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Formulation of Artificial Diet for Silkworm *Bombyx mori* L.

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Artificial diet (AD) refers to man-made food or non natural food prepared for consumption of any living being. Silkworm (*Bombyx mori* L.) being monophagous insect feed solely on mulberry leaves. Artificial diet encourages the rearing of silkworm throughout the year with less dependence on natural food. The formulation of artificial diet is a scientific process and requires detailed information about the nutrients required for successful growth and development of silkworm. The quantity and quality of each ingredient is measurable in artificial diet for long term preservation and utilization. The formulation of AD chiefly depends on feeding behavior of silkworms. Attracting factor, biting factor and swallowing factor depicts the feeding behavior of silkworms on artificial diet. Many ingredients including mulberry leaf powder, defatted soyabean powder, cellulose powder, vitamin C etc are added in specific amounts to prepare artificial diet for silkworm. The concept of artificial diet provides immense scope for chawki rearing of silkworms at commercial stage in addition to silkworm as biological model for other molecular and advanced studies.

Keywords: silkworm, artificial diet, formulation, biting factor, mulberry.

Introduction

Man made food or non-natural food for insects may be referred to as artificial diet (Grenier, 2012). The artificial diet for insects was first of all developed by E. Bogdanow in 1908 for rearing of blue bottle fly,*Calliphora vonitoria.* The artificial diet for blue bottle fly was prepared from meat extract, peptones, starch and mineral salts (Northrop, 1917; Piper, 2017). Silkworm (*Bombyx mori* L.) being monophagous insect, occupies a special place within insect species suitable for several scientific studies (Gautam et al., 2022). Mulberry leaves (*Morus* sp.) are the natural sole food source for silkworms (Qadir *et al.*, 2022; Li *et al.*, 2023). These leaves are palatable due to presence of volatile compounds (Chang *et al.*, 2021). The performance of silkworm and its productivity depends on the nutritional constituents of mulberry leaves. The nutritional quality of mulberry leaves is superior in spring season than in autumn (Rahmathulla, 2012). The other factors which influence the quality of nutritional quality of mulberry leaves are mulberry cultivar, maturity level of mulberry leaves and harvesting time of leaves (Yu *et al.*, 2018; Nayab *et al.*, 2020). Artificial diet possesses some remarkable property in terms of quality feed which is germ-free and non-season specific. Hence silkworms can be reared in any season on artificial diet (Saviane *et al.*, 2014). Since silkworms are most attractive towards fresh mulberry leaves, but the artificial diet is considered as pathogen-free when silkworms are particularly reared as biological model for bioreactor to produce recombinant proteins and for many diseases, genetic or silk biomaterial

studies (Paudel *et al.*, 2020). The rearing of the silkworm, *Bombyx mori*, on artificial diets was first achieved in 1960 (Horie, 1995). The practical application of artificial diets for silkworm rearing has saved a greater proportion of labour (Bhattacharyya*et al.*, 2016). The silkworm as a biological model in research is more accessible due to short gestation period, low-cost breeding, and does not require ethical approval (Aznar-Cervante *et al.*, 2021). This article is aimed to highlight the formulation of artificial diet for silkworm *B. mori*.

Prospects of artificial diet for silkworm

1. Mass rearing of silkworms
2. Rearing of silkworms throughout the year
3. Rearing of silkworm in controlled conditions
4. Less dependence on mulberry leaf
5. Low inputs are required for rearing
6. Mulberry production on larger scale can be lowered
7. Labour costs can be saved as artificial is supplied once in every 3-4 days
8. Less chances of disease outbreak as no material is taken from outside environment
9. Less chances of pathogen contamination
10. Easy to rear silkworm at any place, not particularly in any traditional sericultural area
11. Specialized rearing space is less required
12. Supplementation of feed with required quantity of particular nutrient.
13. Low cost production of silk
14. Small landless farmers can be encouraged to take up sericulture
15. Artificial diet can be used for rearing silkworm for laboratory studies including genome investigation, proteomic studies and systematic biology based researches.

Formulation

The mulberry chawki gardens were promulgated to meet all the nutritional requirements of young instar worms. It requires a lot of space, time, labour and maintenance of garden to achieve successful chawki rearing. Artificial diet was developed to overcome the issues pertaining to successful chawki rearing (Bhattacharya *et al.*, 2016). The formulation of artificial diet depends on the feeding behavior of silkworms. However feeding behavior of silkworms plays a great role in rearing of silkworms on artificial diet (Cappellozza *et al.*, 2005; Dong *et al.*, 2017). The feeding behavior of silkworms depends mainly on three factors (Song *et al.*, 2021).

a) **Attracting factor:** These attract silkworms on to the leaves. Alpha-hexanol, beta-hexanol, citral, linalyl acetate, linalol and terpenyactate have been identified as attractants.
b) **Biting factor:** These induce larvae to bite or chew the leaves. Biting factors identified are beta-sitosterol, isoquercitrin and morin.
c) **Swallowing factor:** These stimulate the swallowing of leaves followed by biting and chewing process. The swallowing factors have been identified as cellulose, sugar, inositol, silica and potassium phosphate (Hamamura, 1959)

The combinations of these factors have been found important for positive acceptance of food and factors have identified chemically. The first successful rearing of silkworm B. mori on artificial diet from hatching to spinning was carried out by Fukuda *et al.* (1960). The composition of artificial diet for mulberry silkworm is given in table 1. The addition of fresh leaf alcohol to fresh leaf aldehyde attracted *Bombyx mori* silkworm (Watanabe, 1958). Terpenes and esters were found to show the same action. The chlorogenic acid found in water soluble part of mulberry leaves (Yamada and Kato, 1966) and role of polyphenolic acid in growth of silkworm (Hamamura *et al.*, 1966) was reported. Ascorbic acid is usually added to

silkworm food (enrichment) in a quantity generally varying from 1–2% of the dry weight of the artificial diet, which is considered as optimum content of this vitamin (Ito, 1978). It is possible to eliminate ascorbic acid from the formulation of artificial diet, at least for fifth instar stage without affecting the production or larval (Cappellozza *et al*., 2005). The possibility of utilization of ammonia by the silkworm, *Bombyx mori*, is of interest in connection with the biological role of silk formation because the removal of silk glands from 3rd- or 4th-instar larvae elicited aminoacidaemia and most larvae died before pupation. Ammonium nitrogen is used by the silkworm, *Bombyx mori*, for silk production in the same manner as non-essential amino acids (Hirayama *et al.*, 1995). The artificial diet of silkworm in influenced by many nutritional, qualitative and quantitative factors including physical factors, pH, diet palatability and contaminants.

Table 1: Composition of artificial diet for silkworm *Bombyx mori*

Ingredient	Quantity (g)
Mulberry leaf powder	400
Defatted soyabean powder	200
Phytosterol	3
Sucrose	40
Cellulose powder	115
Corn starch	56
Citric acid	37
Vitamin C	10
Salt mixture	40
Sorbic acid potassium	2.40
Vitamin B mixture*	3.82
Agar powder	75
Soybean powder	13
Chloromycetin	0.15
Propionic acid	6 .00 ml
Distilled water	2.55 litre
Total	**995.37**

Figure 1: Feeding of silkworms on artificial diet (Roychodhury *et al.*, 2003)

Conclusion

Artificial diet has greater scope for the development of sericulture. The untimely rearing provision on a smaller space opens door of implementation of sericulture activity to small landless farmers as well. Artificial diet plays an important role while systematic biological studies including genetic and proteomic analysis throughout the year. It provides immense scope for silkworm as biological model for other molecular and advanced studies. Besides the implementation of artificial diet concept for sustainable development of sericulture, the artificial diet concept is quite fascinating when silkworm is studied as biological model for specific molecular and advanced studies.

References

1. Aznar-Cervantes, S.D., Monteagudo Santesteban, B., & Cenis, J.L. (2021). Products of sericulture and their hypoglycemic action evaluated by using the silkworm, *Bombyx mori* (Lepidoptera: Bombycidae), as a model. *Insects*, *12*, 1059.
2. Bhattacharyya, P., Jha, S., Mandal, P., & Ghosh, A. (2016). Artificial diet based silkworm rearing system-A review. *International Journal of Pure and Applied Biosciences*, *4*(6), 114-122.
3. Cappellozza, L., Cappellozza, S., Saviane, A. & Sbrenna, G. (2005). Artificial diet rearing system for the silkworm *Bombyx mori* (Lepidoptera: Bombycidae): effect of vitamin C deprivation on larval growth and cocoon production. *Applied Entomology and Zoology*, **40:** 405- 412.
4. Chang, B. Y., Koo, B. S., & Kim, S. Y. (2021). Pharmacological activities for Morus alba L., focusing on the immunostimulatory property from the fruit aqueous extract. *Foods*, *10*(8), 1966.
5. Dong, H.L., Zhang, S.X., Tao, H., Chen, Z.H., Li, X., Qiu, J.F., Cui, W.Z., Sima, Y.H., Cui, W.Z. & Xu, S.Q. (2017). Metabolomics differences between silkworms (Bombyx mori) reared on fresh mulberry (Morus) leaves or artificial diets. *Scientific reports*, *7*(1), p.10972.
6. Fukuda, T., Higuchi, Y., & Suto, M. (1960). Silkworm raising on artificial food. In *Verhandlungen: pt. 1. Symposium 1-2, 5-17* (p. 163). Organisationskomitee des XI. Internationalen Kongresses für Entomologie.
7. Gautam, M. P., Singh, D. K., Singh, S. N., Singh, S. P., Kumar, M., & Singh, S. (2022). A Review on Silkworm (Bombyx mori Linn.) An Economic Important Insect. In *Biological Forum–An International Journal* (Vol. 14, No. 4, pp. 482-491).
8. Grenier, S. (2012). Artificial rearing of entomophagous insects, with emphasis on nutrition and parasitoids-general outlines from personal experience. *Karaelmas Fen ve Mühendislik Dergisi*, *2*(2), 1-12.
9. Hamamura, Y. (1959). Food selection by silkworm larvae. *Nature*, *183*(4677), 1746-1747.
10. Hirayama, C., Kotaro, K. & Shinbo, H. (1995). Utilization of Ammonia as a Nitrogen Source in the Silkworm, *Bombyx mori. Journal of Insect Physiology,*, **42:** 983-988.
11. Horie, Y. (1995). Recent advances of nutritional physiology and artificial diet of the silkworm, Bombyx mori, in Japan. *Journal of Sericultural and Entomological Science*, *37*(2), 235-243.
12. Ito, T. (1978). Silkworm nutrition in the silkworm an important laboratory tool. Tazima, Y. (ed), Ko.Ltd. , Tokyo, 121- 157.
13. Li, J., Deng, J., Deng, X., Liu, L., & Zha, X. (2023). Metabonomic analysis of silkworm midgut reveals differences between the physiological effects of an artificial and mulberry leaf diet. *Insects*, *14*(4), 347.

14. Nayab, S., Razzaq, K., Ullah, S., Rajwana, I.A., Amin, M., Faried, H.N., Akhtar, G., Khan, A.S., Asghar, Z., Hassan, H. & Naz, A. (2020). Genotypes and harvest maturity influence the nutritional fruit quality of mulberry. *Scientia Horticulturae, 266*, 109311.
15. Northrop, J. H. (1917). The role of yeast in the nutrition of an insect (Drosophila). *Journal of Biological Chemistry*, *30*(2), 0181-7.
16. Paudel, A., Panthee, S., Hamamoto, H., & Sekimizu, K. (2020). A simple artificial diet available for research of silkworm disease models. *Drug Discoveries & Therapeutics*, *14(4)*, 177–180.
17. Piper, M. D. (2017). Using artificial diets to understand the nutritional physiology of Drosophila melanogaster. *Current Opinion in Insect Science*, *23*, 104-111.
18. Qadir, J., Sudan, N., Gupta, D., Dar, R.S., Singh, H. & Murali, S. (2022). Impact of high temperature during chawki stage on the biological and cocoon parameters of silkworm *Bombyx mori* L. *International Journal of Agricultural Sciences*, 14(12):12111-12113
19. Rahmathulla, V. K. (2012). Management of climatic factors for successful silkworm (Bombyx mori L.) crop and higher silk production: a review. *Psyche: A Journal of Entomology*, *2012*(1), 121234.
20. Roychodhury, N. (2003). Rearing performance of silkworm *Bombyx mori* on artificial diet. *Indian Journal of Entomology*, *65*(4):483-487.
21. Saviane, A., Toso, L., Righi, C., Pavanello, C., Crivellaro, V., & Cappellozza, S. (2014). Rearing of monovoltine strains of *Bombyx mori* by alternating artificial diet and mulberry leaf accelerates selection for higher food conversion efficiency and silk productivity. *Bulletin of Insectology*, *67(2)*, 167–174.
22. Song, W. T., Zhu, F. F., & Chen, K. P. (2021). The molecular mechanisms and factors affecting the feeding habits of silkworm (Lepidoptera: Bombyxidae). *Journal of Asia-Pacific Entomology*, *24*(4), 955-962.
23. Watanabe, T. (1958). Substances in mulberry leaves which attract silkworm larvae. *Nature*, **182:** 325-326.
24. Yamada, H. & Kato, Y. (1966).Chlorogenic acid as an indispensable component of the synthetic diet for the silkworm. *Pro Jap Acad.*, **42:** 399-403.
25. Yu, Y., Li, H., Zhang, B., Wang, J., Shi, X., Huang, J., Yang, J., Zhang, Y. & Deng, Z. (2018). Nutritional and functional components of mulberry leaves from different varieties: Evaluation of their potential as food materials. *International Journal of Food Properties*, *21*(1), 1495-1507.