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RESEARCH ARTICLE

The Effect of Organic Food Consumption on Longevity and Healthspan in *Drosophila melanogaster*

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ABSTRACT: This study investigates the effects of consuming specific organic food items—bananas and sugar—on longevity and healthspan using *Drosophila melanogaster* as a model organism. Contrary to popular belief, fruit flies fed on organic banana pulp showed no significant difference in lifespan compared to those fed on conventional banana pulp. Surprisingly, flies fed conventional banana peels exhibited increased lifespan, possibly due to faster decay and enhanced yeast production. Similarly, experiments with organic sugar showed no lifespan differences. Healthspan metrics, including climbing ability and fecundity, showed no significant improvements with organic food consumption. When given a choice, fruit flies preferred conventional over organic food. These findings challenge assumptions about organic food benefits and emphasize the need for evidence-based evaluation of organic food consumption's impact on health and longevity.

KEYWORDS: Biomedical and Health Sciences, Nutrition and Natural Products, Organic food, Lifespan, *Drosophila*.

Introduction

Recently, as people's interest in health has increased, there has been much attention on organically grown foods. Organic food is defined as produce grown without or with minimal use of artificial chemicals. Non-organic food, on the other hand, is food grown using conventional farming methods that include the use of pesticides, chemical fertilizers, and antibiotics. The debate over the potential benefits of organic food encompasses a variety of issues, including dietary choices, environmental conservation, and food safety.

For starters, several meta-analyses and individual studies have reported that organic foods contain more antioxidants.[1-3] One large meta-analysis published in 2014, for example, found that organic produce had, on average, 20-40% higher levels of antioxidants than non-organic produce.[1] The study synthesized data from 343 existing studies and found that the concentration of antioxidant compounds, particularly polyphenols, tended to be higher in organic foods. This difference may stem from the nature of organic farming methods. Organic farming limits the use of chemical fertilizers and pesticides, and plants can produce more antioxidants by activating their natural defense mechanisms. For example, in non-organic farming, pests and diseases are suppressed with chemicals, whereas in organic farming, these stressors may contribute to the plants' increased production of antioxidants. However, there is controversy over whether differences in antioxidant content translate into actual health benefits, and more research is needed to determine whether higher antioxidant content can cause significant physiological changes in the human body or what the health effects are. So, while the research is consistent that organic foods have higher antioxidant content, more research is still needed to determine the actual health benefits.

In contrast, several studies have shown that there is no significant difference in nutrient content between organic and non-organic foods.[4,5] For example, a recent meta-analysis of 237 articles published over the past 45 years found that while organic foods may contain a slightly higher percentage of antioxidants, as mentioned before, they do not differ significantly in the content of essential nutrients such as vitamins and minerals.[4] These results have been consistently reported in subsequent studies, and the practical impact of nutritional differences between organic and non-organic foods on health appears to be limited.[6,7]

Because organic foods limit the use of chemical fertilizers and synthetic pesticides, they generally have lower levels of pesticide residues than non-organic foods.[8] Some studies have reported that children who consume organic food show significantly lower urinary concentrations of organophosphorus pesticides.[9] However, some argue that pesticides and insecticides have become more regulated and less harmful, suggesting that even pesticide-treated crops are acceptable as long as they are properly washed.[10,11] Research on the long-term health effects of pesticide residue levels is still lacking and needs further investigation.

Potential health benefits of eating organic foods include reduced allergic reactions, increased antioxidant content, and a lower risk of certain diseases, but these are based primarily on observational studies.[4] These benefits have not been consistently shown in rigorous studies, such as randomized controlled trials.[12,13] In addition, the positive health effects of consuming organic foods may be related to improved overall dietary habits or lifestyle changes.

Research on the effects of consuming organic foods on aging is very limited. A recent study reported that fruit flies fed an organic diet lived longer than those on a conventional diet; however, one limitation of this study was that some of the foods provided to the flies, such as potatoes and soybeans, were not part of their natural diet. Although Chhabra *et al*. also included bananas and employed a standardized preparation method by blending and autoclaving the produce with agarose,

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which effectively minimized confounding effects from decay or fermentation, this study instead used fresh banana pulp and peel to better reflect the flies' natural feeding conditions. Thus, the differences in methodology should be taken into account when comparing the two studies.[14] For example, fruit flies fed conventional soybeans had an average lifespan of only eight days. Therefore, in this study, the effects of organic banana and sugar consumption on longevity and healthspan were investigated in Drosophila to provide a model-based perspective on how specific organic foods influence aging. Fruit flies are an excellent animal model for aging studies, sharing over 70% of the proteins found in humans and exhibiting similar aging mechanisms, but have a shorter lifespan of 60 to 70 days.[15]

Methods

1. Drosophila Stock and Husbandry:

All experiments utilized wild-type Canton-S *Drosophila melanogaster*. Flies were maintained at 25°C and 65% relative humidity, following a 12-hour light and 12-hour dark cycle. To prevent overcrowding during larval development, approximately 150 eggs were seeded into 250 cm^3 fly bottles containing 25–30 mL of culture medium.[16] The standard larval diet consisted of cornmeal-sugar-yeast-agar medium, prepared with 5.2% cornmeal (Hansol Tech, Korea), 11% sugar (Hansol Tech, Korea), 2.5% yeast (Saf-instant, Lesaffre, France), 0.5% propionic acid (Junsei Chemical Co., Ltd., Japan), 0.04% methyl-4-hydroxybenzoate (Yakuri Pure Chemicals Co., Ltd., Japan), and 0.8% agar (Milyang Agar Co., Ltd., Korea).

2. Lifespan Assay:

Lifespan measurements were conducted using three independent cages per condition, each containing 100 flies separated by sex. Organic bananas were sourced from local retailers selling both organic and conventional produce. Bananas were stored in a refrigerator without washing until use, and the pulp and peel were separated with sterile instruments immediately before experimentation to minimize additional contamination. The flies' diet was refreshed with new medium every 2–3 days, during which dead flies were removed and recorded. Organic sugar (CJ, Korea) and conventional sugar (CJ, Korea) were obtained from the same manufacturer to minimize batch variation. The control condition was defined as flies maintained on the standard cornmeal–sugar–yeast–agar diet prepared with conventional sugar, while the experimental condition replaced the sugar component with certified organic sugar. Survival analyses were performed with JMP software (SAS Institute), using both the log-rank test and the Wilcoxon test to assess differences between groups.

3. Bacterial culture:

Microbial samples were harvested from the surfaces of banana peels by sterile swabbing. The bananas used for microbial sampling were the same specimens shown in Figure 3 and were also part of the batches used in the lifespan assays. Cultures were incubated at 37°C under constant shaking at 180 rpm to ensure aerobic growth and uniform bacterial expansion.

4. Measurement of climbing ability:

Males were fed either organic or conventional bananas for 7 days before assessing locomotor function through the rapid iterative negative geotaxis (RING) assay. Ten flies of the same sex were introduced into a climbing device and gently tapped down three times to trigger negative geotaxis. Their positions were recorded 4 seconds after the start of climbing, and the number of flies that surpassed a 4 cm mark was counted. Each experiment included 20 replicates and four independent trials per group, with statistical comparisons made using Student's t-test.

5. Measurement of fecundity:

To assess reproductive output, newly eclosed males and virgin females were collected separately every 3 hours. Virginity was confirmed by the absence of larvae after 24 hours in isolation. On the second day, mating pairs (2 males: 1 virgin female) were established in vials. Every 24 hours, flies were transferred to new vials containing fresh organic or conventional banana food, and the number of eggs laid per female was counted daily for 10 days. Each treatment included 20 replicate vials, and data were analyzed via t-test.

6. Preference test:

A choice assay was conducted by positioning two vials containing either organic or conventional food on opposite sides of a cage. Funnels made of filter paper were inserted into the vials to restrict fly movement to one-way entry. After a 4-hour starvation period, 100 flies were released into the cage, and the number of flies that entered each vial was counted after 30 minutes.

7. Statistical analysis:

Survival analyses were conducted using the standard survival model in JMP software, employing log-rank tests for survival data. Fecundity and locomotion data were analyzed through one-way ANOVA. Statistical significance was denoted in figures by asterisks ($^*p < 0.05$, $^{**}p < 0.001$) when compared to controls.

Results

1. Lifespan changes with organic food consumption:

In the first experiment, the pulp and peel of bananas were separated and provided to the fruit flies. It was deemed meaningful to separate the pulp from the peel, as the pulp is less affected by pesticides and is the part typically consumed by humans. When comparing the lifespan of fruit flies fed organic bananas to those fed conventional bananas, there was no significant difference between the two groups for both females and males. In males, the average lifespan of fruit flies fed organic bananas was 26.23±0.91 days, while that of those fed conventional bananas was 26.45±0.76 days (Figure 1, χ^2=0.0474, p=0.8277). For females, the average lifespan of fruit flies that consumed organic bananas was 37.01±1.54 days, compared to 36.24±1.61 days for those consuming conventional bananas (Figure 1, χ^2=0.0147, p=0.9036).

Unexpectedly, for the peel, the lifespan was longer in the conventional banana group for both males and females. In males, the average lifespan of fruit flies fed organic banana peels was 3.12±0.04 days, while those fed conventional banana peels lived an average of 14.19±0.57 days (Figure 2, χ^2=333.65, p<0.001). In females, the average lifespan of flies fed organic banana peels was 6.9±0.27 days, whereas those fed conventional banana peels lived 24.23±0.51 days (Figure 2, χ^2=272.18, p<0.001), representing a more than threefold difference in lifespan for both males and females.

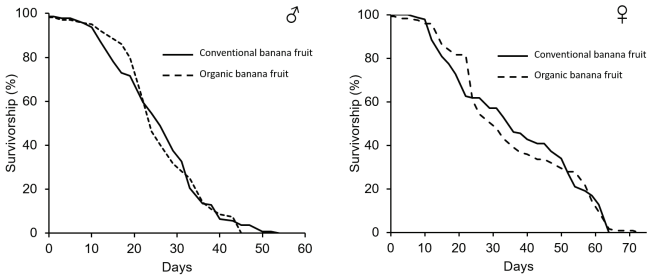

Figure 1: Lifespan of male (A) and female (B) fruit flies fed pulp from organic or conventional bananas. No significant differences were observed between groups in either sex.

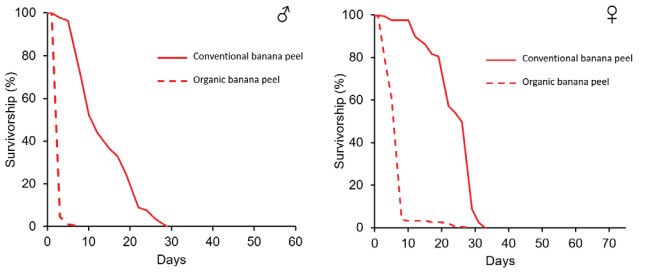

Figure 2: Lifespan of male (A) and female (B) fruit flies fed peel from organic or conventional bananas. The lifespan of flies fed conventional banana peel was longer than that of those fed organic banana peel in both sexes.

2. Difference in decay rate between organic and conventional bananas:

Based on the results above, it can be concluded that the pulp is nutritionally superior to the peel. A decrease in the lifespan of flies fed the peel from the conventional group was anticipated due to the presence of pesticides; however, the opposite result was observed. To investigate these unexpected outcomes, the decay rates of organic and conventional bananas were compared. The results indicated that the peel of conventional bananas decayed relatively faster than that of organic bananas (Figure 3), and the types and amounts of microorganisms cultured from the two groups were significantly different, confirming the nutritional disparity (Figure 4).

Figure 3: Representative images showing decay of organic (upper) and conventional (lower) bananas after 7 days at room temperature.

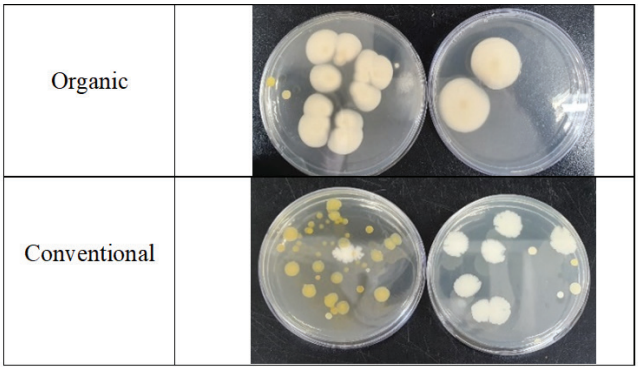

Figure 4: Microbial cultures isolated from the peels of organic (upper) and conventional (lower) bananas.

Since the primary energy source for fruit flies is the yeast produced during decay, conventional bananas likely provide more yeast than organic bananas. To eliminate the variable of nutritional differences between the two groups, the experiment was repeated using organic and conventional sugars—the Drosophila synthetic diet contains both yeast and sugar. Similar to the banana pulp experiment, no lifespan difference was found between the two groups (Figure 5, Male median lifespan, conventional 36.9±0.85 vs organic 37.4±0.91, p<0.5653; Female median lifespan, conventional 37.8±0.95 vs organic 37.2±1.02, p=0.4987). Compared to bananas, which may not provide the same nutrients due to various variables, sugar provides the same nutrients, and experiments using organic sugar yield more reliable results for confirming the hypothesis.

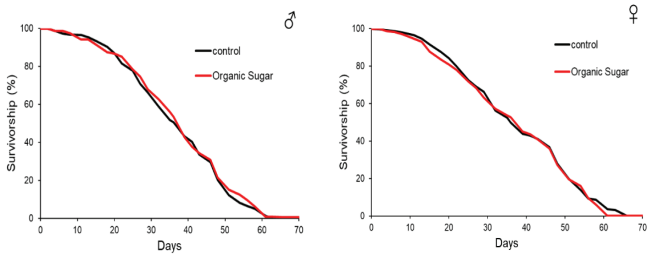

Figure 5: Lifespan of male (A) and female (B) fruit flies fed organic or conventional sugar diets. No significant difference was observed between groups.

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3. Healthspan changes with organic food consumption:

Fruit flies exhibit negative geotaxis behavior, which is an upward movement against gravity. This behavior decreases with age and is widely used as an indicator of healthy aging in fruit flies.[6,8] It is well known that many interventions that increase longevity also increase climbing ability.[6] Whether fruit fly motility changed with organic food consumption was tested, and no significant differences were found between the two groups (Figure 6).

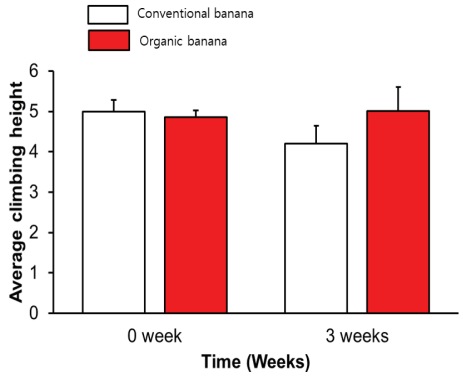

Figure 6: Climbing ability of male fruit flies fed organic or conventional banana pulp, measured at 1 week or after 3 weeks. No significant differences were observed between groups.

Fecundity in fruit flies decreases with age (reproductive senescence), and changes in this metric are commonly used as a marker of healthy aging.[6] When it was examined whether the fertility of fruit flies was affected by organic food consumption, a trend toward a decrease was observed in the group that consumed organic bananas, although this was not statistically significant (Figure 7).

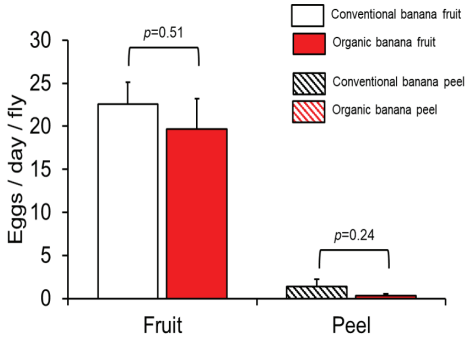

Figure 7: Fecundity of female flies fed organic or conventional banana pulp/peel. Egg production did not differ significantly between groups across 10 days.

4. Preference between organic and conventional bananas:

Human consumers choose food based on a combination of appearance, freshness, nutritional value, and taste. In contrast, animals select what and how much to eat based on a variety of interacting factors, such as nutritional requirements, satiety, reproductive status, food micronutrient composition, and the presence of defensive or toxic chemicals.[17] When fruit flies are given a choice between organic and conventional food, which do they prefer? Do they opt for conventional food due to its faster decay and higher nutritional value (Figure 3), or do they favor organic food because it has fewer preservatives and pesticide residues?

When fruit flies were presented with a choice between organic and conventional food, the majority chose conventional food (Figure 8). It can be concluded that fruit flies are more attracted to the yeast produced by the decay of conventional food than they are deterred by the preservatives or pesticides present in it. To the best of my knowledge, this is the first study to demonstrate that fruit flies prefer conventional bananas over organic ones, highlighting the balance they strike between toxicity and nutritional value in their food choices.

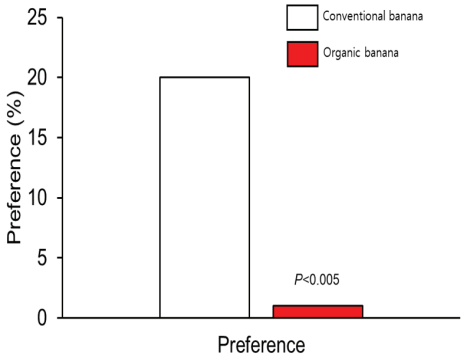

Figure 8: Food preference assay comparing organic and conventional bananas. A greater proportion of fruit flies entered vials containing conventional bananas, indicating a stronger attraction to conventional food sources.

Discussion

Using fruit flies as a model organism, this study aimed to investigate the effects of consuming specific organic foods—bananas and sugar—on lifespan and healthspan. The results provide insights into the impact of organic versus conventional food on the health and lifespan of fruit flies, challenging common assumptions about the benefits of organic food.

Contrary to popular belief, the study found no significant difference in lifespan between fruit flies fed organic banana pulp and those fed conventional banana pulp, suggesting that, at least for fruit flies, consuming organic food does not necessarily lead to increased lifespan. Unexpectedly, flies fed conventional banana peels exhibited a statistically significant increase in lifespan compared to those fed organic banana peels. This counterintuitive finding highlights the complexity of factors influencing lifespan and underscores the need for caution when making broad claims about the health benefits of organic foods.

The difference in lifespan observed in the peel experiment may be attributed to the faster decay of conventional banana peels, which enhances yeast production, a key food source for fruit flies. These findings emphasize the importance of considering both the nutritional content and microbial ecology of foods, rather than solely focusing on the presence or absence of pesticides, when assessing their health impacts. Differences in postharvest quality and decay in organic and conventional fruits may be linked to variations in the microbial community during storage, as demonstrated in a recent study.[18]

While the faster decay of conventional banana peel and subsequent yeast production likely explain the observed lifespan

extension, an alternative explanation should also be considered. Because *Drosophila* are routinely maintained on media containing preservatives such as nipagin (methyl-4-hydroxybenzoate) and propionic acid, flies may have developed long-term adaptation to such exogenous chemicals. This adaptation could potentially mitigate any harmful effects of pesticide residues present in conventional peel, thereby contributing to the improved survival observed in this group. Additionally, it is important to emphasize that banana peels are neither a typical component of the human diet nor a nutritionally adequate food source for fruit flies. The extremely short lifespan observed in the organic peel group (3–6 days) suggests that malnutrition or possible toxic effects, rather than intrinsic differences in peel quality, may have influenced the outcome. Thus, the peel feeding experiment should be interpreted with caution, and further studies using food sources that more closely reflect the natural diet of fruit flies are warranted.

Interestingly, when given a choice, fruit flies preferred conventional food over organic food. This preference may stem from the higher nutritional value of conventional food due to increased yeast production resulting from its faster decay. However, it should be emphasized that the preference assay provides only observational evidence, and the precise cause behind this behavior remains unclear. Because *Drosophila* is highly sensitive to volatile compounds such as ethanol and other fermentation byproducts, factors including scent profiles, microbial composition, and nutritional content may also have influenced the flies' choices. Future studies incorporating chemical analyses and detailed behavioral assays will be necessary to clarify the mechanisms driving this preference.

It is interesting to note that our results differ from those of Chhabra *et al*.[7] The previous study used food purchased from a Whole Foods Market and did not label the origin of the food. On the other hand, this study used bananas imported from the Philippines, and bananas imported into South Korea have strict pesticide standards, so there may be a difference in the amount of pesticides used in the conventional foods in the two studies. Bananas are one of the most consumed and traded fruits in the world, with 114 million tons produced in 2017, and are a highly pesticide-intensive crop. Many countries set maximum residue limits (MRLs) as a way to regulate the use of pesticides, which are typically expressed as the maximum concentration of a pesticide that can remain in food, expressed in mg/kg. These MRL values can vary from country to country, and in some cases can be quite different. For example, the MRL for the pesticide malathion in apples is 0.02 mg/kg in the United States and 8.0 mg/kg in the European Union, about 400 times higher.[19]

While this study provides valuable insights, there are several limitations. First, although fruit flies are a well-established model for studying aging, and many of the findings from fruit flies also apply to mammals[8] remains unclear to what extent these findings can be generalized to humans. Future research should explore similar issues in mammalian models. Second, this study primarily used bananas as the main food source and organic sugar as a secondary source. Expanding the range of foods to include organic yeast could provide a more comprehensive understanding of the impact of consuming organic foods; however, yeast was excluded from this study due to variations in quality and nutritional value among different food companies.

Conclusion

In conclusion, this study emphasizes the importance of an evidence-based approach when evaluating the health benefits of organic foods. While organic farming may offer environmental benefits and reduce pesticide use, its direct impact on longevity and healthspan may be less straightforward than commonly believed. Future research should aim to bridge the gap between these findings in fruit flies and their potential implications for human health.

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