FRASS newsletter

Insect Rearing Group

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Gelling Agents for Insect Diet: From Mush to Medium

N.C. Leppla

In recent DSIR Biological Industries Group Newsletter, I noticed an article entitled "Science, Technology, and Imagination — A Fable by Roderigo. It described an enterprising technician in New Zealand who found that the stems of kiwi fruit trees are composed of about 20% gum or mucilage. This mucilage has properties similar to commercial imported gums such as sodium alginate. After one or two false starts and inferior brews, when vagrant yeasts and bacteria tried to make the mucilage into wine, they ended up with about 100g of the world's first pure commercially available kiwi fruit mucilage. Armed with the romance of kiwi fruit and visions of commercial success, the Nightly Prunings Laboratories Ltd. got underway. Their product, "Sylk with genuine kiwi fruit mucilage" was sent to the Dervish Jellybaby Company. Perhaps some day the jellybaby company will actually order some!

Polysaccharides

What are these mucilages, gums, thickeners, or "gelling agents" we encounter in nature? Primarily they are carbohydrates such as monosaccharides, polysaccharides, and mucopolysaccharides but they also include mucopeptides, proteins, and fatty acids in some cases. The overwhelming majority of carbohydrates in nature exist as polysaccharides, high molecular weight molecules that hydrolyze to yield monosaccharides. The most common of these are D-glucose, D-mannose, D- and L-galactose, D-xylose, L-arabinose as well as glucuronic, galacturonic, and mannuronic acids.

Cellulose is the most abundant polysaccharide, comprising more than 50% of all carbon in vegetation. Cotton for example, is at least 90% pure cellulose. Hydrolysis of cellulose yields glucose and partial hydrolysis yields cellobiose.

Cellulose is the structural plant polysaccharide and starch is the nutritional reservoir. There are two general types of starch, amylose and amlopectin.

Glycogen is the animal counterpart of the starch, found primarily in liver and muscle. Glycogen granules in cells are much smaller than those of plant starch. Like amlose and amlopectin, glycogen hydrolyzes to glucose.

Commercial Gelling Agents

Now that we have refreshed our memories concerning polysaccharides, we can discuss the sources and characteristics of commerical gelling agents. The most common source of industrial gums is seaweed or more specifically, marine algae. There are only about 30 species of "higher plants" in the oceans but there are many thousands of species of algae.

Agar

Agar is a complex polysaccharide extracted from agarocytes of *Gelidium* sp. and other Rhodophyceae species found primarily in the Pacific and Indian Oceans and the Sea of Japan. Agar can be separated into a neutral gelling fraction, agarose and a sulfated non-gelling fraction, agaropectin. It is soluble in hot water and 1% forms a stiff gell upon cooling.

Agar's use in biology apparently began with the wife of one of Koch's students, W. Hess, in 1881. She suggested substituting 1.5 to 3.0% agar, used for making jelly, for gelatin. As we know, from that day on agar became the standard gelling agent for bacterial media.

Carrageenan

Carrageenan is a galactan obtained by extracting the Rhodophyceae, *Chondrus crispus* and *Gigartina stellata* or *mammillosa* found mostlty in the North Atlantic from Norway to North Africa. Galactan is a complex mixture of polysaccharides composed of both 3,6 anhydro-D-galactose and sulfated D-galactose chains with molecular weights of several thousand. It causes agglomeration of milk proteins, so it is especially useful in milk products. Marine colloids produces a carrageenan called Gelcarin GP812 that is soluble in cold water, and unlike agar can be premixed with diet ingredients. Incidently, the curious word "carrageenan" comes from the Irish coastal town of Carragheen.

Calcium and Sodium Alginate

Algin is a polysaccharide extract of giant kelp, *Macroystis pyrifera* and other Phaeophyceae. This seaweed may grow up to 2 feet per day in the Pacific waters of North and South America, New Zealand, and Australia. This prodigious growth rate produces 4 cuttings per year.

In Europe the word kelp actually means the ash of seaweed from which soda was derived in the 18th and 19th centuries for glazing pottery, and manufacturing glass and soap. Kelco started commercial production of algin in 1929. Alginates are largely copolymers made of mannuronic, guluronic acid, and mannuronic and guluronic acid blocks occurring in the same molecule.

Kelco produces a variety of "Kelgins" that are soluble in cold or hot water. Algenic acid absorbs 200 to 300 times its weight in water and forms gells so strong they are used to make artificial ivory.

Locust Bean Gum

Locust bean gum is made from the endosperms of seeds removed from carob tree pods, *Ceratonia siligua* (Leguminosae). Carob seed was used by the ancient Arabs as a unit of weight called a karat, today's carat of precious stones. Carob fruit has been immortalized in the Bible as the food of St. John the Baptist. The Egyptians used carob paste to coat the strips used to bind mummies. The Greeks used the fruit as medicines. The beans have been used extensively for curing tobacco and for roasting as a coffee substitute.

General Mills (Henkel Corp.) has a locust bean gum product called Supercol 903. A 1% solution heated to 185° for 10 minutes and cooled to 77° has a viscosity of 2400 cps (centipoises). One of the special uses for locust bean gum is in oil and other types of drilling. It controls the collodial properties of the clay/water mixture.

Guar Gum

Guar gum is the ground endosperms of *Cyanopsis tetragonolobus,* an annual, pod-bearing legume. The guar plant was introduced into the U.S. in the early 1900s from India and Pakistan, where it is used as animal feed. Commercial production of guar gum was originally intended to replace locust bean gum but these galactomnnans have different properties. Guar gum has been particularly useful for reconstituting tobacco and waterproofing explosives.

Xanthan Gum

Xanthan gum is derived from the bacterium, *Xanthomonas campestris.* It is a polysaccharide composed mostly of D-glucose, D-mannose, D-glucuronic acid and pyruvate.

Xanthan gum is an exocellular product, a cell wall coating presumably used by the bacterium to survive dessicating conditions. The polysaccharide in unique to the so-called procaryotic algae (blue green) and bacteria characterized by having nondistinct nuclei. Because of their nonmitotic cell replication, they are referred to collectively as schizophytes. Blue green algae are not used as a principle source of gelling polysaccharides because they are less abundant than the brown and red forms. *Xanthomonas* bacteria, however, provide a virtually unlimited source.

Kelco built a $37 million fermentation plant in Okmulge, Oklahoma to produce Xanthan and other biogums. They market a food grade xanthan gum, Keltrol, and an industrial grade, Kelzan. These products dissolve in cold water and form gells in the presence of metallic salts.

Starch Graft Polymer — SGP

Starch graft polymer (SGP) is a combination of starch and petrochemical polymers. Corn starch, amylopectin, is grafted with acrylonitrile, the material used to make acrylic fiber and synthetic rubber. SGP is a hydrophilic polymer that absorbs 80 to 100 times its weight in water within 30 seconds.

ARS Chemists developed a process that General Mills uses to produce a starch graft polymer called "Super Slurper". It can be used to coat seeds, prevent soil erosion, fight fires, and absorb chemical spills.

Application for Gelling Agents in Insect Rearing

Commercial gelling agents have been useful in the development of insect diets but they are too expensive and the supply too undependable for mass rearing. Unfortunately for Roderigo and his kiwi fruit mucilage our best option for the future is to use less exotic plant starch.

The FRASS Newsletter is published bi-annually by the Insect Rearing Group, which is composed of over 600 scientists involved in insect rearing in 27 countries. Comments, information, requests, articles, etc. are invited. This issue is brought to you by the FMC Corporation, Agricultural Chemical Group. Edited by Dennis R. Edwards, FMC Corporation, Box 8, Princeton, NJ 08540. (609) 452-2300.

FRASS Editors

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1980	R.E. Wheeler, Chevron Corporation
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1982	Not Published
1983	Not Published
1984	Not Published
1985	D.R. Edwards, FMC Corporation

"Call for Papers"

The 1985 Insect Rearing Formal Conference will be held in Hollywood, Florida. Your suggestions regarding specific topics, titles and/or speakers are welcome. Send ideas to this year's moderator:

William Schultz
USDA Western Regional Research Center
800 Buchanan Street
Albany, CA 94710
(415) 486-3380

Titles, including brief descriptions must be received by April 30. Papers accepted for the formal conference will be submitted by W. Schultz to ESA. Those papers not accepted for the conference will have to be submitted to ESA by the author.

Conversion Table

10^{-12} dillies	=	1 picodilly
2 tribes	=	1 diatribe
10 cards	=	1 deccacards
1/10 yell	=	1 decibel
3 unicorns	=	1 triceratops
2×10^{6} pinpricks	=	1 MHz (megahertz)
1 mentality	=	100 centimentality
3 camp beds	=	1 tricot
18^{18} microfishe	=	1 whale
10^{9} antics	=	1 gigantic
10^{-12} surprises	=	1 picoboo

(an a kiloboo is enough to scare you to death!)

From "Chemical and Engineering News"

Arthropod Cultures

FRASS is compiling an updated register of arthropod cultures. Your input is imperative. Please send a list of your colonies, including order, genus, species and common name along with your name, address and phone number, by July, to:

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The Polycorder Monitors Screw Worm Environment

By Susan Smith
Omnidata International Inc.

Reprinted with permission from
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Deep in southern Mexico, in the town of Tuxtla Gutierrez, a unique facility produces 2 billion sterile flies monthly. It's the rearing facility of the Mexican-American Screw Worm Eradication Commission, a joint effort of the U.S. Department of Agriculture and its Mexican equivalent SAHR. Omnidata recently designed and installed an environmental monitoring and alarm system for their growth rooms.

Project Background

The screw worm is the flesh eating larva of the screw worm fly, whose natural habitat ranges from the southern U.S. through Mexico, Central America, and South America. Infesting the wounds of warm-blooded animals, the worm can itself be deadly, or it can render the animal vulnerable to other killing diseases. Potentially harmful to humans, the worm's greatest economic impact falls on the livestock industry. Prior to the inception of the eradication project, it is estimated that the combined cost of losses and control measures was three to four hundred million dollars per year.

A technique for eradicating the screw worm was originally developed in the 1950s in the United States and was later successfully applied in the southeast and southwest regions of this country.

The eradication technology consists of releasing great numbers of sterile flies over a specified area. As sterile male flies compete with fertile natural flies over generations, the population is reduced and finally wiped out. Once the fly has been eradicated in an area, a barrier zone between the eradicated area and non-eradicated areas must be maintained to prevent reinfestation.

As the screw worm knows no political boundaries, a cooperative effort between the U.S. and Mexico was necessary to extend the eradication zone across the border. In the mid-1970s, an international agreement was signed establishing the Mexican-American Screw Worm Eradication Commission. By 1976, under the joint sponsorship of the U.S. and Mexico, the fly rearing facility at Tuxtla Gutierrez was established.

Description of Operations

The plant is responsible for producing 500 million flies weekly. In the main rearing area, eggs are carefully incubated. When the larvae hatch, they are moved to trays lined with cotton soaked in a nutrient-rich brew of blood and milk derivatives. When the larvae mature, they crawl off the trays and fall to the floor, following an instinct which in the natural setting would find them in the soil where they would pupate. At the plant, the pupae are irradiated to ensure their sterility.

Next, the pupae are transferred in bulk to release centers throughout Mexico. There they are placed in cardboard boxes and allowed to emerge as adult flies. Airplanes distribute the flies by dropping the cardboard containers throughout the countryside.

The New Strains Facility

A secondary rearing plant is dedicated to development of new genetic strains and produced 30 million flies each week. This production area is divided into eight separate rooms reflecting eight distinct life cycle stages. A batch of eggs that starts out in the incubation room stays together as a batch, progressing from room to room as they mature.

For their new strains facility, the commission wanted a monitoring system that could tell them the temperature and relative humidity in any of the eight rooms at any given time. These are apparently the two most important environmental parameters affecting the development of the screw worms. They also wanted to keep track of the growing degree hours experienced by each batch at each station.

Workers must exchange their street clothes for work uniforms before they enter the rearing facility, then change and shower before leaving the area. Since simply getting in and out was so time-consuming, it was desirable to have the monitor operable from one central control site outside the plant. The monitor was to alert the operator if temperature or relative humidity got out of the predetermined optimum range, or if a batch was overdue to be moved to the next room.

For research purposes, the commission also wanted three portable environmental monitoring systems to collect a variety of parameters. These systems would have to be fairly flexible, for the commission expected that as data was analyzed and they learned more, they might change sampling rates, locations of sensors, and even types of data collected.

Polycorders Fit the System Design

The system designed by Omnidata consists of an IBM XT data acquisition system connected to eight Polycorders. While the operator uses a keyboard and video display to request information, the printer supplies hard copies of the data. A second control station provides backup in case of hardware malfunctions.

Polycorders are ideally suited for the on-site data gathering in several respects, and the manner in which they were implemented illustrates the usefulness of many Polycorder features.

One Polycorder was set up in each of the eight rearing rooms. One relative humidity sensor and up to nine temperature probes are connected to each unit. The Polycorder scans the sensors and records data in the autolog mode. That is, without any operator present, the Polycorder can read the sensors and save the data at ten-minute intervals around the clock.

Each batch of flies is identified with a bar code tag. Whenever a worker brings a batch into one of the growth rooms, he scans the tag with the bar code wand. The Polycorder saves the batch identification number and the time of day. The time of day later serves as a basis for computing growing degree hours on the central computer.

The system design also employs the Polycorder's ring line. An unattended Polycorder can be interrupted for special functions by raising the voltage on pin 22 of the serial I/O connector. When the ring line is activated, the Polycorder looks in its directory for a file called "RING" and executes it. This is how the control computer is able to get the Polycorder's attention when it wants to display the current humidity and temperature from the room or when it wants to collect data.

Data transmission to the central computer is done under program control. Although the Polycorder's Modes 2 and 3 are most commonly used to transmit or load big blocks of data, the Polycorder can send messages or single lines of data under program control. A protocol was established between the control computers and the Polycorders so the computer can ask for data in different forms.

Thanks to the Polycorder's versatility, the commission could purchase Polycorders to serve both as the stationary loggers and the portable data collection units. The overhead associated with maintaining two different types of equipment was minimized, and the portable, research-oriented Polycorders serve as backups for the more crucial stationary, production-oriented Polycorders.

Control Station

The central control computer is programmed to interrogate the Polycorders a number of different ways. With database management techniques, the computer can offer several different types of reports to the operator. The operator can view the current temperature and humidity in each room. This report includes warning messages if conditions are out of range. He may ask for a list of every batch presently in the plant, along with its current location and total growing degree hours. He may look at the history of any particular batch, including the growing degree hours in each room and the maximum and minimum temperatures and humidity experienced by the batch. Similarly, he can look at the history of conditions in any particular room.

The fly rearing rooms at Tuxtla Gutierrez represent a unique application for the Polycorder. As components of an integrated information system, they offer scientists both real-time data for making operational decisions and record-keeping capabilities for increasing their knowledge of the screw worm phenology. In addition, the system saves time and labor as it eliminates the need for human intervention while monitoring.

For information on this system contact:

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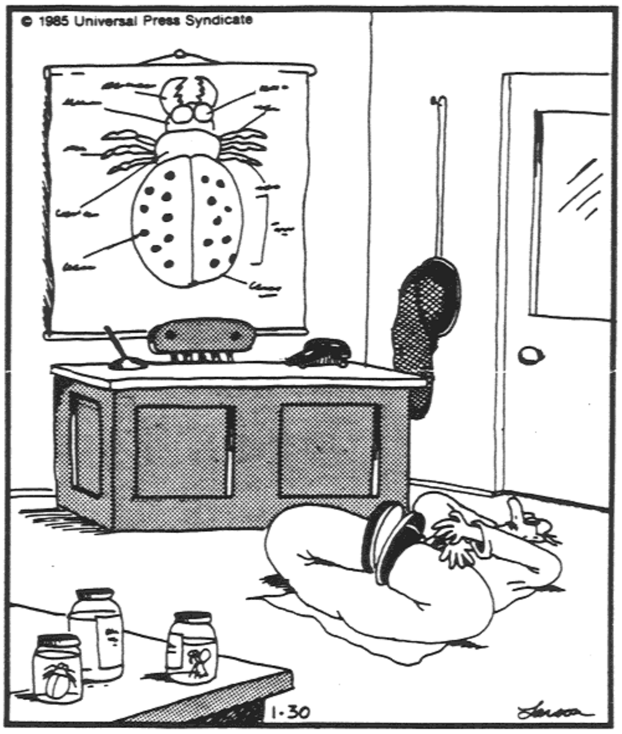
THE FAR SIDE By GARY LARSON



How entomologists pass away

IMPORTANT NOTICE!

Because FRASS has not been published for three years, the mailing list has become antiquated. It will be purged after this issue. In order to be on the mailing list you must return your name and address to:

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