
Thomas H. Bradley
Associate Professor
Department of Mechanical Engineering,
Colorado State University,
Fort Collins, CO 80523

Christopher L. Melby
Professor
Department of Food Science and Human Nutrition,
Colorado State University,
Fort Collins, CO 80523

Wong’s article seeks to model the energy balance of humans inclusive of both sensible and oxidative energy content of food with the objective of finding means to modify the human energy balance and reduce obesity [1]. The author proposes that the temperature at which foods and beverages are consumed can make a significant contribution to whole body energy balance, and the temperature of foodstuffs can be manipulated to minimize risk for either positive or negative energy balance. He indicates that this important concept has been neglected in conventional nutritional science. With the current epidemic of obesity and associated disease sequelae, researchers in the field can appreciate the importance of exploring novel approaches to its prevention and treatment. However, the conclusion that sensible heat in foods can be a source of significant energy input to the human diet must be discounted due to unit conversion errors and some general misunderstandings of human heat balance, thermoregulation, and energy metabolism.

The energy in food is measured by and communicated to the general public through a metric of its oxidative energy content. The traditional way of measuring the energy content of foodstuffs is to use a “bomb calorimeter” in which the heat produced when a sample of food is combusted (under high pressure of oxygen) is measured. The total heat liberated (expressed in kilocalories or kilojoules) represents the gross energy value or heat of combustion of the food [2,3]. However, the net value of any food is not based on its gross energy value, but rather its availability for use in the body, which takes into account digestibility and cellular access to the food’s organic molecules, i.e., carbohydrates, fats, and proteins that undergo oxidative metabolism. In the article, Wong does not differentiate between the units of food calories (equal to 1 kcal) and the units of small calories (equal to 1 cal) [4]. With this correction, the 10,100 cal of sensible heat that is available to the human body from 500 g of soup is approximately 10% of the 98,000 cal of oxidative energy content available in the same soup and is less than 0.3% of 2,800,000 cal of gross energy of food required per day. In the example carried through to the article’s conclusion, to gain 600 kcal from the sensible heat in the food, the human body would have to consume 28 liters of hot tea per day. So, although sensible heat in food is a component of the well-established understanding of human energy balance [5,6], its effect is 1000 times smaller than is described by Wong.

As speculated upon in the article, the human body does indeed have many mechanisms to reduce its core temperature when the body is heated by ingestion of hot food or to increase its core temperature when the body is cooled by ingestion of cold food. Whether by perspiration, dilation, or constriction of peripheral blood vessels or shivering, the body is actively acting out a variety of heat generation and heat transfer mechanisms to maintain a homeostatic core body temperature [5,6]. Actuating these mechanisms causes metabolism to increase from the basal metabolic rate when the core temperature of the body cannot be maintained. These effects have been measured due to changes in ambient temperature [7], clothing type [8], or ingestion of cold or hot water [9,10]. The high sensitivity of the body’s thermoregulatory control system means that the ingestion of hot or cold water causes a small change to the body’s abdomen temperature (on the order 0.01–0.1°C [11,12]), resulting in large thermo-effector responses and active feedback control of the body’s core temperature [13]. The human thermoregulation system is sensitive because the metabolic costs of changes in body temperature are high [14]. By definition, the absorption of sensible heat involves a change in temperature. So, although Wong’s first law analysis is correct that sensible heat is a component of human energy balance, the body’s ability to absorb sensible heat from food is limited because the action of the human thermoregulation system serves to stabilize core body temperature.

Next, Wong suggests that a person who increases the amount of sensible energy consumed would displace an equivalent amount of oxidative energy, leading to satiation under energetic imbalance and therefore weight loss. He suggests that consumption of hot foods and drinks could reduce the energy intake requirements for an average male from 2800 to 2200 kcal without creating a metabolic energy imbalance. According to this logic, the sensible energy of the food and beverages would reduce the body’s daily energy expenditure by obviating the need to oxidize carbohydrates, lipids, and proteins to generate 600 kcal of heat necessary to maintain body temperature. This hypothetical mechanism is not supported by the literature on animal metabolism. In fact, the consumption of either cold or hot foods requires oxidative energy to bring the food to body temperature [9]. Although the effect is relatively negligible in humans (due to the very small fraction of food energy that is sensible heat, as indicated earlier), it can be significant in other organisms. For example, hummingbirds eat four times their body weight per day in nectar that can be at ambient temperatures of 5°C. Under these conditions, the energy required to warm this volume of nectar can lead to a ~2% weight loss per day [15,16]. When the human body’s mechanisms of thermoregulation are saturated, the sensible heat of food or drink will play a more sizeable or measurable role in energy balance [17,18]. For example, exercising humans can reduce their bodies’ core temperature by ingesting cold drinks, and hypothermia can be treated with warm drinks (although again, the effects are insignificant when compared to daily energy expenditure) [19].

Any article claiming to instigate reform of the U.S. Department of Agriculture, U.S. Department of Health and Human Services, and “conventional nutritional science” should be held to special scrutiny. Wong’s article does not present credible recommendations due to unit errors, a simplified analysis, and general misunderstanding of the role of sensible heat, metabolism, and thermoregulation in the energy balance of humans.

References


