FoodTrack

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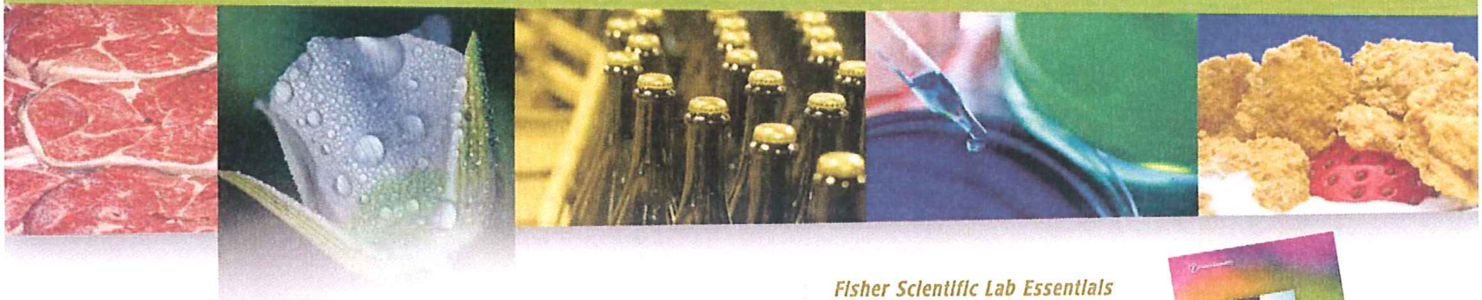

HIGHLIGHTS

- *Really* counting calories, using a "bomb" from IKA
- QA with the same bug every time—lyophilized microorganisms from MicroBioLogics
- Beyond moisture content—the critical importance of water activity in food safety

Measuring Calories in Food: the Bomb Calorimeter

IKA®

By Kai-Oliver Linde, IKA-Works, Inc.

Did you ever wonder how the "calories" on your favorite food labels are determined? How did they know that seven pretzels equate to 130 calories, or that one cup of herbal tea will cost you two calories? There are actually a number of different ways to calculate the amount of calories in food.

Measuring Calories

The most commonly used method for food labeling is to determine the amount of each component in the food (i.e., proteins, fats, carbohydrates, alcohol, organic acids) and add up the amounts of energy for each component. One of the main procedures to calculate these values, the "4-9-4 Method," was developed by Professor W.O. Atwater. Further, more detailed information about this procedure can be found at the U.S. Department of Agriculture Web site, **www.usda.gov**.

The concept itself is simple, but how do we know the amount of energy or the number of calories contained in each component? To answer that question, we will begin by defining "calorie." Short and sweet: one calorie is the amount of heat needed to increase the temperature of 1kg (or 1L) of water from 14.5°C to 15.5°C. With the help of a bomb calorimeter, the actual amount of energy produced by food if oxidized (burned) completely can be measured.

What is a Bomb Calorimeter?

Derived from the Latin terms calor meaning "heat" and metron meaning "measure," a calorimeter is simply an instrument used to measure the heat of something. There are many different types of calorimeters available on the market. IKA manufactures the so-called "bomb" or "combustion" calorimeter. Other types of calorimeters include Solution Calorimeters, Differential Scanning Calorimeters (DSC), Titration Calorimeters, Gas Calorimeters and Reaction Calorimeters.

> A bomb calorimeter is used to measure the heat created by a sample burned under an oxygen atmosphere in a closed vessel.

A bomb calorimeter is used to measure the heat created by a sample burned under an oxygen atmosphere in a closed vessel (bomb), which is surrounded by water, under controlled conditions. The measurement result is called the Combustion-, Calorific- or BTU-value. (BTU-value is more common in the U.S.A.) **Note:** The term "bomb" is misleading, but it is the most commonly used description for this kind of equipment. We will use the term "decomposition vessel" instead of bomb from this point on.

The Combustion Process

About 1g of solid or liquid matter (food) is weighed in a crucible and placed inside a stainless-steel container (the "decomposition vessel") filled with 30 bar (435psi) of oxygen. Next, the sample is ignited through a cotton thread connected to an ignition wire inside the decomposition vessel and burned (combusted).

During combustion, the core temperature in the crucible can rise up to 1000°C (1800°F), and the pressure rises for a short period of time to approximately 200 bar (2900psi), or sometimes even higher. All organic matter is burned under these conditions, and oxidized. Inorganic matter (minerals) will be oxidized; often, even vitrification takes place. The heat created during the burning process can be determined in different ways.

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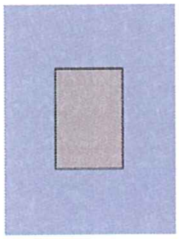

Figure 1

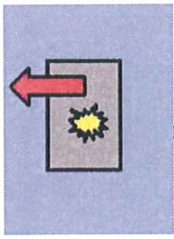

Figure 2

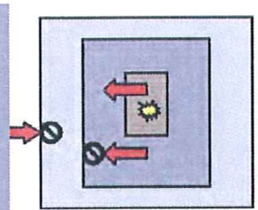

Figure 3

(Figure 1) A vessel filled with water (inner vessel) surrounds the decomposition vessel.

(Figure 2) The heat created by the combustion process is transferred into the surrounding water.

(Figure 3) To ensure that the heat created during combustion does not get out of the system or heat gets into the system from the environment (room temperature changes), another water-filled outer vessel is used as insulation.

To measure the temperature inside the water, very sensitive, high-resolution temperature sensors are used.

Decomposition vessels, can be operated in a variety of different modes. The "adiabatic," "isoperibol," "isotherm," or "dynamic" modes are the most common. These modes describe the working principles of the calorimeter in terms of the temperature control between the inner and outer vessel surrounding the decomposition vessel.

Physical and Physiological Calorific Value

After calibrating the decomposition vessel with a substance of a known heat, we know how much heat is necessary to heat up the water by 1°C. After that, the food will be burned and the unit displays the amount of energy inside the food sample in units of calories, J, or BTU per gram. This is the physical calorific value. All elements that compose the food are burned/oxidized. Hydrogen to water, carbon to carbon dioxide, nitrogen will react to nitric acid, minerals will be oxidized, etc.

Some food samples burn better inside the calorimeter than others. (In fact, some burn too fast!) It is sometimes necessary to determine the best possible application in order to optimize and control the burning process. Therefore a variety of methods and combustion aids can be used, including pressing pellets, PE-bags, acetobutyrate, gelatin capsules, combustible crucibles, etc.

Since your body does not burn food in exactly the same way as the decomposition vessel, the result measured is higher than the reality. The body does not digest certain components like fibers, and we also need a certain quantity of energy to actually digest the food. Other parts are transferred into fat and stored inside our bodies. Hence, it is a far more complex process. Additionally, some of us have to work out hard to actually burn some calories, while others have such a well-running metabolism that they seem to burn the food on the spot, as they eat it.

In order to get the physiological calorific value of the food burned inside the calorimeter, further corrections are necessary. With animal food, for example, scientists measure the food (input), and the animal's feces and urine (output) to determine how effective certain types of food are for the animal. In this manner, food can be optimized for better results.

For more information on bomb calorimeters, visit **www.oxygenbombcalorimeter.com**. See **www.fishersci.com** for IKA products such as catalog number **14-505-131**.