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# Stored Grain Preference of the Red Flour Beetle *Tribolium castaneum* (Tenebrionidae: Coleoptera)

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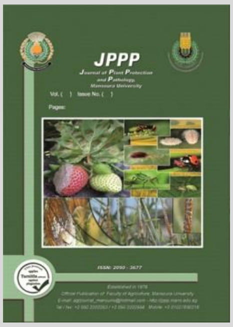


## ABSTRACT

The life history, development time, survival rate and other activity parameters of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) were studied on five flour commodities at 30 ± 1°C, 75 ± 5% RH and 12L:12D photoperiod in two separate experiments (choice and non-choice assays). The larval stage exhibited the shortest duration on wheat grains (11.7±0.3 days) followed by rice (15.6 ± 0.16 days) and barely (16.3 ± 0.26 days), where-as the longest duration was on corn (20.6±0.40 days) followed by oat (19.5±0.43 days). Moreover, the highest larval survival rates were on wheat and barley, and the one was on oat grains. Furthermore, the highest weight loss was on barely (8.8 %) followed by wheat (8.4%) and corn grains (7.2%). Adult longevity was the longest on oat and wheat grains with an average of 235.2 ± 5.15 and 234.3 ±5.16 days, respectively. The choice test experiment revealed that the number of attracted individuals, the number of deposited eggs, the number of emerged progeny and the percentage of the weight loss were the highest on wheat and barley grains. The findings of this study could be applied to maintain the quality of stored grains and processed grains food by-products, as well as to further investigate the connections between kernel hardness and sensitivity to stored product insects.

***Keywords***: Graminaceous; Varieties; Red flour beetle; Population development; Biological parameters

## INTRODUCTION

The most significant staple crops in Africa are cereal grains. Reducing the projected $4 billion in annual grain losses brought by pests and weather is one of the major obstacles to enhancing food and nutritional security in Africa (FAO, 2010). In the Eastern and Southern African (ESA) region, graminaceous plants constitute the most important source for food and income for millions of smallholders who are resource-poor. Although annual per capita consumption varies greatly, many nations have higher per capita consumption levels than the world average (Hassan *et al*., 2001; Pingali, 2001). The red flour beetle, *Tribolium castaneum* (Herbst) (coleoptera: Tenebrionidae) and other stored insect pests have been identified as an increasingly significant concern in Africa (Arthur *et al*., 2015; Campbell *et al*., 2015; Toko, 2015). Good (1936) was the first to identify this bug as Kansas's most significant wheat mill pest. Although it is frequently thought of as a pest of wheat flour, it can also devour a wide range of processed grain products, even some whole grains like brown rice (Kavallieratos *et al*., 2019). This insect is one of the main pests of goods that are kept in storage, including broken grain, milled grain products, meal, cereals, beans, almonds, crackers, spices, cake mix, pasta, chocolate-dried pet food, and dried flowers (Fedina and Lewis, 2007, Oppert *et al*., 2010). Through feeding damage or contamination with the insect's fragments and uric acid, *T. castaneum* infestations of host diets result in a loss of biomass and a reduction in food quality (Bekon and Fleurat, 1992). Recently, the population dynamics of various stored product insects on wheat have been the subject for numerous studies, including the creation of an expert system to manage bulk-stored wheat (Flinn *et al*., 2007). Predicting the increase of the insect population in stored rough rice has, however, received considerably less attention. In the south-central United States, unaerated and aerated rough rice was preserved, and this technique was used to forecast population increase (Arthur *et al*., 2011). In contrast to the storage of raw grains, population dynamics and development rates are probably considerably different in structures where grains are ground. In comparison to bulk stored grain, the mill beetle diet is more diverse, temperature and other environmental factors are more changeable, and food resources are patchier (Campbell *et al*., 2015). Studies have shown population dynamics and growth in wheat and rice mills after sulfuryl fluoride or methyl bromide fumigations have been applied (Campbell *et al*., 2010a, b; Campbell *et al*., 2015). According to Buckman *et al*. (2013), seasonal temperature variations appear to have a significant impact on *T. castaneum* population dynamics in rice mills. Populations grew more slowly in rice mills than in wheat mills, possibly because of the greater seasonal temperature variation but also possibly because of the diet. There hasn't been much published a study on how *T. castaneum* develops in a rice mill, particularly how temperature and rice components and by products affect development. Developmental conditions can have an impact on an individual's adult fitness features in addition to the effects of temperature and food on development time and the likelihood of reaching the adult stage. Poor nutrition of insects during development often led to smaller-sized adults with lower fecundity and smaller offspring, and shorter longevity than those received high quality food (Colasurdo *et al*., 2009; Dimitriew and Rowe, 2011).

Synthetic pesticides have been the mainstay of the management of storage insect pests (Collins *et al*. 1993; Hertlein *et al*. 2011). Studies to identify more

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environmentally safe control strategies have been prompted by issues with the use of numerous pesticides, such as poor application expertise, high persistence, genetic resistance, and health risks (Herron 1990; Daglish 2006). Research efforts are presently concentrated on the adoption of resistant hosts, which are secure and environmentally beneficial, as a substitute for synthetic insecticides (Borzoui *et al*.,2017, Majd-Marani *et al*., 2017). When creating pest management strategies, such as the genetic engineering of resistant crops, it is necessary to identify the characteristics of host crops (such as protein and carbohydrate levels) that affect performance of *T. castaneum*.

Although biology of *T. castaneum* and physiology of its digestive enzymes has been previously investigated in relation to a few host commodities (Fabres *et al*., 2014; Sagheer *et al*., 2014), this study looked at a wider range of commodities to see how the physicochemical characteristics of the tested commodities affect the life history and physiology of this pest. We postulated that larvae raised on high-nutrient foods would feed more effectively than those raised on low-nutrient foods. Additionally, it has predicted that adults produced from larvae fed on specific commodity flours would mature more quickly and exhibit high levels of fecundity and fertility. Thus, understanding the nutritional physiology of *T. castaneum* when reared on different commodities and determining factors affecting its life history would be helpful to retrofit host commodities against this pest.

## MATERIALS AND METHODS

The present experiments were conducted under laboratory conditions at temperature 30 ±1 °C and 65±5 % relative humidity at the laboratory belong to the Economic Entomology Department Faculty at Agriculture, Mansoura University. The red flour beetle *Tribolium castaneum* has been reared on creaked graminaceaous grains on wheat, corn and rice for three generations before starting the present experiment.

The creaked graminaceous grains which used for the experiments were initially stored for at least three days at – 20 °C to killed different stages at the storage pests which they might be found in the kernels and remove the grains with damage symptoms. The grains after that were transferred into transparent plastic buckets and maintained under laboratory conditions until use it in the following experiments. The graminaceous grains were wheat, barley, corn, rice and oat were obtained at the Crop Research institute, Sakha Agriculture Research Station, kafr El-Shikh, Ministry of Agriculture.

**Non –choice test**:

The present experiments were conducted to study the biological parameters of the insect pest when reared on different graminaceous stored grains. Enough numbers at the emerged unsexed adults aged between 5 and 7 days were introduced in ten glass jars (250ml) and allow to mating and egg laying. The incubation period for all treatments were calculated and recorded. The newly hatched larvae were transferred to petri – dishes contained 10 g at feeding grains and each petri – dish contained only two larval individuals and each stored grain replicated fifty times.

The developmental periods larvae and pupae survival and the adult emergence were daily recorded. Feeding grains loss for rearing the larvae only were calculated and recorded. After the adult insect's emergence, each ten unsexed pairs were transferred in plastic jars containing the creaked graminaceous grains to recording the ovipositional periods, adult longevity and the number of F1 progeny under non – choice test and replicated three times for each grain species.

**Choice test**

In these experiment, three glass jars accommodate were used as a replicates. Each accommodate contained five petri_ dishes and each petri- dish contained 5 g of the creaked tested grains. Ten pairs of the newly emerged insect's aged between 5 and 7 days old were placed in the center of each jar to allow for the insect free choice to preferred the grain species and allow for the adult to mating and oviposit on any grains species. The parents were allowed to egg_ laying for ten days and were removed after the ten days of the treatments beginning. The number of the attractive individuals for each grain species were recorded. Also, the number of the egg laid in each grain and the number of the emerged progeny for first generation after one month were calculated and recorded moreover, the weight loss for each grain species were recorded

**Date analysis:**

Data of developmental times, survival, pre-oviposition , oviposition and post-oviposition periods, and female longevity of *T. castaneum*, were analysed using one-way ANOVA, and the means were separated using Student-Newman-Keuls Test (Costat Software, 2004).

## RESULTS AND DISCUSSION

Non-choice test and free choice test were carried out to determine the perferability of different graminaceous stored grains to *T. castaneum* according to the biological parameters.

**Non-choice test:**

The present result illustrated in the Table (1) showed the effect of different stored grains types on the developmental stages on the red flour beetle *T. castaneum* under laboratory conditions at 30±1°C and 65±5%R.H. In respect to the incubation period for the insect pest on a different stored grains it was ranged between 4.5±0.17 and 4.8±0.24 days with no significant difference.

Regarding to the larval stage on wheat grains was shortest duration followed by rice and barely and presented by 11.7±0.3, 15.6 ± 0.16 and 16.3 ± 0.26 days, respectively. While, on corn followed by oat were the longest larval duration and presented by 20.6±0.4 and 19.5±0.43 days, respectively. Statistical analysis revealed that, a highly significant differences were obtained between the larval stage duration according to different stored grains (Table 1).

In the other hand, the pupal stage duration was the shortest (5.0 ± 0.21days) on the wheat grains followed by barely (5.5 ± 0.17 days) and rice (5.7±0.21days) and the longest pupal stage duration was recorded on corn (7.3±0.15 days) with significant difference (Table 1).

The obtained result arranged in Table (1) showed the total developmental stages duration according to the deferability on different stored grains types. The shortest total developmental stages were recorded when the larvae reared on wheat grains followed by rice grains and barely grains and represented by 21.2 ± 0.42, 25.8 ± 0.2 and 26.3 ± 0.42 days, respectively. Meanwhile, the longest developmental stages were recorded when the larvae reared on corn grains and presented by 32.7 ± 0.54 days. Statistical analysis revealed that, a highly significant differences were obtained between the developmental stages durations according to different stored grains types

**Table 1. Effect of different stored grains on development (± SE) of the red flour beetle *T. castaneum* under laboratory conditions (30 ±1°C and 65 ±5 % RH).**

| Biological Parameters (days) | Stored grains | | | | |
|---|---|---|---|---|---|
| | Rice | Oat | Barley | Corn | Wheat |
| Incubation Period | 4.5 ±0.17 a | 4.7 ± 0.21 a | 4.5 ±0.17 a | 4.8 ±0.24 a | 4.5 ±0.17 a |
| Larval stage | 15.6 ± 0.16 c | 19.5± 0.43 b | 16.3 ± 0.26 c | 20.6 ± 0.4 a | 11.7 ± 0.3 d |
| Pupal stage | 5.7 ± 0.21 c | 6.4 ± 0.16 b | 5.5 ± 0.17 cd | 7.3 ± 0.15 a | 5.0 ± 0.21 d |
| Total development (Egg-Adult) | 25.8 ± 0.2b c | 30.6 ±0.56 b | 26.3 ± 0.42 c | 32.7 ± 0.54 a | 21.2 ± 0.42 d |

**Means followed by different letters in a row are significantly different at 5% probability level (ANOVA, Student- Newan-Keuls Test).**

The obtained data presented in Table (2) show the survival rate on the red flour beetle *T. castaneum* when reared on the different stored grains it can be noticed that, the larval survival rate ranged between 82% to 95%. The highest larval survival rates were 95% when the larvae reared on wheat or barely while, the lowest larval survival rates were 82% when the larvae reared on oat grains. Moreover, the pupal survival rates ranged between 93.9% on oat grains and 98.9% on wheat grains

As shown in Table (2), the survival rates during the developmental stages for the larvae until emergence of the adult ranged between 77% to 94%. It can be noticed that, the highest survival rates 94, 93 and 91% when reared the insect pest on wheat grains, barely grains and rice grains, respectively. Meanwhile, the lowest survival rates were 77% followed by 86% on oat grains and corn grains, respectively

**Table 2. Survival rates of the red flour beetle *T. castaneum* when reared on different stored grains under laboratory conditions (30 ±1°C and 65 ±5 % RH).**

| Biological Parameters (Mean ±SE) | Stored grains | | | | |
|---|---|---|---|---|---|
| | Rice | Oat | Barley | Corn | Wheat |
| Larval stage | 93% | 82% | 95% | 91% | 95% |
| Pupal stage | 97.8% | 93.3% | 97.9% | 94.5% | 98.9% |
| Larval – Adult | 91 a | 77 b | 93 a | 86 a | 94 a |

**Means followed by different letters in a row are significantly different at 5% probability level (ANOVA, Student- Newan-Keuls Test).**

Data arranged in Fig (1) show the percentage of the weight losses after reared on larvae only on different stored. It can be noticed that, the lowest percentage on the weight loss after reared the larvae only were 8.8 followed by 8.4% and 7.2% recorded on barely followed by wheat and corn grains, respectively. While, the highest percentage on the weight loss were recorded on oat grains followed by rice grains and presented by 5.8 and 6.2 %, respectively.

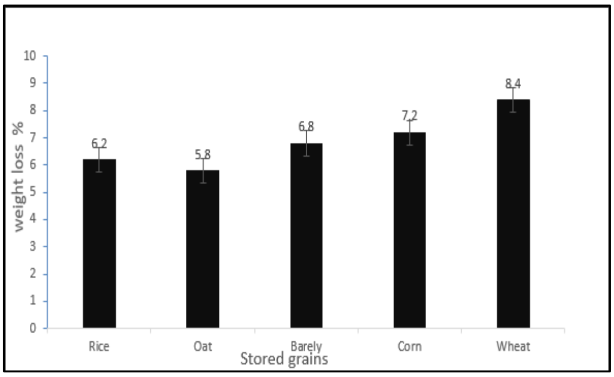


**Fig. 1. Weight loss percentages by feeding larvae on different stored grains under non-choice test.**

Data illustrated in Table (3) show effect of different stored grains on the ovipositional periods, female longevity and the number of F1 progeny of the red flour beetle ***T. castaneum*** under laboratory conditions (30 ±1°c and 65 ±5 %). Regarding to the pre-oviposition period was ranged between 5.7±0.21days on rice grains and 6.2 ± 0.13 on corn grains with no significant differences.

**Table 3. Effect of different stored grains on oviposition periods, female longevity and number of F1 progeny (mean ± SE) of the red flour beetle *T. castaneum* under laboratory conditions (30 ±1°C and 65 ±5 RH%).**

| Biological Parameters | Stored grains | | | | |
|---|---|---|---|---|---|
| | Rice | Oat | Barley | Corn | Wheat |
| Pre – ovipostion period | 5.7 ± 0.21 b | 6.2 ± 0.25 b | 5.5 ± 0.17 b | 6.2 ± 0.13 a | 5.9 ± 0.27 b |
| ovipostion period | 184.8 ± 5.75 d | 222± 5.07 a | 204.5 ± 1.37 b | 160.0 ± 4.83 c | 222.5 ± 4.9 a |
| Post –ovipostion period | 5.6 ± 0.22 c | 7 ± 0.26 b | 5.4 ± 0.16 c | 15.4 ± 0.16 a | 5.9 ± 0.28 c |
| Female longevity | 196.1 ± 5.61 c | 235.2 ± 5.15 a | 215.4 ± 1.32 b | 181.6± 4.86 d | 234.3 ±5.16 a |
| No of F1 Progeny / Female | 592.4 ± 4.15 b | 205 ± 2.03 d | 586.7 ± 4.84 b | 312.4 ± 2.98 c | 623.7 ± 3.66 a |

**Means followed by different letters in a row are significantly different at 5% probability level (ANOVA, Student- Newan-Keuls Test).**

In respect to the oviposition periods were the shortest on corn grains followed by rice grains and presented by 160.0 ± 4.83 days and 184.8 ± 5.75days, respectively. Meanwhile, the longest oviposition periods were recorded on wheat grains followed by oat grains and presented by 222.5 ± 4.9 and 222± 5.07 days, respectively. Statistical analysis revealed that, a highly significant differences were obtained between the oviposition periods under the effect of different stored grains types.

Regarding to the post oviposition periods, were the shortest on barely grain (5.4 ± 0.16 days) and on rice grains (5.6 ± 0.22 days) while, the longest post oviposition periods were 15.4 ± 0.16 days on corn grains with a significant difference

The adult longevity was the longest on oat and wheat grains with an average on 235.2 ± 5.15 and 234.3 ±5.16 days, respectively. Moreover, the shortest adult longevity was recorded on corn grains followed by rice grains and presented by 181.6± 4.86 and 196.1 ± 5.61 days, respectively. Statistical analysis revealed that, a highly significant differences were obtained between the adult longevity periods under the effect of different stored grains types.

The number of progeny for the first generation were the highest on wheat grains followed by rice grains and barely grains and presented by 623.7 ± 3.66, 592.4 ± 4.15 and 586.7 ± 4.84 individuals /females, respectively. On the other hand, the lowest average Number of progeny were recorded on oat grains and presented by 205.0 ± 2.03 individuals / females. Statistical analysis revealed that, a highly significant differences were obtained between the number of progeny for the first generation

**Choice test experiment**

Results arranged in Table (4) show that the effect of different stored grains on the attractive adult, egg-laying and

No. Of emerged progeny f1 with free choice test under laboratory conditions (30 ±1°c and 65 ±5 %). It can be noticed that, a high relatively number of individuals were attractive to wheat grains and barely grains which recorded 5.6 and 4.8 individuals, respectively. While a low relatively number of the insect pest were attractive to oat and presented by 2.2 individual with a highly significant difference

Wheat grains and barely grains achieved the maximum egg-laying during the ten-day period, with 64.4 1.21 and 53.0 1.22 eggs, respectively. In contrast, oat and maize grains were shown to be the least preferred for egg laying, as seen by the 42.4 1.96 and 43.2 2.01 eggs that were produced, respectively.. Statistical analysis revealed that, a highly significant differences were obtained between the egg-laying preferred during ten days'.

Regarding to the number of emerged progeny, wheat grains followed by barely grains and rice grains were recorded the good grains for rearing the immature stages and presented by 55.8 ± 1.46, 47.2 ±1.46 and 41.6 ± 1.75individuals, respectively. Statistical analysis revealed that, a highly significant differences were obtained between a significant differences Number of emerged progeny F1 under the effect of different stored grains types.

**Table 4. Effect of different stored grains on number of attracted adults, egg-laying and Number of F1 emerged progeny under free choice test at conditions of 30 ±1°C and 65 ±5 RH%.**

| Biological Parameters (Mean ±SE) | Stored grains | | | | |
|---|---|---|---|---|---|
| | Rice | Oat | Barley | Corn | Wheat |
| No. of attracted adults | 3.8 ± 0.49 bc | 2.7 ± 0.37 c | 4.8 ± 0.49 ab | 3.6 ± 0.51 bc | 5.6 ± 0 .4 a |
| No. of egg deposited ( during 10 days) | 49.4 ±0.51 b | 42.4 ± 1.96 c | 53.0 ±1.22 b | 43.2 ± 2.01 c | 64.4 ± 1.21 a |
| No. of emerged progeny F1 | 41.6 ± 1.75 c | 29.8 ± 0.8 d | 47.2 ±1.46 b | 32.6 ± 1.28 d | 55.8 ± 1.46 a |

**Means followed by different letter in a rows are significantly different at the 5% probability level (ANOVA, Student- Newan-Keuls Test.**

The obtained result in Fig (2) show the percentage of weight losses after the reared larvae only on different stored grains with free choice test. It can be noticed that, the highest percentage of weight loss after reared the larvae only were 11.7, 9.8 and 9.4% recorded on wheat grains, barely grains and rice grains, respectively. While, the lowest percentage of the weight loss with free choice test was recorded on oat grains and presented by 3.5%.

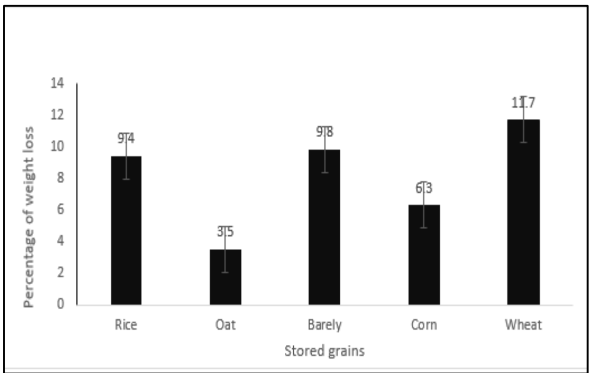


**Fig 2. Weight loss percentages by feeding larvae on different stored grains under free choice test:**

## Discussion

The quality and quantity of food consumed, as well as the physiochemical characteristics of the host diet, can all affect the nutritional performance of herbivorous insects (Behmer, 2009; Karasov *et al.*, 2011). As a result, this study found that the various cultivars tested significantly affected the nutritional physiology of *T. castaneum* larvae. The red flour is a generalist feeder that consumes a range of grain products in addition to wheat flour; it can also consume other types of flour as well as processed foods. For optimal growth, development, and fertility of herbivorous insects, the balance of nutrients is believed to be a crucial element (Nation, 2002). In this study, *T. castaneum* immature stages fed on maize, rice, and wheat flours for a shorter period of time than those reported by Kheradpir (2014) on these hosts.

According to previous studies (Phillipson, 1981; Li *et al*., 2004), body weight is related to the type and amount of food consumed. One of the key ecological characteristics of insect pest population dynamics is body weight (Liu *et al*., 2004). The consumption of food and weight gain by the larval stage are found to be shortest duration when they were fed wheat grains followed by rice and barely (Fig. 1), showing that larvae fed wheat received more nutrients than those fed other cultivars. Kheradpir (2014) assessed *T. castaneum's* food preferences among four different types of flour and found that it greatly preferred wheat flour and strongly avoided potato flour. The nutritional parameters of *T. castaneum* in response to feeding on wheat, maize and barley flour were examined by Sagheer *et al.* (2014), who found that barley flour was the least suitable host for this pest. According to Khan *et al*. (2012), who assessed the digestive amylolytic activity of *T. castaneum* larvae raised on various diets, the host plant, the artificial food, or both affected the activity and isoform patterns of -amylase. A similar positive response to the presence of cracked grains has been also reported for the population growth of the psocid *Liposcelis bostrychophila* Badonnel (Psocoptera: Liposcelididae) (Athanassiou *et al*. 2010), *T. castaneum* (Meagher *et al*. 1982), and the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) (Coleoptera: Laemophloeidae) (Throne and Culik, 1989).

Insect food has an effect on population expansion through influencing immature stage development as well as adult mortality, female fecundity, and egg production. For instance, *Tenebrio molitor* L. (Coleoptera: Tenebrionidae), a yellow mealworm, revealed in Morales-Ramos *et al.* (2010) that the food considerably affected the total developmental period, the number of instars, as well as the duration of most of the larval ages. It follows that the development of *T. castaneum* on rice bran is not surprising. Additionally, in our trials, *T. castaneum* developed more quickly on bran than on other diets, had longer elytra, and occasionally had higher body weights, which might be a sign of the bran's nutritional value. The fact that neonates exposed to rice flour nonetheless emerged as adults at almost the same percentages as those exposed to the other diets shows that *T. castaneum* can adapt to less-than-ideal diets despite the fact that development was delayed. Both entire and fractured kernels that had been ground were appropriate for development. The rate of development may have also been influenced by the texture of the rice flour. All of the aforementioned diets, with the possible exception of milled broken kernels, might be packaged and sold individually, indicating that they are all potentially susceptible to *T. castaneum* infestation at the retail level. Additionally, it's possible that these diets may collect in rice mill structures and machinery and serve as resources for *T. castaneum* infestations.

Despite the fact that *T. castaneum* was able to finish development on a variety of rice fractions, a slower growth rate can have adverse fitness impacts that are undetectable in a lab setting. The longer an immature's development period, the higher the risk of fatality may be. Adults that wait longer to mate will produce fewer offspring (Gerken and Campbell, 2018). Other research (Liu *et al*., 2004; Athanassiou *et al*., 2017) has demonstrated that various sub-optimal diets can significantly affect the net reproductive rates of pest species that attack stored products over a longer time frame. Even while *T. castaneum* may grow on less-than-ideal diets, the longer it takes for pupation and adult emergence eventually has an impact on expected population growth and may have pest-related effects in a food facility. By allowing treatments to be more efficient or substances like insect growth regulators to affect earlier developmental stages over a longer period of time, this longer developmental time may also boost the efficiency of pest management strategies.

## CONCLUSION

*Triolium castaneum* uses embryonic plasticity to adapt to the impacts of ingested nutritionally poor diet. In addition to this alteration in growth, insects also exhibit remarkable flexibility in the functioning of their digestive enzymes, which lowers any expenses associated with an unbalanced food intake. It is important to take into account the variety of amylolytic and proteolytic activity found in the gut of *T. castaneum*, as well as how easily they can be expressed in response to the calibre of the diet. For the purpose of choosing the proper inhibitors and their transgenic expression for insect resistance, it is also important to primarily study how insects react to proteinaceous inhibitors. The findings of this research will be extremely helpful in developing practical measures to combat this significant pest of stored goods and in understanding the systems that regulate. The findings of this study will be very helpful in developing effective defences against this significant pest of stored goods and in understanding the mechanisms that control the proper breakdown and absorption of proteins and carbs.

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## تفضيل الحبوب المخزونة لحشرة خنفساء الدقيق الصدئية *Tribolium castaneum* (Herbst)

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### الملخص

تم دراسه دورة حياة وفترات النمو ومعدل البقاء ومقياس النشاط لخنفساء الدقيق الصدئية على دقيق خمس انواع من الحبوب على درجة حرارة 30 ± 1م° ورطوبة نسبية 75 ± 5 % (12 ساعه إضاءة ) حيث يتم إجراء تجربتين منفصلتين لتقييم ( إختيارية – إجبارية التغذية ) .كان أعلى معدل بقاء لليرقات على حبوب القمح والشعير واقلها على حبوب الشوفان .علاوة على ذلك و كانت أعلى نسبة فقد في الحبوب عند تربية اليرقات على حبوب الشعير 8.8% ويليها حبوب القمح 8.4% وحبوب الذرة 7.2% . وكانت أطول فترة لحياة الحشرة الكاملة على حبوب الشوفان يليها حبوب القمح وذلك بمتوسط 235.2 ± 5.15 و 234.3 ± 5.16 يوما على التوالى .اشارت التجارب الإختيارية الى ان عدد الأفراد وعدد البيض الموضوع وعدد أفراد الجيل الاول ونسبة الفقد فى الحبوب كانت أعلى ما يكمن على حبوب القمح والشعير . وتؤدى نتائج هذه الدراسة الى إمكانية تطبيق برامج المكافحة المتكاملة لحماية جودة المخزونة ومنتجاتها الثانوية بالإضافة للتنبؤ بالعلاقة بين غلاف الطبقة الخارجية للحبوب وحساسيتها للإصابة الحشرية .