

# Considerations in Selecting Sugars for Feeding to Honey Bees

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## Abstract

Sugars which poison honey bees, and impurities in commercial sugars which are harmful are discussed. There is no sugar better than pure sucrose.

Cost is a primary consideration in agricultural feeds. But, the sweetness of cheapness can be quickly forgotten with a bitter taste of the short-comings of a cheap product. High costs of table sugar (sucrose) and a good market for honey prompted beekeepers to test cheaper bee feeds. Some substitutes for table sugar were consistently disappointing; others were successful. The factors limiting the effectiveness of carbohydrates in bee nutrition are not explainable with trademarks; they need to be better understood. Certain sugars, which are nutritious to mammals, can poison honey bees. Considerations of toxins in sugars should provide insight into some problems of honey bee nutrition.

Sugars which poison bees when fed at low levels in sucrose syrup include galactose, arabinose, xylose, melibiose, mannose, raffinose, stachyose, and lactose (Barker and Lehner, 1974b; Barker 1976a). Pectin, agar, and many gums are toxic or can hydrolyze to toxic sugars. On the other hand, glucose, fructose, maltose, sucrose, melezitose, and trehalose are safe and nutritious. The reasons some sugars are poisonous at low dosages are unknown; conflicting theories have been published. Even important biochemical processes which produce honey from nectar remain cloaked in ignorance.

Honey, which is mostly fructose and glucose, did not sustain caged worker bees as long as did sucrose syrup (Barker and Lehner, 1973). Nevertheless, many beekeepers consider honey to be an ideal food for bees in spite of the risks of spreading disease with it. Consequently, table sugar that has been hydrolyzed to invert syrup containing glucose and fructose is often fed to bees. Justification for this practice is not based upon nutritional data but on an assumption that hydrolysis aids digestion. Syrups are convenient to feed, and hydrolysis reduces granulations in syrup. Also, robbing may be less of a problem with inverted sugar because glucose and fructose become less attractive than sucrose when bees reach foraging age (Barker and Lehner, 1974c). Although the inverted sugar tastes sweeter to man, it is no more attractive than sucrose to bees.

Recently, high fructose syrups produced by enzymatic fermentation of corn starch (Aschengreen, 1975) have become available at a lower cost than sucrose. Except for minor differences in salts (Shallenberger et al., 1975) and major differences in flavors, these syrups are chemically indistinguishable from honey. High fructose corn syrup was fed to caged bees by Bland (1975), Floyd E. Moeller of Madison, WI (personal communication), and by Barker and Lehner (unpublished) without adverse effects but with no survival advantage over sucrose.

Doull (1974) fed 3 syrups produced by hydrolysis of wheat starch. These invert syrups were detrimental to bees in confinement. Doull suspected undigested polysaccharides, particularly starch, to be harmful. He obtained better results with sucrose than with his invert syrups.

"Formose," a sugar mixture synthesized from formaldehyde, caused growth inhibition and death of worker bees (Mizuno et al., 1973).

Refined beet and cane sugar are pure sucrose and, of course, are safe and nutritionally equivalent. Unrefined sugars have poisoned bees. The toxic factors in molasses and in brown sugars have not been identified. Bailey (1966) found that semi-refined cane sugar was harmless but that semi-refined beet

sugar decreased the life of bees. So, impurities in his unrefined beet sugar must be toxic. Crude beet sugar may be toxic because of pectins or galactosides in it (Barker, 1976a). Bailey also found that 8-year-old honey had dysenteric effects much like poisonous sugars: an absorption peak matching hydroxymethyl furfural correlated with toxicity of old honey and of acid-hydrolyzed syrups. Recent tests (Jachimowicz and El Sherbiny 1975; Barker 1976b) show that hydroxymethyl furfural can be toxic when fed in glucose plus fructose at dosages found in some samples of acid-hydrolyzed or heated syrup and old or heated honey.

Sugar refuse such as mill sweepings or surplus candy sometimes furnishes an inexpensive source of sucrose, but salt or flour in it may be harmful. Piskovoi et al. (1964) found that common table salt, sodium chloride, in levels as low as 0.125% in sugar syrup, caused dysentery and mortality in caged bees. Bees in overwintering colonies with honey stores containing 0.35 to 1.16% salt were dying prematurely. Refuse high in flour or dextrins, when added to water, ferments and kills bees. The toxicity should be influenced by the microorganisms which happen to be present. Toxicity of flour and of dextrins is sometimes attributed to indigestibility and compaction in the rectum of bees. This seems unreasonable. We routinely feed powdered cellulose without harm to caged bees. Furthermore, many pollen walls are indigestible but harmless.

Sugars which have poisoned bees are acceptable in rations if they are sufficiently diluted with sucrose. Bailey demonstrated that his samples of acid-inverted sugars had no deleterious effect when diluted 8 to 1 with sucrose. Honey and nectars contain traces of toxic sugars such as raffinose, mannose, and galactose (Percival 1961; Siddiqui, 1970). Sublethal levels of these sugars in pollen, honey, or nectar could modify effects of sugars in supplementary diets. Conversely, generous stores of safe sugars could dilute toxins in supplemental feeds. We agree with the ancient philosopher, Paracelsus, who admonished that poisoning is a consequence of quantity, not substance. "Toxic" simply means too much.

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