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The Effect of Cerelac on the Starvation Resistance in *Drosophila melanogaster*

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Abstract

D.melanogaster serves as a prominent model organism for investigating physiological traits such as starvation resistance. Among various external factors, dietary composition plays a pivotal role in influencing this trait. In the present study, flies were cultured on wheat cream agar and diets supplemented with 10%, 20%, and 30% cerelac to evaluate the impact of nutritional enhancement on starvation resistance. Results demonstrated a clear dose-dependent relationship between cerelac concentration and starvation resistance. Flies reared on 30% Cerelac exhibited the highest starvation resistance, followed by those on 20% Cerelac with moderate resistance. Flies maintained on 10% Cerelac showed lower resistance, and those cultured on wheat cream agar alone had the least starvation tolerance. Sex-specific differences were also observed: female flies consistently showed greater starvation resistance than males across all diet types. Furthermore, within both sexes, mated and unmated individuals differed significantly in starvation resistance depending on the dietary condition. These findings suggest that increasing Cerelac concentration in the diet likely due to its high nutritional and protein content can effectively enhance starvation resistance in *D. melanogaster*.

Keywords: Cerelac, Starvation Resistance, Drosophila melanogaster, Dietary composition, Nutritional Enhancement etc.

Introduction

Starvation refers to an animal's ability to endure periods without food, which may be brief or extended. Prolonged starvation, often caused by seasonal food shortages, can lead to death (McCue, 2010) [14]. Many animal species regularly face food scarcity, and their reproductive success is closely linked to foraging efficiency (Chippindale *et al*., 1996; Wayne *et al*., 2006) [4]. Food scarcity is one of the most significant environmental challenges animals encounter, and their diet and nutritional condition play key roles in their survival under such stress. While starvation resistance has been extensively studied in *Drosophila* species from an ecological and evolutionary perspective, its nutritional basis remains less understood (Lee and Jang, 2014) [10].

Natural populations often experience reduced food availability, making the study of physiological adaptations to starvation important for understanding evolution and its implications for human health. For instance, Hoffmann and Harshman (1999) [8] examined variations in *D. melanogaster* populations exposed to starvation and drought. An animal's ability to withstand starvation depends greatly on its nutritional status, which is shaped by feeding history and diet quality. As heterotrophs, fruit flies like *D. melanogaster* rely on consuming, digesting, and assimilating nutrients to support growth, reproduction, and energy storage. The lipid content in these flies is particularly crucial for starvation resistance, although the mechanisms behind nutrient balance in their bodies are still not fully clear (Lee and Jang, 2014) [10].

Food intake both in quantity and quality affects key life traits such as reproduction, lifespan, immunity, and stress resistance (Kiran and Krishna, 2023) [11]. Diet effects can be either quantitative (food amount) or qualitative (nutrient composition). The amount of food consumed and how efficiently it is digested and absorbed directly influence an animal's energy and nutrient levels (Singh and Sisodia, 2012) [22]. Some species regulate food intake through feedback mechanisms that respond to nutrient availability (Simpson *et al*., 2012). While energy was once seen as the primary concern of aging animals, current research emphasizes the importance of nutrient balance for overall fitness. Notably, higher fat reserves are strongly linked to better starvation tolerance. Several studies, including those by Chippindale *et al*. (1996) [4], have shown a close correlation between lipid storage and resistance to starvation, with lipid levels being a primary factor in this trait across different genetic backgrounds (Hoffmann and Harshman, 1999) [8].

Previous studies shows Starvation significantly reduces the life span of *Drosophila*. Flies typically die within 2-3 days without food, though access to water can prolong survival slightly. The degree of tolerance can vary by sex and genotype (Mair, and *et al* 2005) Starvation as been shown to reduce fecundity in female flies and delay mating behaviour.

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Energy is redirected from reproduction to survival, which is a common stress response across species. (Hion, *et al* 2014)
Cerelac is typically made from a variety of grains (wheat, rice, oats, barley) mixed with vitamins, minerals, and other nutrients. The product is known for its easy-to-digest texture, making it ideal for babies Cerelac is typically made from a variety of grains (wheat, rice, oats, barley) mixed with vitamins, minerals, and other nutrients (Black *et al*, 2013). However effect of cerelac starvation resistance has no been studied. Therefore presence study was undertaken in *D.melanogaster.*
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Materials and Method
The cerelac was purchased from a Shree Medical Store #14, Shop no. 1, 6th main, vinayakanagara Mysuru-570012 and used as a dietary component in the experimental setup.

Establishment of Stock
Experimental Oregon K strain of *Drosophila melanogaster* used in the study was collected from *Drosophila* stock centre. Department of studies in Zoology, University of Mysore, Mysore and this stock was cultured in bottles containing wheat cream agar media (100g of jaggery, 100g of wheat cream rava, 10g of agar was boiled in 1000ml distilled water and 7.5ml of propionic acid was added). Flies were maintained in laboratory conditions such as humidity of 70% and 12 hours dark 12 hours light cycles and temperature 22° C+ 1° C, where these were collected to conduct our experiment.

Establishment of Experimental Stock
The flies obtained as above were used to establish the experimental stock with different diet media. [Wheat cream agar media: Wheat cream agar media was prepared from 100g of jaggery, 100g of wheat cream rava, 10g of agar boiled in 1000ml distilled water and 7.5ml of propionic acid added to it. 10% of Cerelac media: is prepared from100g of jaggery, 90g of wheat cream rava, 10g of cerelac powder, 10g of agar boiled in 1000ml of distilled water and 7.5ml of propionic acid added to it. 20% of cerelac media: is prepared from 100g of jaggery, 80g of wheat cream rava and 20g of cerelac powder, 10g of agar boiled in 1000ml of distilled water and 7.5ml of propionic acid added to it. 30% of cerelac media: is prepared from 100g of jaggery, 70g of wheat cream rava and 30g of cerelac powder, 10g of agar boiled in 1000ml of distilled water and 7.5ml of propionic acid added to it]. The flies emerged from the wheat cream agar media and other experimental treated media under the same laboratory conditions as mentioned above were used to study the starvation resistance experiment in *D.melanogaster*.

Experimental Procedure
Starvation resistance: To study starvation resistance five days old unmated (virgins) and mated flies obtained from wheat cream agar, 10% cerelac, 20% cerelac and 30% cerelac media were used. Fifteen flies were observed by transferring them to empty vials with each vial containing 5 flies. These vials were kept at 22± 1°C under constant light condition and resistance to starvation of each fly was observed in 1 hour interval until its death. A total of 3 replicates (each with 5 flies) were carried out for each of the wheat cream agar, 10% cerelac, 20% cerelac and 30% cerelac media. Separate experiment was carried out for mated and unmated flies.

Results
The mean and standard error value of starvation resistance in mated male and mated female flies cultured in Wheat cream agar media. Mixed media and Whey protein media are shown in Fig.1. This data showed that mated male had shown greater starvation resistance than mated females in all the diet provided except 20% cerelac media. Among mated males, flies raised in 30% Cerelac media showed greater starvation resistance compared to more or less same in 10%, 20% cerelac media and Wheat cream agar media. Among mated males, flies cultured 30% Cerelac showed highest starvation resistance than others.
The above starvation resistance data subjected to two-way ANOVA followed by Tukey's Post hoc test showed significant variation in between. However. Insignificant variation in starvation resistance wan noticed between sexes and also treatment. Tuckey's post hoc test showed significant difference in Starvation resistance between diets.

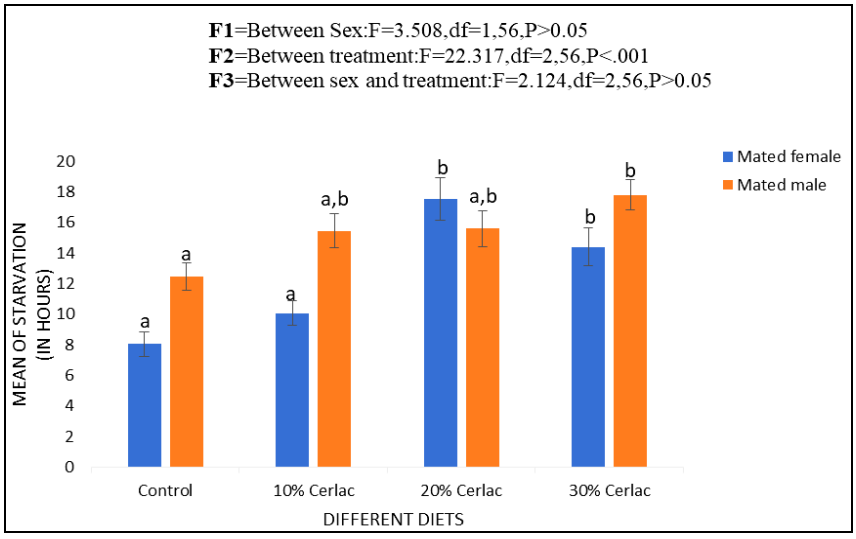

Fig 1: Effect of the cerelac on the starvation resistance in the mated female and male of *D.melanogaster.*

The different letters on the bar graph indicate the significant variation between the different diet by Tukey's post hoc test at 0.05 level.

Figure 2: presents the mean and standard error values for starvation resistance in unmated female and male flies reared on Wheat cream agar, 10%, 20% and 30% cerelac media. The results indicate that, across all diets, unmated female flies exhibited greater starvation resistance than their male counterparts. Among the females, those raised on the 20% cerelac displayed the highest resistance, while those on the Wheat cream agar, 10% and 30% cerelac media showed the average. In unmated males, the highest resistance was observed in those fed the 20% cerelac media, with relatively similar resistance levels in the other three diets. Notably, both unmated males and females raised on cerelac exhibited comparable starvation resistance.

A two-way ANOVA followed by Tukey's post hoc test revealed a significant difference in the duration of survival under starvation across sexes and dietary conditions. However, the interaction between diet type and sex showed no significant effect on starvation resistance.

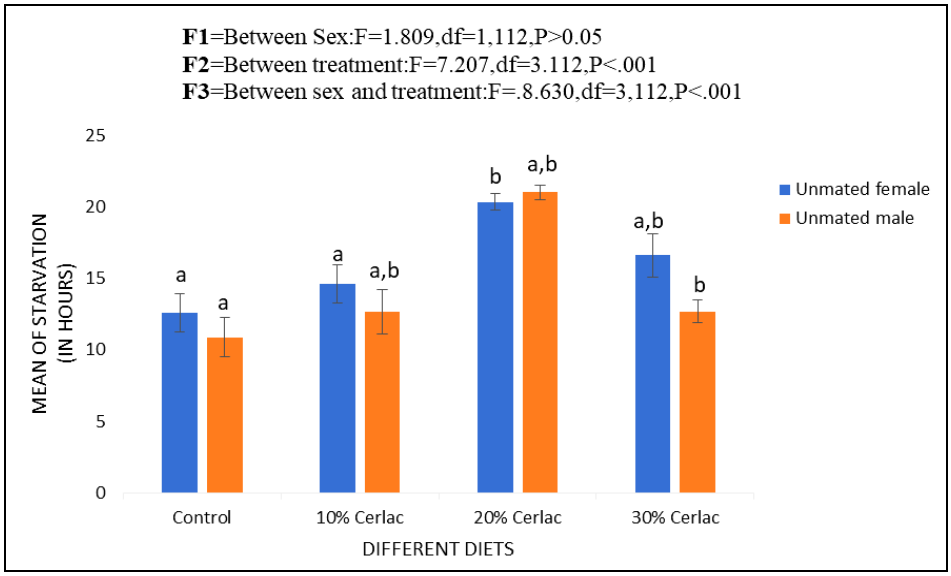

Fig 2: Effect of the cerelac on the starvation resistance in the unmated female and male of *D.melanogaster.*

The different letters on the bar graph indicate the significant variation between the different diet by Tukey's post hoc test at 0.05 level.

Figure 3: illustrates the average starvation resistance of unmated and mated female flies reared on Wheat cream agar10%, 20% and 30% cerelac media. The data indicate that unmated females raised on 20% cerelac media exhibited the highest starvation resistance, while those raised on Wheat cream agar showed the lowest. Among mated females, those reared on 20% cerelac media demonstrated the greatest resistance, whereas those on Wheat cream agar 10% and 30% cerelac media displayed similar levels of starvation resistance.

A two-way ANOVA followed by Tukey's post hoc test revealed a significant difference in starvation survival time among unmated female and mated female flies across the10%, 20% and 30% cerelac media diets. However, the interaction between treatment type and sex did not show a statistically significant effect. Tukey's test further confirmed significant differences in starvation resistance between diets.

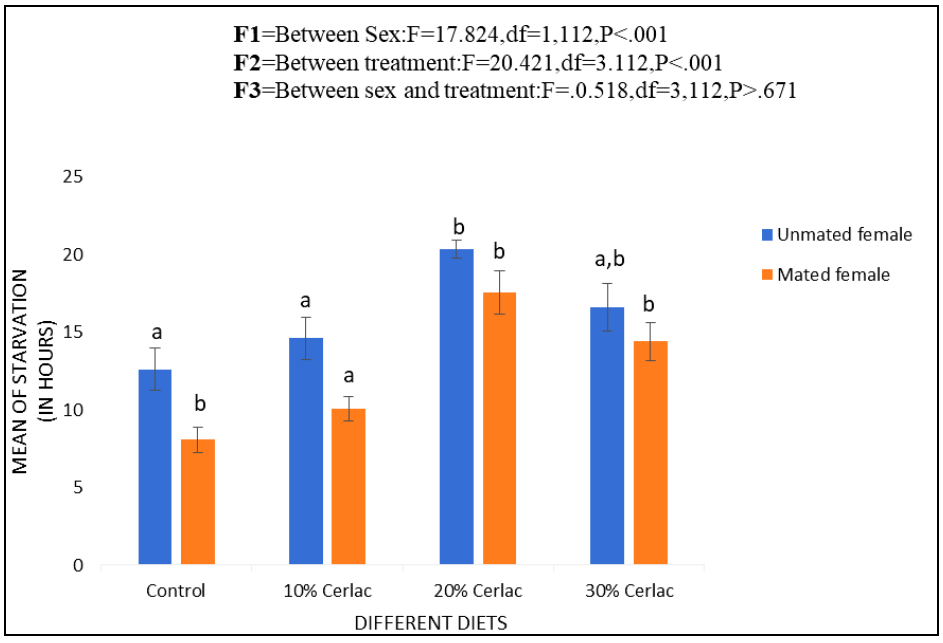

Fig 3: Effect of the cerelac on the starvation resistance in the unmated female and unmated male of *D.melanogaster.*

The different letters on the bar graph indicate the significant variation between the different diet by Tukey's post hoc test at 0.05 level.

Figure 4: the mean and standard error value of starvation resistance in unmated male and mated male flies cultured in Wheat cream agar media, 10%, 20% and 30% cerelac media is represented. This data showed that starvation resistance was greater in unmated male flies raised in 20% cerelac media compared to other media. Among mated males, flies raised in Wheat cream agar media showed less starvation and unmated male flies raised in wheat cream agar, 10% and 30% cerelac media showed more or less equal starvation.

The above starvation resistance data subjected to two-way ANOVA followed by Tukey's Post hoc test showed significant variation in time taken by unmated male and mated male flies cultured in wheat cream agar media, 10%, 20% and 30% cerelac media to survive in food deprived condition. However, significant variation in starvation resistance was noticed interaction between treatment and sex, and also treatment.

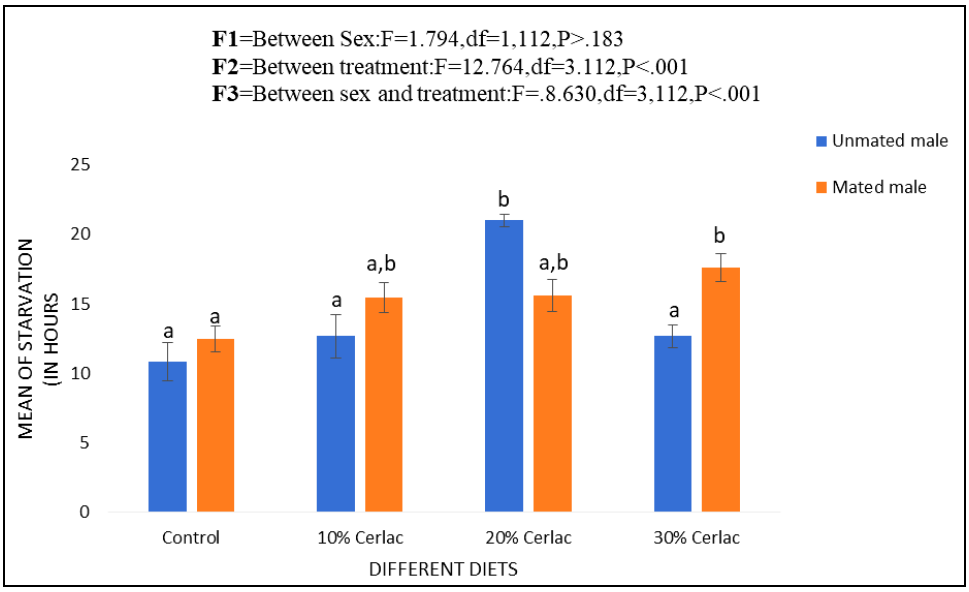

Fig 4: Effect of the cerelac on the starvation resistance in the unmated male and mated male of *D.melanogaster.*

The different letters on the bar graph indicate the significant variation between the different diet by Tukey's post hoc test at 0.05 level.

Discussion

Food plays a fundamental role in the growth, development, health, reproduction, and survival of organisms. The availability and nutritional quality of food directly influence an organism's ability to resist starvation. Numerous internal and external factors such as nutrition, social interactions, age, genetic diversity, and temperature also have an impact in the physiological relationships associated with starvation (Vermeulen *et al*., 2006, Pijpe *et al*, 2007; Rush *et al*., 2007) [16, 18].

In the present study, *D. melanogaster* reared on a 20% and 30% cerelac media-based diet exhibited higher starvation resistance compared to those on a 10% cerelac media, while the lowest resistance was observed in flies fed on wheat cream agar media (Fig. 1–4). These findings suggest that starvation resistance is influenced by the nutritional content and quality of the diet. Since flies cannot acquire energy during starvation, they rely on previously stored reserves. *Drosophila* increases its resistance to starvation by storing energy in the form of lipids, carbohydrates, and proteins, regulating the consumption of these reserves based on metabolic demand, or tolerating greater energy depletion. Previous studies have linked starvation resistance in *D. melanogaster* to elevated lipid storage, particularly triglycerides (Chippindale *et al*., 1996; Harshman *et al*., 1999) [4, 8]. Jang and Lee (2018) reported that exposure to higher temperatures (18–23°C) reduced starvation resistance, likely due to an increased metabolic rate and faster depletion of lipid reserves. Similarly, Prakash *et al.* (2014) found that low humidity enhanced both starvation resistance and lipid levels, while high humidity reduced resistance. However, in this study, environmental factors such as temperature (22 ± 1°C) and humidity (~70%) were kept constant, minimizing their effect on starvation resistance. Our findings are in line with those of Shreeraksha *et al*. (2023) [20], who demonstrated that protein-rich diets (e.g., spirulina) enhance starvation resistance, and differ from the results of Kiran and Krishna (2023) [11], who reported higher resistance in flies on a mixed diet than those on millet-based feed.

Furthermore, the present study found that female flies consistently showed greater starvation resistance than males across all diet types (Fig. 2 and Fig. 3). This may be attributed to sex-specific differences in energy metabolism. Males and females often have different nutritional requirements, which can result in varying starvation responses (Hoyenga and Hoyenga, 1982). In *D. melanogaster*, sex-based differences in starvation resistance are influenced by genetic background, mating status, age, and experimental conditions (Service, 1989; Huey *et al*., 2004; Vermeulen *et al*., 2006; Matzkin *et al*., 2009) [19, 9, 13]. During starvation, females tend to utilize stored lipids and glycogen, while males rely predominantly on lipids. Enhanced starvation resistance has been associated with greater energy storage or slower utilization of these reserves (Hoffmann and Harshman, 1999; Rion and Kawecki, 2007; Gibbs and Reynolds, 2012) [8, 17]. Additionally, differences in tissue composition and the efficiency with which each sex uses energy stores may contribute to this variation (Aggarwal, 2014).

Our results (Fig. 4) also indicate that unmated males on 20% cerelac diets exhibited greater starvation resistance than their mated counterparts. This aligns with previous findings showing that mating reduces starvation resistance due to

energy expenditures associated with mating behaviors and the transfer of sperm and accessory gland proteins (Service, 1989; Rush *et al*., 2007; Goenaga *et al*., 2012) [19, 18, 6]. However, in the case of mated males on a different concentrations, the combined presence of carbohydrates and proteins might have mitigated the energy loss incurred during mating.

Interestingly, mated females showed higher starvation resistance than unmated females when fed on different concentrations of c cerelac (Fig. 1 and 3). This could be due to the increased food intake and lipid accumulation that occur post-mating, as mating in females is known to enhance feeding behavior, reduce receptivity, and stimulate egg production (Carvalho *et al*., 2006). These changes are induced by sex peptides present in the male seminal fluid (Chen *et al*., 1988; Hendon and Wolfner, 1995).

Thus in *D. melanogaster* mass gainer increases starvation resistance, in all the diet studied female had greater starvation resistance than male flies. Furthermore the mated males and females had greater resistance to the starvation compared to unmated male and female.

Conclusion

Hence our experimental study we can conclude that, the flies developed with cerelac supplemented diet had the greater resistance to the starvation than the flies fed with wheat cream agar media further starvation resistance increased with increasing the concentration of cerelac. Thus these studies suggesting that quality and quantity of nutrients present in cerelac affects heat resistance in *D. melanogaster.*

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