The Offspring Number of *Drosophila melanogaster* Meigen Consuming Monosodium Glutamate for Two Generations

Anggun Risma Atika*, Ahmad Fauzi; *****
* Department of Biology Education, Universitas Negeri Malang
** Departement of Biology Education, Universitas Muhammadiyah Malang
*** Al Ya'lu Middle School

Article Info

Article history:

Received Jul 12th, 2017
Revised Aug 20th, 2017
Accepted Oct 26th, 2017

Keyword:

Drosophila melanogaster
flavor enhancer
food additive
monosodium glutamate
offspring number

ABSTRACT

Monosodium Glutamate (MSG) is one of the flavor enhancer that most commonly used in various foods but its safety is still in doubt. In this research, a study was conducted to examine the effects of MSG administration on offspring number of *Drosophila melanogaster* for two generations. *D. melanogaster* ♂ wild-type strain was crossed with ♀ wild-type strain in glass bottle were fed with two different concentrations of 2.0% and 2.5% of MSG. Along with treated, the control flies were also set up without MSG. Based on ANOVA result, F count concentration variable on offspring number was 25.159 with the p-value 0.000 < 0.05 and F count generation variable on offspring number was 14.095 with the p-value 0.001 < 0.05. Administration of 2.0% MSG caused the increasing of offspring number but at 2.5% level, MSG caused the decreasing of offspring number. Furthermore, first generation had a significantly higher offspring number than second generation. The result indicated there was an accumulation of negative impacts of MSG consumption in the second generation.

Corresponding Author:

Ahmad Fauzi,
Department of Biology Education
Universitas Muhammadiyah Malang,
Jl. Raya Tlogomas No. 246 Malang, East Java, indonesia, 65144
Email: fauizou91@gmail.com

1. INTRODUCTION

Many foods taste delicious because those foods often used flavor enhancer [1]. One of the best-known flavor enhancers is Monosodium Glutamate or MSG [1]. MSG is widely used as a flavor enhancer in various foods [1-3]. It has been used to enhance flavor since it was discovered in 1908 by Kikunae Ikeda, a chemistry professor in Tokyo [3]. This substance is practically odorless and may have either a slightly sweet or slightly salty taste [2]. This taste is better known as umami taste [4]. Umami is also known as savory taste that some people also describe as meaty or brothy [5].

Unfortunately MSG has often been the subject of controversy in the food industry [6]. MSG has been controversial since Dr. Robert Ho Man Kwok, a Chinese-American medical researcher, described adverse reactions reactions attributed to MSG-containing foods eaten in Chinese restaurants [7,8]. The adverse reaction includes numbness in the back and neck and heart palpitations [8]. These symptoms typically began about 15-20 minutes after the first dish was consumed and continued for about two hours [7]. Since this first report appeared, many other articles studying and reviewing the effect of MSG have been published.

Several articles have reported MSG may produce negative effects when given to both experimental animals and man. For example, MSG was reported induce kidney damage by oxidative stress [9]. MSG also causing disruptions and distortions of the cyto-architecture of the kidneys of Wistar rats [10]. Moreover, MSG toxic also may effects on central nervous system, adipose tissue, hepatic tissue and reproductive organs were shown in numerous animal studies [11].

On the other hand, some references state MSG is considered safe for adult [1]. Moreover, a eport from the Federation of American Societies for Experimental Biology (FASEB) concluded that MSG was safe for most people when eaten at customary levels [12]. Related to the potency of MSG for inducing oxidative damage, consuming antioxidant may have protective potential against oxidative stress induced by MSG [13]. In fact, there are reports that conclude dietary supplementation with up to 4 % MSG is safe and improves growth performance in post-weaning pigs [14].

Although there have been various reports related to the potency of MSG on health risk, in various countries, including Indonesia, daily foods often contain high concentrations of MSG. These foods are consumed every day and still eaten from one generation to the next. In this regard, no studies have examined the long term effects of consuming MSG for several generations. Therefore, in this study, the effect of MSG for several generations was observed. Fruit fly, *Drosophila melanogaster*, was choosen as model organism in this study. The short life cycle of fruit fly became one of the reason for choosing this organism [15,16].

2. RESEARCH METHOD

2.1. The organsim and environmental conditions

D. melanogaster wild-type strain from Genetic Laboratory FMIPA UM were used in this study. Flies were cultured in a 200 ml cylindrical glass bottle, with 7 cm diamater and 9 cm height, filled with 30 ml standard food, as described in Fauzi et al [17]. The flies cultures were kept in a research room at Genetic Laboratory FMIPA UM. When there were blackened pupae, the pupae were isolated into plastic tube with 1 cm diameter and 5 cm height. Adult flies that emerge from this plastic tube were using for crossbreeding at treatment stage.

2.2. Treatment stage

D. melanogaster ♂ wild-type strain was crossed with ♀ wild-type strain in glass bottle that the same size as cultured bottle, both of it 2 X 24 hours after hatching from pupae. For experiments, a pair of four replicates of *D. melanogaster* were fed with two different concentrations of 2.0% and 2.5% of MSG. Along with treated, the control flies were also set up without MSG. After 2 x 24 hours crossed, male fly was removed from the bottle. This study was conducted over two generations.

2.3. Data collection and analysis

The data of offspring number were obtained by recording the number of adult filial at each generation. Then, the data were calculated with two way ANOVA test at a significance level of 0.05 if normally distributed assumption were meet. Furthermore, LSD test performed when the ANOVA test result was significant. If normality assumption were not met, the data were calculated using Scheirer-Ray-Hare Test.

3. RESULTS AND ANALYSIS

Fig. 1 is the graphs show the average of offspring number in control and experimental group. Based on the graph, it can be seen that the offspring number appears differ at each difference MSG concentration and at each generation. In addition, first generation always had higher offspring number than second generation.

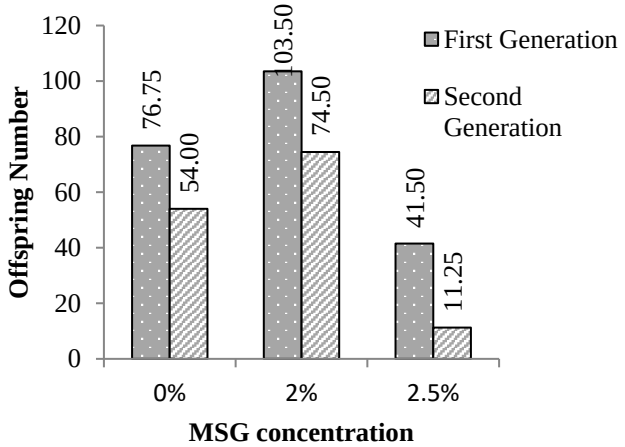

Figure 1. The average of offspring number in control and experimental group

The summary of ANOVA test on the nondisjunction frequency can be seen in Table 1. Based on ANOVA result, F count concentration variable on offspring number was 25.159 with the p-value 0.000 < 0.05. Thus, null hypothesis was rejected and research hypothesis states was accepted. Based on LSD result that can be see in Fig. 2., the 2.0% treatment had a significantly higher offspring number than the other groups and the 2.5% treatment was the lowest. An increasing of flies number at the 2.0% MSG treated indicated MSG at the concentration had no negative impact on fruit fly.

Table 1. Summary of ANOVA Test on Offspring Number of *D. melanogaster*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	20550.000[a]	5	4110.000	12.923	.000
Intercept	87121.500	1	87121.500	273.943	.000
Concentration	16002.750	2	8001.375	25.159	.000
Generation	4482.667	1	4482.667	14.095	.001
Concentration * Generation	64.583	2	32.292	.102	.904
Error	5724.500	18	318.028		
Total	113396.000	24			
Corrected Total	26274.500	23			

a. R Squared = .782 (Adjusted R Squared = .722)

Based on the results of this study, it can be seen that the presence of MSG can affect the number of flies. This is in agreement with the results or statement obtained by several authors who informed environmental variation may influence body condition and fecundity via nutritional effects resulting from variability in food type availability [18-20]. Then, at the 2.5% MSG treated, the number of flies significantly decrease. This result indicate at the level 2.5%, MSG had negative impact on fly. Similar results were reported recently in that report the addition of several food additives in the diet of Drosophila causing the decreasing of adult filial number of this flies [20].

The decreasing of flies number can be caused of the decreasing of fertility, fecundity, hatchability, and viability of flies. But, until now, there is still no researcher who reviewed the effect of MSG fecundity and fertility in Drosophila. However, some researchers have studied it in the other model organisms, such as in rat and mice. Administration of MSG in rat were reported causing reduction sperm cell count and sperm motility [21,22]. MSG also induced histological changes in the testes, both the germinal epithelium and Leydig cells were affected and there was fewer spermatogenic cell in many of seminiferous tubules Swiss Albino mice [23]. Moreover, MSG consumption is capable of causing impairment in male reproductive function an may probably be implicated in infertility via alteration in both semen characteristics and testes in Wistar rats [10].

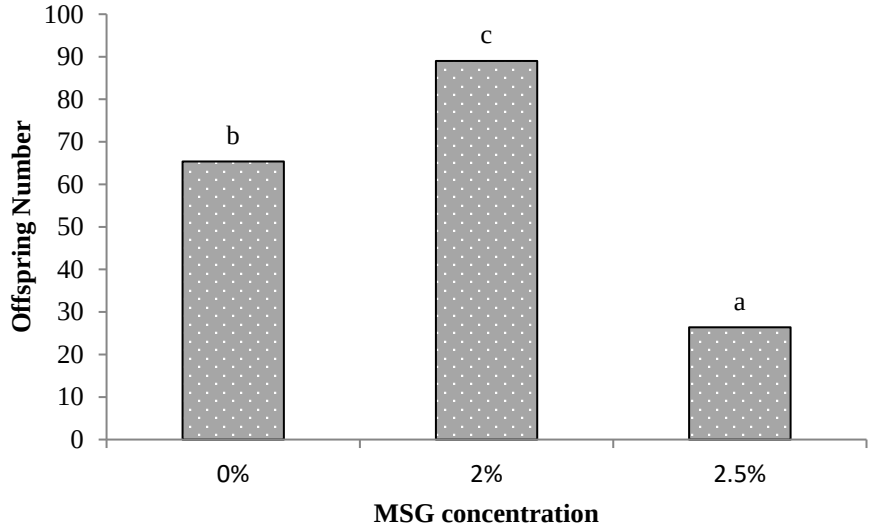

Figure 2. Summary of LSD test Concentration Variable on Offspring number of *D. melanogaster*

Not only in male, MSG administration but also affected female reproductivity. MSG was indicated induced considerable structural changes, including degeneration of follicles, oocytes, and medulla with vacuolas having congested blood vessels in the ovaries of Sprague-Dawley rats [24]. Moreover, MSG administration of MSG to adult wistar rats have been demonstrated causing cellular hypertrophy, degenerative and atrophic changes in adult Wistar rats ovaries [25]. MSG administration has also been reported decreasing hatcability and viability of Drosophila [20]. Both of it can also affect the filial number of flies.

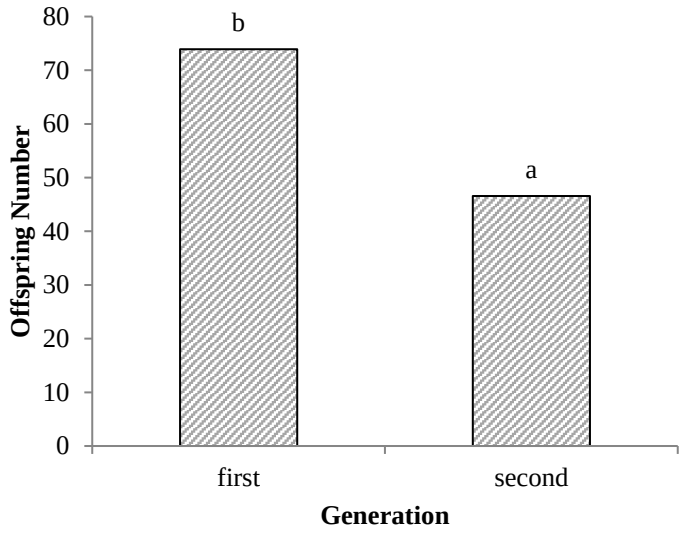

Figure 3. Summary of LSD test Generation Variable on Offspring Number of *D. melanogaster*

Based on ANOVA result in Table 1, F count generation variable on offspring number was 14.095 with the p-value 0.001 < 0.05. Thus, null hypothesis was rejected and research hypothesis states there were significant differences of offspring number in different generation was accepted. Based on LSD result that can be seen in Fig. 3., first generation had a significantly higher offspring number than second generation. This result is agreement with previous study reported the effects of MSG were less severe in F1 generation but much in F2 generation [26]. One reason is there is an accumulation of MSG in the second generation of the previous generation. Moreover, several study have reported that MSG act as mutagen [27]. So, in the present results, it suggests MSG might have caused a new mutation which is recessive in its action [26].

4. CONCLUSION

Result presented in current study indicate higher concentration of MSG administration, lower filial number of *D. melanogaster*. Furthermore, the effects of MSG were more severe in second generation of the previous generation. For further studies, it is recommended to add replication and treatment levels, studies using different model organisms, and using more generation to validate the findings of this study and to get more information about the effect of MSG on various organisms.

REFERENCES

[1] Whitney EN, Rolfes SR. Understanding Nutrition. Stamford: Cengage Learning; 2016. 648 p.
[2] Burdock GA. Fenaroli's Handbook of Flavor Ingredients, Fifth Edition. Boca Raton: CRC Press; 2005. 1339 p.
[3] Sardesai V. Introduction to Clinical Nutrition, Third Edition. Boca Raton: CRC Press; 2012. 529 p.
[4] Ziegler E, Ziegler H, editors. Flavourings: Production, Composition, Applications, Regulations. Weinheim: Wiley-VCH; 1998. 317 p.
[5] Centamore A. Tasting Wine and Cheese: An Insider's Guide to Mastering the Principles of Pairing. Beverly: Quarry Books, 2015. 14 p.
[6] Deshpande SS. Handbook of Food Toxicology. New York: Marcel Dekker, Inc; 2002. 269 p.
[7] Watson DH, editor. Food Chemical Safety: Additives. Cambridge: Woodhead Publishing Limited; 2003. 156 p.
[8] Myers RL. The 100 Most Important Chemical Compounds: A Reference Guide: A Reference Guide. Westport: Greenwood Press; 2007. 183 p.
[9] Sharma A. Monosodium glutamate-induced oxidative kidney damage and possible mechanisms: a mini-review. Journal of Biomedical Science [Internet]. 2015 Oct [cited 2017 June 23];22(93):1-6. Available from: https://jbiomedsci.biomedcentral.com/articles/10.1186/s12929-015-0192-5 DOI: 10.1186/s12929-015-0192-5

[10] Eweka AO, Om'Iniabohs FAE. Histological studies of the effecst of monosodium glutamate on the kidney of adult Wistar rats. Electron J Biomed [Internet]. 2008 May [cited 2017 June 23]. Available from: http://biomed.uninet.edu/2008/n2/eweka.html.
[11] Husarova V, Ostatnikova D. Monosodium Glutamate Toxic Effects and Their Implications for Human Intake: A Review. JMED Research [Internet]. 2013 Dec [cited 2017 June 23];2013(2013):1-12. Available from: www.talkingaboutthescience.com/studies/Husarova2013.pdf DOI: 10.5171/2013.608765
[12] DEvere R, Calvert M. Navigating Smell and Taste Disorders. New York: Demos Medical Publishing; 2011. 63 p.
[13] Darombi EO, Onyema OO, Farombi EO. Monosodium glutamate-induced oxidative damage and genotoxicity in the rat: modulatory role of vitamin C, vitamin E and quercetin. Human & Ekperimental Toxicology [Internet]. 2006 May [cited 2017 June 23];25(2006): 251-259. Available from: http://journals.sagepub.com/doi/pdf/10.1191/0960327106ht621oa DOI: 10.1191/0960327106ht621oa
[14] Rezael R, Knabe DA, Tekwe CD, Dahanayaka S, Ficken MD, Dielder E, et al. Dietary supplementation with monosodium glutamate is safe and improves growth performance in postweaning pigs. Amino acids [Internet]. 2012 Nov [cited 2017 June 23];44(3): 911-923. Available from: https://checkout.springer.com/checkout/cart?1&wt_mc=ThirdParty.SpringerLink.3.EPR653.AbstractPage_Article-new DOI: 10.1007/s00726-012-1420-x
[15] Jennings BH. Drosophila – a versatile model in biology & medicine. Materialstoday [Internet]. 2011 May [cited 2017 June 21]; 14(5): 190-195. Available from: http://www.sciencedirect.com/science/article/pii/S1369702111701134 DOI: 10.1016/S1369-7021(11)70113-4.
[16] Fauzi A, Corebima AD, Zubaidah S. The Utilization of Drosophila melanogaster as a Model Organism in Genetics I and Genetics II Courses in Faculty of Mathematics and Natural Science, State University of Malang. In: International Conference on Education and Training 2016 [Internet]; 2016 Nov 4-6; Malang; Faculty of Education, State University of Malang; 2016 [cited 2017 June 23]; p: 51-56. Available from: http://icet.fipum.com/wp-content/uploads/2017/03/PROCEEDINGS-2ND-ICET-BOOK-1-.pdf
[17] Fauzi A, Corebima AD, Zubaidah S. The Fluctuation of Adult Filial Number and Eclosion Time of Drosophila melanogaster that Exposed by Mobile Phone in Multiple Generations. In: the 6th Annual Basic Science International Conference [Internet]; 2016 March 2-3; Atria Hotel and Conference, Malang, Indonesia; Faculty of Mathematics & Sciences, Brawijaya University; 2016 June [cited 2017 June 23]; p: 124-128. Available from: http://basic.ub.ac.id/files/proceeding/PROCEEDINGS-BASIC-2016.pdf
[18] Simpson SJ, Casas J, editors. Advances in Insect Physiology: Locust Phase Polyphenism: An Update, volume 36. London: Academic Press; 2009. 84 p.
[19] Dempster JP, McLean IFG. Insect Populations In theory and in practice. Dordrecht: Springer Science+Business Media; 1998. 196.
[20] Neethu BK, Babu YR, Harini BP. Flavors supplemented in diet regulate the hatchability and viability in Drosophila. Dros. Inf. Serv [Internet]. 2014 [cited 2017 June 26];2013(2013):24-28. Available from: http://www.ou.edu/journals/dis/DIS97/Neethu%2024.pdf
[21] Igwebuike UM, Ochiogu IS, Ihedinihu BC, Ikokide JE, Idika IK: The effects of oral administration of monosodium glutamate (msg) on the testicular morphology and cauda epididymal sperm reserves of young and adult male rats. Veterinarski Arhiv. [Internet]. 2011 [cited 2017 June 26]; 81(4): 523-534. Available from: http://www-staro.vef.unizg.hr/vetarhiv/papers/2011-81-4-9.pdf
[22] Kadir RE, Omotoso GO, Balogun T, Oyewopo AO. Effects of Monosodium Glutamate on Semen Quality and the Cytoarchitecture of the Testis of Adult Wistar Rats. International Journal of Biomedical and Health Sciences [Internet]. 2011 March [cited 2017 June 26]; 7(1): 39-46. Available from: https://www.researchgate.net/profile/Olaiya_Omotoso/publication/256437842_Effects_of_Monosodium_Glutamate_on_Semen_Quality_and_the_Cytoarchitecture_of_the_Testis_of_Adult_Wistar_Rats/links/00b495228cef218970000000/Effects-of-Monosodium-Glutamate-on-Semen-Quality-and-the-Cytoarchitecture-of-the-Testis-of-Adult-Wistar-Rats.pdf?origin=publication_detail
[23] Das RS, Ghosh SK. Long term effects of monosodium glutamate on spermatogenesis following neonatal exposure in albino mice – a histological study. Nepal Med Coll J [Internet]. 2010 [cited 2017 June 26]; 12(3): 149-153. Available from: nmcth.edu/images/gallery/Editorial/I3kxErs_das.pdf
[24] Oladipo IC, Adebayo EA, Kuye OM. Effects of Monosodium Glutamate in Ovaries of Female Sprague-Dawley Rats. Int.J.Curr.Microbiol.App.Sci [Internet]. 2015 [cited 2017 June 26]; 4(5): 737-745. Available from: http://www.ijcmas.com
[25] Eweka AO, Om'Iniabohs FAE. Histological Studies of the Effects of Monosodium Glutamate on the Ovaries of Adult Wistar Rats. Ann Med Health Sci Res [Internet]. 2011 Jan[cited 2017 June 26]; 1(1): 37-43. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3507099/
[26] Sarfaraz S. Effects of Monosodium Glutamate on Drosophila melanogaster. LAP LAMBERT Academic Publishing; 2014.
[27] Ataseven N, Yuzbasnoglu D, Keskin AC, Unal F. Genotoxicity of monosodium glutamate. Food and Chemical Toxicology [Internet]. 2016 May [cited 2017 June 26]; 91: 8-18. Available from: https://www.ncbi.nlm.nih.gov/pubmed/26929995 DOI: 10.1016/j.fct.2016.02.021