Exploring Novel Superfoods: Cockroach Milk as a Potential Alternative to Traditional Mammalian Milk

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Introduction

The significance of natural products in our daily lives cannot be overstated, considering their pervasive presence and diverse applications. Among these, enriched food sources play a vital role in supplementing essential nutrients, constituting a complete dietary package. The term "superfood" is commonly associated with items rich in nutrients, proteins, and other crucial supplements. Mammalian milk, with its myriad bioactive components such as immunoglobulins, lactoferrin, and peptides, exemplifies the nutritional richness of traditional sources. The contemporary landscape witnesses the emergence of various superfoods, gradually carving out their place alongside conventional dietary staples.

A notable contender in this evolving scenario is cockroach milk, which presents itself as a potential superfood and a noteworthy alternative to traditional mammalian milk. The Pacific beetle cockroach, scientifically known as Diploptera punctata, exhibits unique characteristics, including viviparity - giving birth to live offspring. Intriguingly, this species possesses the capability to produce a milk-like substance containing protein crystals through specialized midgut epithelial secretions. This substance serves as a nutritive source for the cockroach's offspring's, raising the prospect of cockroach milk becoming a viable consumable in the near future.

As we contemplate the future of our diets, exploring unconventional yet nutrient-rich sources like cockroach milk opens doors to innovative possibilities. This research delves into the potential of cockroach milk as a superfood, considering its nutritional profile and the possibility of it becoming a mainstream alternative to traditional mammalian milk.

Cockroach milk asSuper food- Nutritional composition: The milk extracted from the cockroach species D. punctata exhibits a superior nutritional profile compared to conventional mammalian milk. It boasts abundant reserves of essential nutrients, including oleic acid, conjugated linoleic acid, omega-3 fatty acids, short-chain and medium-chain fatty acids, as well as a diverse array of vitamins and minerals. Notably, its composition comprises 45% protein, 5% amino acids, 25% carbohydrates, and 16 to 22% lipids. Analysis of maternal haemolymph revealed lower levels of sodium and chloride, coupled with higher levels of potassium.The lipid component of this cockroach milk includes phospholipids, cholesterol, and minor quantities of other lipids, alongside a protective waxy substance that envelops the embryos. The gut contents of embryos receiving secretory nourishment are rich in protein, present in both liquid and crystalline forms, with only trace amounts of carbohydrates(Ingram et al., 1977).

Pioneer works in Cockroach milk as super food:

1. Dr. Barbara Stay and her pioneer work on Diploptera punctata

During the 1970s, Barbara Stay, known as the "cockroach lady" from Iowa University, initiated research on protein-rich milk derived from the Pacific beetle cockroach. Her investigations delved into various aspects of milk secretion physiology, including the timing of milk appearance and its hormonal support, the developmental

stages and chemical composition of embryos, the mechanism behind protein secretion, and the influence of juvenile hormone on milk secretion along with its inhibition post-parturition.

2. Dr. Ramaswamy. S and his structure finding of cockroach milk crystals analysis

Despite being a rich source of proteins, the consumption of cockroach milk by humans remained largely unexplored until the early 2000s. Subsequently, the potential of milk crystals garnered attention, leading to comprehensive studies. Dr. Ramaswamy, S., with a discerning mindset, delved into the structural analysis of these milk crystals. Recent advancements in microcrystallography techniques, coupled with the emergence of X-ray free-electron lasers, facilitated the determination of diverse protein structures derived from crystals cultivated in cellulo.

The research presents an atomic resolution (1.2A°) crystal structure of heterogeneous milk proteins cultivated inside a living organism within their functional niche. The findings unveiled glycosylated proteins adopting a lipocalin fold, binding lipids and organizing into a densely packed crystalline lattice. Remarkably, a single crystal is estimated to contain over three times the energy of an equivalent mass of dairy milk. This distinctive storage form of nourishment for developing embryos provides continuous access to a comprehensive supply of nutrients.

Noteworthy is the high heterogeneity of crystalline cockroach-milk proteins concerning amino-acid sequence, glycosylation, and bound fatty-acid composition. These results showcase a unique instance of protein diversity within a single in vivo-grown crystal of a natural protein in its native environment, elucidated at atomic resolution(Banerjee et al., 2016).

Molecular mechanisms

The exploration of molecular mechanisms governing milk secretion involved a comprehensive approach, incorporating combined RNA-seq analysis, RNA interference, and various assays to delineate molecular and physiological alterations. Comparative assessments across four stages of the female reproductive cycle and between males unveiled distinct gene expression profiles specific to each stage and sex. Among the differentially regulated transcripts of significance were the well-recognized family of milk proteins and transcripts linked to juvenile hormone metabolism(Jennings et al., 2020).

Conclusion

Historical laboratory analyses indicate that cockroach milk is exceptionally nutritious, offering abundant carbohydrates, fats, vitamins, minerals, proteins, and all nine essential amino acids. Furthermore, it is free of lactose. Despite its impressive nutritional profile, limited research has been conducted on cockroach milk, and its commercial availability seems unlikely at present. Consequently, it cannot currently be endorsed as a non-dairy milk alternative. Nevertheless, the future may hold different possibilities and outcomes.

References

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