Salt an EssentiaLNutrient: Advances in UnderstandinG Salt Taste DetectiOn UsinG *Drosophila* as a MOdeLSYstem

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ABSTRACT: Taste modalities are conserved in insects and mammals. Sweet gustatory signals evoke attractive behaviors while bitter gustatory information drive aversive behaviors. Salt (NaCl) is an essential nutrient required for various physiological processes, including electrolyte homeostasis, neuronal activity, nutrient absorption, and muscle contraction. Not only mammals, even in *Drosophila* melanogaster, the detection of NaCl induces two different behaviors: Low concentrations of NaCl act as an attractant, whereas high concentrations act as repellant. The fruit fly is an excellent model system for studying the underlying mechanisms of salt taste due to its relatively simple neuroanatomical organization of the brain and peripheral taste system, the availability of powerful genetic tools and transgenic strains. In this review, we have revisited the literature and the information provided by various laboratories using invertebrate model system *Drosophila* that has helped us to understand NaCl salt taste so far. We hope that this compiled information from *Drosophila* will be of general significance and interest for forthcoming studies of the structure, function, and behavioral role of NaCl-sensitive (low and high concentrations) gustatory circuitry for understanding NaCl salt taste in all animals.

KEYWORDS: Taste, *Drosophila melanogaster*, neural circuits, salt, gustatory neurons, brain

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Introduction

Dietary sodium is consumed as a common salt—sodium chloride (NaCl). Sodium, which is present in dietary table salt, is an essential nutrient required for many physiological processes including electrolyte homeostasis, nutrition absorption, maintenance of cell plasma volume, acid-base balance, transmission of nerve impulses, and normal cell physiology. Sodium contributes to the establishment of the membrane potential of most cells and plays a direct role in the action potential required for the transmission of nerve impulses and muscle contraction.

Sodium is a mineral that occurs naturally in foods like flour, mushrooms, celery, beets, and milk and is added in ionized form to table salt (40% sodium and 60% chloride). Packaged and prepared foods like canned soups and frozen eatery items often have added salt during their processing as a measure of preservation. The presence of salt makes food more palatable than the same food with no salt. According to World Health Organization (WHO) details, people in various parts of the world are consuming too much salt in their diets—on an average 9 to 12 g/d which is much more than WHO salt intake guidelines (less than 1500 mg/d, ie, 0.75 teaspoon—3.75 g/d should be consumed). Shown by many groups, extreme intake of salt results in various health issues and causes hypertension, strokes, stomach cancer, osteoporosis, autoimmune diseases, kidney stone, water retention, and bone weakening. Lack of dietary salt intake is also associated with health problems like low blood pressure. Hence, an appropriate amount of salt should be consumed for proper functioning of our body parts and to live longer and healthier.

It is ironic that despite the high incidence of cardiovascular diseases, stroke, elevated blood pressure, and high hypertension-related mortality, we currently do not fully understand the molecular and cellular mechanisms by which low and/or high salt concentrations are perceived or differentially encoded throughout peripheral tissues and in the brain. Furthermore, it is not clear how low or high salt dietary salt intake influences complex feeding behaviors. More research is required in this direction.

This review highlights the studies within *Drosophila melanogaster* that have begun to shed light on the mechanisms of salt detection, how salt influences feeding behaviors, and the influence of salt on other physiological functions. The findings from these studies hold potential to help us understand similar mechanisms that exist in higher order species and may therefore lead to the identification of targetable pathways in human disease.

Drosophila Taste System

Food palatability, or how food tastes, is the main driving factor for initiating a bout of feeding. Like mammals, insects can detect and discriminate among different gustatory stimuli, such as sugars, bitter substances, and various salt concentrations, which induce an attractive or a repulsive response in behavioral tests. Gustatory signals have been shown to play vital roles in controlling behavior, such as searching for food or finding sexual partners.[1] *Drosophila* is among the most highly studied genetic model systems for investigating feeding behaviors and peripheral and central taste coding. A total of 60 genes in the gustatory receptor (GR) gene family encode 68 receptor proteins.[2-4] A number of studies within the past decade have focused on understanding the molecular and cellular mechanism by which different taste modalities (i.e. sweet, bitter, water, salt) are perceived in *Drosophila*. The response