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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2024; 10(1): 83-89 Derleme Makale/Review Article

The Importance of Calcium in Crayfish Farming

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Abstract

Crayfish (*Astacus leptodactylus* Eschscholtz, 1823), an ecologically and economically important species worldwide, is a species obtained from inland waters, which is among the export products in our country. Crayfish production in Turkey is based on fishing from natural water sources, dam lakes, and ponds. One of the most important elements in the growth of crayfish is calcium. This review aims to contribute to the development of crayfish farming by examining the importance of calcium in shell change and growth of crayfish.

Kerevit Yetiştiriciliğinde Kalsiyumun Önemi

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Öz

Dünya çapında ekolojik ve ekonomik olarak önemli bir tür olan kerevitler (*Astacus leptodactylus* Eschscholtz, 1823) ülkemiz içinde ihraç ürünleri arasında yer alan iç sulardan elde edilen bir türdür. Türkiye'de kerevit üretimi doğal su kaynakları, baraj gölleri ve göletlerden yapılan avcılığa dayanmaktadır. Kerevitlerin büyümesinde en önemli elementlerden biri kalsiyumdur. Bu derlemenin amacı, kerevitlerin kabuk değişimi ve büyümesinde kalsiyumun önemi incelenerek, kerevit yetiştiriciliğinin gelişmesine katkı sağlamaktır.

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INTRODUCTION

Crayfish are one of the crustaceans that live in freshwater throughout their lives. Under natural conditions, most of them are cytenohaline. Some crayfish species can survive in brackish waters as well as in low salinities (Susanto & Charmantier, 2000). Crayfish living in freshwater have a constant loss of ions in their bodies and an inflow of water through osmosis. Crayfish are hyperosmotic in freshwater at low salinity and isosmotic at high salinity (Susanto & Charmantier, 2000; Khodabandeh et al., 2005).

Calcium is one of the most important elements in crayfish growth. They spend almost all of their cuticular calcium during shell change. Therefore, they need a lot of calcium after shell change (Wheatley & Ayers, 1995; Wheatley & Gannon, 1995). Alpbaz (2005) states that the shell of crayfish consists of 40% calcium carbonate and 7% calcium phosphate. Many activities and feeding are reduced before shell change. When preparing feed for crayfish, it is thought that it can be accelerated by adding calcium to the feed. During the shell change process, calcium dissolved in the lower part of the shell is first extracted to increase the flexibility of the shell (Reynolds, 2002). For the new shell to form and harden, 10-20% calcium is needed, which is supplied from calcium stored in the stomach stones (Taugbøl et al., 1996). The dissolved calcium in the stomach stones is absorbed during shell replacement and is used for recalcification of shell sections after continued feeding. Only a small fraction of the calcium needed in stomach stones is stored, whereas the calcium needed after shell exchange is met by eating the discarded shell (Reynolds, 2002).

As mentioned above, calcium can also be obtained from feed (Aiken & Waddy, 1987). The availability and importance of exogenous calcium varies between species. After shell change, ionized calcium in water also helps to harden the shell (Malley, 1980; Taugbøl et al., 1996).

The most important function of the gills in crayfish is to regulate ion exchange between water and hemolymph (Wheatly &Gannon, 1995; Wheatly, 1999; Barradas et al. 1999). They have mechanisms to take up, assimilate and store calcium from the aquatic environment through their gills. Assimilation is reduced at low pH, in the absence of bicarbonate and at low temperature. Depending on nutrient requirements and after shell replacement, nutrient deficiency leads to reduced calcium assimilation (Greenaway, 1985). Calcium intake from different sources is important and a significant amount of calcium is consumed during shell formation (Malley, 1980). In this review, the importance of calcium in shell change and growth of crayfish was examined (Figure 1).

Figure 1. Crayfish *(Astacus leptodactylus* Eschscholtz, 1823)

The Importance Of Calcium In Shell Change And Growth Of Crayfish

The growth process of crayfish is characterized by the shedding of each old shell and the formation of a new one. In other words, crayfish growth is based on a series of shell changes. The molting event is the secretion of a new and larger shell that occurs before hardening. The soft stage, when the new skeleton develops, is a sensitive period for crayfish and they have a soft shell. If there is insufficient shelter to cope with the population density, there are losses due to cannibalism. The calcium needed during the hardening of the skeleton is supplied from the body or water. The molting activity is normal or slow depending on the calcium status. Calcium deficiency causes molting to proceed slowly. They also need calcium for the new shell to harden. As can be understood, the new shell uses calcium gradually as it forms. During the molting phase calcium is used for calcification and feeding is continued during this phase. Calcium stored in the gastrolith is used in small amounts as needed. During the hardening of the new shell, the body rapidly increases its mass by taking in water and air into its tissues. The crayfish then builds new tissues to fill its new expanding shell. Very rapid growth is achieved during this period. The main tissue increase in crayfish occurs during the intermolt stage (Lowery, 1988; Huner & Barr, 1991).

Calcium is very important in the formation of the shell. In this respect, the water for crayfish farming should be rich in calcium content (Alpbaz, 1993; Groves, 1985; Hunner, 1994).

Calcium ions in the water help hardening of the new shell. However, optimum calcium values for *A. leptodactylus* in crayfish populations are 50-100 mg/L, with 5-130 mg/L being the limit values (Köksal, 1988). Decreasing calcium concentration has a limiting effect on growth and reproduction, with the growth and reproduction of Astacus juveniles slowing down when the calcium content in the water is lower than 1 mg/L (Hessen et al., 1991; Rukke, 2002).

Freshwater crayfish are known to eat old shells that they discard from their bodies. On the other hand, when the calcium saturation level is 5 mg/L or less, freshwater crayfish cannot successfully form new shells because shell calcification is incomplete (James & Huner, 1985; Rukke, 2002). The literature states that the calcium level in water should be 2 mg/L for crayfish to survive. Some research results have shown that the amount of calcium in the water should be more than 10 mg/L for crayfish to survive. It has been reported that increasing the calcium concentration in the habitat increases the survival rate of crayfish and partially slows down shell change (Parkyn, 2002). Although calcium deficiency in the environment affects shell change, metabolic activity, and growth of crayfish, high calcium concentration in water can be toxic to crayfish (Winkler, 1986). Studies have shown that the calcium requirements of cold-water crayfish species are higher than those of temperate-water species (Berber & Mazlum, 2009; Mazlum, 2007).

Environmental factors such as water temperature, water quality (pH, calcium, and magnesium), light transmittance, photoperiod, and stocking density play an important role in crayfish growth (McClain et al., 1992; Nyström, 1994; Jover et al., 1999; Paglianti and Gherardi, 2004; Ramalho et al., 2008). The physicochemical properties of water are also important for crayfish. Calcium has a wide range of biological functions in crayfish life, such as growth and shell change, and has an important structural role in crayfish. They must obtain the calcium needed for the hardening of the new shell from water or feed (Hammond et al., 2006). Studies have shown that different calcium concentrations have effects on crayfish survival, growth and shell change (Holdich, 2002).

Although crayfish consumption in Turkey is not sufficient, they have a high economic value in foreign markets. Natural fishing in different geographical regions of Turkey is very rare. On the other hand, diseases in natural production cannot be intervened. In this sense, crayfish farming should be cultivated. Different fish feeds are used in crayfish farming for research purposes and trials are completed by adding different additives to these feeds for experimental purposes.

Taugbol et al. (1996) reported that the survival rate of crayfish was proportional to the increase in calcium concentration in the water, but partially decreased due to mortality caused by shell change. Hammond et al. (2006), in a study on *Paranephrops zealandicus*, reported that crayfish survival was proportional to the increase in the amount of calcium in the water (up to 10 mg/L), but above certain values of calcium in the water (e.g. 80 mg/L) the growth rate did not change. However, some studies have shown that neither high nor low calcium concentrations have a positive effect on growth.

In a related study, it was reported that although calcium deficiency in water affects shell change, metabolic activity and growth of crayfish, high calcium concentrations in water may have toxic effects on crayfish (Winkler, 1986). In similar studies on *Penaeus/Litopenaeus vannamei*, it was found that when Ca/Mg was 1:3, survival and growth rates increased with increasing calcium and magnesium ions, but when calcium concentration reached 30 mg/L, growth and survival rates decreased with increasing calcium and magnesium ions (Chen Ji Wang and Chen, 2004).

Calcium accumulates in the outer shell of many crustaceans, such as freshwater crayfish, which require sufficient calcium for each shell change (Rukke, 2002). Apparently, the calcium content of aquatic environments is important for the growth of freshwater crayfish (Hessen et al., 1989). When there is a calcium deficiency, the molting activity proceeds more slowly. Therefore, the soft-shell period lasts longer and crayfish are vulnerable to intense predator attacks. Cannibalism also increases during this period. Rapid growth and frequent shell changes increase cannibalism and predation. Hammond et al. (2006) showed that cannibalism in crayfish decreases with increasing calcium concentration in water.

Zahmetkesh et al. (2007), examined the growth and survival rates of *Astacus leptodactylus* juveniles by feeding them diets with different levels of calcium (0, 1, 2, 3, and 4%). As a result of the study, the best weight and length increases were observed in the group fed with 3-4% calcium, but there was no significant difference between these experimental groups. The highest growth (11.65 g) was observed in the group fed with 4% calcium. The lowest survival rate (30%) was observed in the group fed with 2% calcium. In this study, it was found that there was a significant increase in growth due to different concentrations of calcium compounds.

The lack of statistical difference between the experimental groups suggests that it is not correct to attribute the results only to calcium compounds. Because water temperature is the primary factor in shell change, survival, feeding, and growth of crayfish (Lowery, 1988; Whitledge & Rabeni, 2003). In general, low temperatures are recommended for the survival of juvenile crayfish and high temperatures are recommended for their rapid growth. Different researchers working with crayfish belonging to Astacid and other families have reported that although temperatures of 20ºC or higher give the best results for crayfish growth, the survival rate of crayfish kept at 15ºC or lower has increased (Westman et al., 1993; Gydemo & Westin, 1989; Mazlum 2007).

Taugbol et al. (1996) *Astacus leptodactylus* reported that 10-20% calcium is needed for the hardening of the new shell and storage of gastroliths. Another result obtained from this study was that gastroliths were found to be larger and heavier in soft-shelled crayfish that had recently changed their shells. One of the most important reasons for this is that new-shelled individuals cannot use gastroliths. Because during shell change, calcium carbonate in the stomach is brought back to dissolved form and used in the formation of the mouth and outer shell. 1/3 of the amount of calcium carbonate required for new shell development is supplied from the stomach, hepatopancreas, and blood (Taugbol et al., 1996; Holdich, 2002).

Cilbiz (2010) study in crayfish fry, 1.5%, 2.0%, 2.5%, 2.5%, and 3.0% calcium was added to the feed, and high levels of feeds containing calcium (2.5%-3.0%) were found to have better specific growth rate and feed conversion ratio.

Türel & Berber (2016) ın the experiment, calcium carbonate was added to the feed at the rates of 1%, 3%, and 5%. Control calcium carbonate was not added to the group. 1% after 90 days of research, crayfish fry fed with feed containing 3% and 5% calcium carbonate ($CaCO_3$) Although not significant, weight gain and specific growth rates were found to be higher. The best survival rate was obtained in feeds containing 5% calcium carbonate. Survival rates in the groups were found to be significantly higher than the control group ($p<0.05$).

Recently, studies have shown that to maximize the growth of crayfish, they should also be fed with other feed sources high in protein (Uzun, 2007). In addition, it is important to add vitamins, minerals, antioxidants, and various other additives to the feed in fry production under artificial conditions (Öz, 2005). One of these additives is calcium. As it is known, the growth of crayfish involves many shell change processes. It follows the shell change. During this shell change, crayfish are exposed to calcium. They need calcium. Calcium deficiency in water can cause crayfish to change their shells, affecting metabolic activity and growth. However, high calcium can also have a toxic effect (Winkler, 1986). Therefore, the calcium content needs of crayfish of different sizes should be determined.

CONCLUSION

Calcium is one of the most important elements in the growth and development of crayfish. Research has shown that; it has been determined that dietary calcium is utilized in at least two ways in crayfish (Hessen et al., 1989).

These are expressed as the absorption of calcium through the digestive system wall and the intake of calcium into the body through the gills. Researchers have stated that calcium intake in crayfish increases with increasing calcium content in the feed.

Crayfish get some of the calcium they need from water. Research has shown that the amount of calcium they get from water is not always sufficient. In this case, the amount needed should be met by adding calcium to the feed.

Studies were carried out with 1%, 2%, 3%, and 4% calcium concentrations and it was found that the study with 4% concentration was effective on growth. However, the levels of effect on growth between the experimental groups were not statistically significant.

Determining the concentration ratio of statistically significant results by adding different concentrations of calcium to the feeds will be important for the culturing of crayfish.

In the trials to be conducted, crayfish trials of different sizes and species should be established and the ideal calcium ratios for each size should be determined. Cultivation should be encouraged by determining feed rations suitable for different geographical conditions of the country.

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