two independent groups by using SPSS (IBM SPSS statistics 25).

3. Results and Discussion

Comparison of microplastics in the broiler and household chickens according to their sizes

The MPs found in the broiler chickens and household chickens were compared according to their sizes and the results are provided in Figure 1.

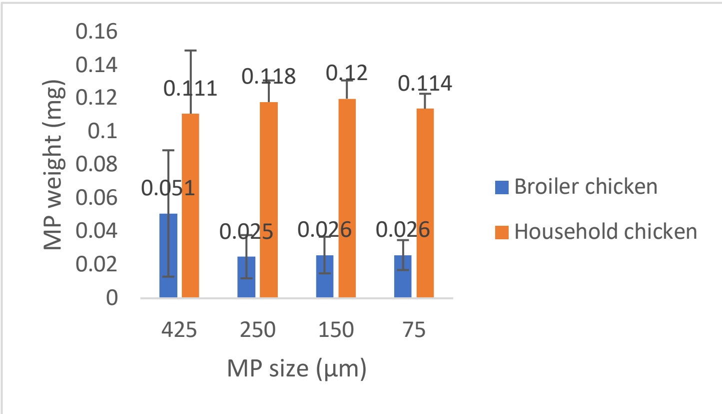

Figure 3. *Weight of MPs in broiler and household chicken according to their sizes*

Table 1

Comparison of mean weight of microplastics obtained from crop and gizzard between broiler and household chickens

Type of chicken	Sample size (n)	Mean ± SD (mg)	P value
Broiler	8	0.129 ± 0.060	0.000
Household	8	0.450 ± 0.073	

The present study found that both broiler and household chickens' crop and gizzard were contaminated with MPs. The mean weight of MPs in the household chickens (0.450 ± 0.073mg) was significantly higher ($p<0.05$, t-test) than the mean weight of MPs in broiler chickens (0.129 ± 0.060mg). The household chickens are free-range birds and may consume MPs from soils and from the other wide range of feed materials they consume through their foraging behaviors. In addition, the duration the household chickens are kept by growers is much longer compared to the broiler chickens for which maximum growing period is 45 days. Thus, the consumption of the higher quantity of MPs by household chickens are much higher than the broiler chickens. As such, the consumption of household chickens by human may lead to a higher level of ingestion of MPs causing more health and environmental consequences than the broiler chickens (Sharma and Vidyarthi, 2024) and also the household chickens may circulate a higher quantity of MPs in the terrestrial environment through food chain compared to the broiler chickens.

The larger size of MPs (425µm) was found in broiler chickens at higher quantities compared to the sizes of 250µm, 15µm, and 75 µm. However, the different sizes of MPs found in the household chickens were almost similar in quantity. The broiler chickens consume MPs mainly from commercial feed which may contain a higher quantity of 425 µm size MPs than the other sizes (Figure 1). The present study did not investigate the source of MPs ingestion in broiler chickens since it was beyond the scope of the study. Therefore, it is recommended to investigate the sources of MPs contamination to the broiler chickens in local farms. Bilal et al. (2023) found that the larger MP particles, ranging between 300–500µm were more abundant than the smaller sizes investigated in their study in meat chickens. According to Habib et al. (2022), the size range of MPs found in the chicken was between 8.24µm –1454.5µm, with a mean size of 104.2µm ± 84.33µm. In the present study, the size of the MPs found in both broiler and household chickens were within the range found by Habib et al. (2022).

Comparing the microplastics in crops and gizzards of broiler and household chickens

The MPs obtained from the crops and gizzards of broiler and household chickens were compared separately and the results are given in Figure 2 and Figure 3.

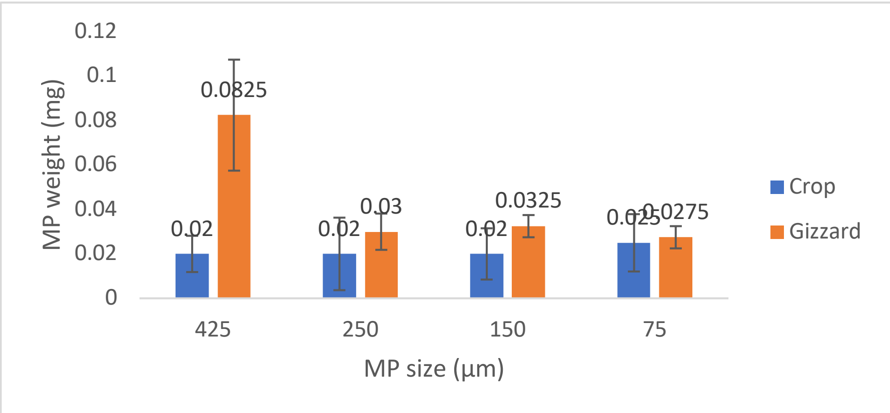

Figure 4. *Weight of microplastics in crop and gizzard in broiler chickens according*

The MPs quantity with the size of 425µm found in the gizzard was higher than the crop in broiler chickens while the other sizes i.e., 250µm, 150µm, and 75µm seem to be similar in quantity (Figure 2). The results may show that larger size of MP particles are trapped in higher quantities in the gizzard of broiler chickens than the smaller sizes. However, in contrast to the present findings, Bilal et al. (2023) found that relatively larger MP particles were abundant in crops than the smaller particle sizes. The present findings and the previous findings indicate that the larger MP particles are abundant in crop and gizzard of broiler chickens which may reveal that the larger MP particles are trapped more by crop and gizzards than the smaller particles by broiler chickens. According to Bilal et al. (2023), the larger particles are less movable in the gastrointestinal tract, hence, they are trapped in crop and gizzard while more movable smaller particles pass through feces. Concerning the village chickens (Figure 3), the quantity of various sizes of MP particles found in crops in percentage was i.e., 23.3% (425µm), 26.7% (250µm), 27.2% (150µm) and 22.8% (75µm). Similarly, in gizzards, it was 26.1% (425µm), 25.6% (250µm), 26.1(150µm) and 22.2% (75µm). These results may show that the MP particles investigated were trapped in crops and gizzards of the household chickens almost in a similar quantity independent of the sizes compared to the broiler chickens. According to Lwanga et al. (2017), MP particles were found in household chickens' gizzards while no MP particles were found in crops. Ferrando et al. (1987) found that the size range of coarse feed particles being trapped from exiting the gizzard in chickens is between 0.5 and 1.5 mm.

The MPs in the present study are non-feed particles, most of them were less than 0.5mm in size. According to Takasaki and Kobayashi (2020), the average size of grit in the gizzard was about 1.84 mm. The mechanisms by which MP particles of different sizes are trapped by crops and gizzards in broilers and household chickens are not known yet.

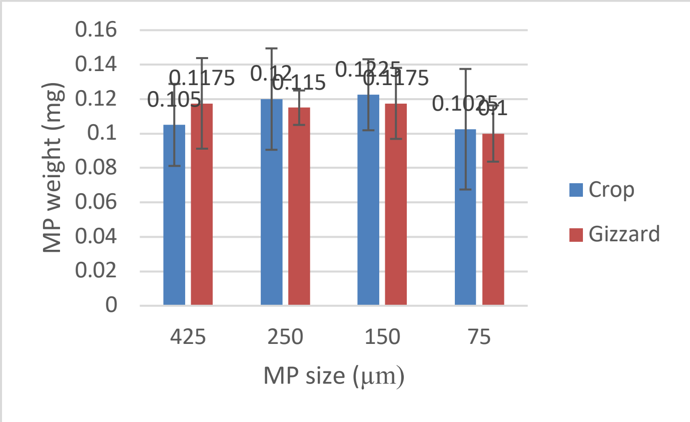

Figure 5. *Weight of microplastics in crop and gizzard in household chickens according to the sizes*

Therefore, the reasons for the MP particles sizes and quantities trapped in the crops and gizzards in the present study are unexplainable.

4. Conclusion

The microplastic contamination was found in crops and gizzards of both broiler and household chickens and the MPs contamination was at a higher level in the household chickens than the broiler chickens in terms of weight. Concerning the sizes, the larger size of MP particles was higher than the smaller sizes in broiler chickens in terms of weight. Whereas the different sizes of MPs in the household chickens were almost similar. Gizzards of broiler chickens trapped higher levels of larger size MP particles than the smaller sizes while the trapping of MP particles of various sizes by crops was almost similar. The study provides insights on MP contamination in broiler and household chickens which will be useful in mitigating the issues arising in relation to MPs circulation in the environments through food chain.

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