Journal of Animal and Veterinary Advances 18 (5): 139-142, 2019
ISSN: 1680-5593


# Fibrous Diets for Herbivore Tortoises

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**Abstract:** Herbivore tortoises such as Hermann's tortoises (*Testudo hermanni)* consume a wide variety of fibrous feeds in the nature. Contrary to that in captivity tortoises get feeds low in Crude Fibre (CF) which leads to fibre deficiency and accelerated growth rate. Aim of our study was to investigate the Dry Matter (DM) intake of Hermann's tortoises in connection with CF and DM contents of the diets. Tortoises (n = 10, body weight: 683.7±89.8 g) were housed individually. Three diets (A: DM 6.6%, CF 16.5%/DM; B: DM 9.5%, CF 22.1% DM and C: DM 18.9%, CF 27.4% DM) were prepared by using the same components (chopped lettuce, carrot and meadow hay) in different proportions. The 24 h feed intakes were tested for 3×4 days/diet with 2 weeks of acclimatisation. The DM intake of the tortoises was lower in case of diet C compared to diet A and B ($p<0.001$). Diet A and B did not differ significantly ($p = 0.801$). According to our results, the CF should be between 22.1-27.4% on DM basis to decrease the feed consumption, hence, preventing the fast growth rate.

**Key words**: Testudo, dry matter intake, diet in captivity, fibre deficiency, accelerated growth rate, prevention

## INTRODUCTION

Diseases of nutritional origin such as fibre deficiency or metabolic bone disease are common in pet chelonians. These conditions are often associated with poor nutrition. Herbivore tortoises such as the Hermann's tortoises (*Testudo hermanni*), consume a wide variety of fibrous feeds in the nature (Nagy *et al*., 1998; Lagarde *et al*., 2003; Mushinsky *et al*., 2003; Hazard *et al*., 2010; Vecchio *et al*., 2011; Iftime and Iftime, 2012). Contrary to that in captivity-according to, a pervious data collection in an exotic pet praxis-tortoises get feeds low in Crude Fibre (CF; e.g., lettuce, cucumber, carrot as diet A). This poor diet leads to fibre deficiency and accelerated growth rate (Ritz *et al*., 2010a, b, 2012; Furrer *et al*., 2004; Gramanzini *et al*., 2013). The aim of our study was to investigate the Dry Matter (DM) intake of Hermann's tortoises associated with CF and DM contents of the diets. We also aimed to examine the effect of CF on the quality of excrement.

## MATERIALS AND METHODS

The same 10 male tortoises (Body Weight (BW): 683.7±89.8 g) were used for each test. Animals were housed individually in 790×570×420 mm transparent plastic boxes with basking place and ad libitum water access. Three diets (A, B and C) were prepared by using the same components (chopped lettuce, carrot and meadow hay) in different proportions (Table 1). Agar powder and water was added to all three diets to keep the ingredients together. It was necessary in diet B and C because of their high hay content. It was added to the diet A as well to have the same jelly structure. All the three diets were tested for 3×4 days with 2 weeks of acclimatisation. Fresh feeds were offered on daily basis at the same time mornings and leftovers were removed 24 h later. All the three diets were fed ad libitum. DM and nutrient content of feeds and leftovers were measured by using standard methods. The BW of animals was checked on weekly basis with digital Sartorius Scaltec SBC61 scale.

Data were modelled with general linear mixed model with a random intercept corresponding to each individual and a fixed three-level explanatory factor representing CF levels. Based on the model, Tukey's post hoc multiple comparison test and confidence intervals were applied to explore simultaneous significance of the differences between mean consumption levels in the fibre categories. The Waltham faeces scoring system (1-5 grade) was used for excrement quality control. Where grade 1 faeces is "bullet like", crumbles with little pressure and grade 5 is a liquid stool.

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Table 1: Composition of diets and Dry Matter (DM) intake of tortoises

| | | | | DM intake (g) related to 100 g BW | | |
|---|---|---|---|---|---|---|
| Diets | DM(%) | CF(%) | Ingredients on DM bases (%) | Average±sd | Range | p-values |
| A | 6.6 | 16.5 | 43.0 lettuce, 36.6 carrot, 10.3 meadow hay | 1.14±0.19 | 0.67-1.51 | $p_{A-B} = 0.801$ |
| B | 9.5 | 22.1 | 23.5 lettuce, 19.7 carrot, 48.7 meadow hay | 1.13±0.20 | 0.62-1.41 | $p_{A-C}<0.001$ |
| C | 18.9 | 27.4 | 3.2 lettuce, 2.6 carrot, 88.9 meadow hay | 0.82±0.18 | 0.41-1.16 | $p_{B-C}<0.010$ |

CF = Crude Fibre, BW = Body Weight

## RESULTS AND DISCUSSION

The DM intake of the tortoises (Table 1) was significantly lower in case of diet C compared to diet A and B (p<0.001). No significant difference was observed between A and B (p = 0.801). According to the scoring system grade 3 and occasionally 3.5 excrement was observed in group A while it was 2 and 2.5 in the other two groups. The quality of the excrement improved when using diets B and C (Fig. 1 and 2) compared to diet A where it was less solid (Fig. 3). The high CF content (diet C) did not cause any health problems.

The DM content increased parallelly with the hay content. Accordingly, the lower consumption of diet C was both because of its higher DM and CF content but the two effects cannot be separated. We can also see that the DM intake of the tortoises related to the BW (0.4-1.5%) is generally much lower than that of the farm animals (3-5% of BW on DM basis; Hailey, 1997; Hatt *et al*., 2005; Sadeghayobi *et al*., 2011; Franz *et al*., 2011). The range in this study fits to our previous results (0.4-1.2%). Franz *et al*. (2011) evaluated 4 tortoise species (*Testudo graeca, T. hermanni, Geochelone nigra, G. sulcata, Dipsochelys dussumieri*) with a wide range of BW (0.5-180 kg). In that study the maximum DM intake of Hermann's tortoises was about 0.6% of the BW. This low intake can be explained by the difference in the diets. The gut fill scales linearly with BW similar to mammals (Franz *et al*., 2011). According to the results of our study, adding chopped hay is a good and applicable method to increase the CF content of the diet.

Digestive flexibility of tortoises makes possible to adjust transit rate and food intake in response to changing CF content of the diet (McMaster and Downs, 2008). *Testudinidae* can digest fibre as well as or better than, herbivores (Bjorndal *et al*., 1990; Franz *et al*., 2011). The primary site of fibre fermentation with short-chain fatty-acids production is the colon (Barboza, 1995). The higher CF level reduces the digestibility, the level of absorbed nutrients and decreases the DM intake (Barboza, 1995; Hatt *et al*., 2005; McMaster and Downs, 2008; Hazard *et al*., 2010; Franz *et al*., 2011). As it was proved in Galapagos giant tortoises (*Geochelone nigra*) a diet containing 77% hay (meaning 20.5% crude fibre) leads to a lower growth rate. In this species the CF may reach 30-40% on DM basis which might be the case in other herbivore chelonians as well (Hatt *et al*., 2005).

Fig. 1: The excrements of the tortoises with diet C (grade 2)

Fig. 2: The excrements of the tortoises with diet B (grade 2.5)

Fig. 3: The excrements of the tortoises with diet A (grade 3-3.5)

Crude Protein (CP) and Ether Extract (EE) content of the diets meets the requirements of the pet tortoises. The requirement of CP in herbivore tortoises is low (about 10-15%). Excess amount of nitrogen and a lower level of CF in the feed leads to higher growth rate in the nature and in captivity as well (Furrer *et al*., 2004; Ritz *et al*., 2010a, b, 2012; Hazard *et al*., 2010). Exothermic animals with low metabolism can satisfy their energy requirements with modest feeding efforts (Lagarde *et al*., 2003; Tracy *et al*., 2006) that is why overfeeding leads to fast growth rate. It is important to mention that lettuce and cucumber are not optimal for Hermann's tortoises as both are poor sources of nutrients and CF. These feeds were added as they are frequently used by pet owners. The quality of the feed mixture for tortoises can be enhanced by adding weeds (e.g., dandelion, chickweed) as these are part of the natural diet (Nagy *et al*., 1998; Lagarde *et al*., 2003; Mushinsky *et al*., 2003; Hazard *et al*., 2010; Vecchio *et al*., 2011; Iftime and Iftime, 2012).

As reptiles do not masticate their food, mean faecal particle sizes are larger and it increases with BW (Fritz *et al*., 2010). In tortoises the ability to crop food and food particle size influence faecal particle size. There is a significant ingesta particle size reduction in the intestine compared to the size in the stomach. The longer ingesta retention times plays an important role in this mechanism beside *Oxyuris* sp. and microbial activity (Fritz *et al*., 2010). The excrement of the tortoises in the nature is full of long undigested fibre. The higher hay content of diet B and especially, C resulted a similar excrement quality. This supports the need for additional fibre in the feed of herbivore tortoises. However, measuring digestibility would be interesting, according to our previous study the method of total collection cannot be used as the tortoises consume the excrement. This phenomenon also makes the indicator method unreliable.

## CONCLUSION

Diet C based on meadow hay (3.2% lettuce, 2.6% carrot and 88.9% meadow hay on DM basis) can be recommended to decrease the feed consumption, avoid fast growth rate and increase the CF content of the feed. According to our results, the CF should be between 22.1-27.4%.

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