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Increased Energy/Reduced Digestion

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Synonyms

Net energy gain

Definition

The role of cooking in increasing energy uptake from the diet as well as reducing the body's costs of digestion.

Introduction

Cooking food is a unique human activity spanning across all cultures, and humans appear to be evolutionarily adapted to this crucial aspect of their diet (Wrangham and Conklin-Brittain 2003). The value of cooking lies in its ability to widen the range of foods that are safe to eat (whether by making their digestion easier or neutralizing toxic compounds) as well as extract more energy from the foods ingested. Both human and animal studies illustrate that the more cooked food there is in a diet, the greater the net energy gain for the eater (Carmody and Wrangham 2009), and a diet of raw foods is energetically inadequate even when various nonthermal processing methods are employed (Koebnick et al. 1999). The effect of cooking on the energy gain from eating includes several mechanisms: increasing digestibility and thus caloric value of ingested foods, lowering the body's energetic costs of digesting, and mounting an immune defense against food pathogens.

Cooking: Digestion Costs

Eating requires the body to use energy: ingesting and assimilating a meal leads to an increase in the metabolic expenditure – termed diet-induced thermogenesis or DIT – that accounts for about 10% of the total energy budget for those of us on a Western diet (Westerterp 2004). DIT increases with masticatory effort, thus softer foods that require less chewing lead to lower metabolic expenditures. Cooking is expected to lower DIT by reducing the structural integrity of foods (Carmody and Wrangham 2009), though no mammal studies have tested this hypothesis. Only one study with pythons provides direct support, where a cooked meat diet resulted in a 13% decrease of digestion costs compared to the raw meat version (Boback et al. 2007). Since nonthermal processing methods – such as using tools to pound or grind foods – would also make food less firm (thus facilitating chewing and lowering digestion costs), some suggest that cooking was not a

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necessary part of ancestral diets as tool use could have increased energetic intake without the need for fire (Cornélio et al. 2016).

Net Energy Gain: Starches

Energy increase from cooked starches is well-known, as heat improves digestibility of such foods in two ways: it causes a collapse of the structures of raw starch granules (termed gelatinization – a process that increases starch degradation in the digestive tract) and it denatures enzyme inhibitors present in the foods leading to better digestion of starches in the human mouth and gut (Svihus et al. 2005).

In order to compare the net energy gain resulting from cooking as opposed to nonthermal processing methods, Carmody et al. (2011) put mice, a model omnivorous mammal, on three versions of a starchy diet – raw, pounded, and cooked sweet potato. A number of studies have already shown that cooking substantially increases digestibility of starchy foods – from 6% to 206% depending on the food item (Carmody and Wrangham 2009). Carmody and colleagues, however, also demonstrate that the effects of cooking specifically exceed the effects of pounding: while mice maintain their weight on the cooked version of the diet, they lose weight on both the raw and pounded versions. In addition, they preferred cooked sweet potatoes the most, after having tasted the raw, pounded, and cooked variations. Since mice were hungry following a fast, the authors suggest that higher preference for the cooked version was partly due to its energetic advantages.

Net Energy Gain: Fats

Cooking also appears to increase caloric gain of dietary lipids: Groopman et al. (2015) show that for cooked peanuts, lipid digestibility as well as net caloric gain (measured by body mass increases of mice) significantly exceeds that of raw peanuts. In addition, their results indicate that non-thermally processed (blended) peanuts do not lead to increased lipid digestibility or net energy gain. Cooking appears to "predigest" oil bodies (structures where peanuts store their lipids), because heat mimics the disruptive effects of a digestive enzyme peptin on the proteins that protect lipids from digestion.

Net Energy Gain: Meat

The effect of cooking on animal foods has been less clear. On the one hand, some consequences of heat processing should increase meat's energy value, such as heat-induced protein denaturation: as heat unwinds proteins, it increases their susceptibility to protein-digesting enzymes in the small intestine. Other positive effects include compromised structural integrity of cooked meat (heat gelatinizes collagen and makes separation of muscle fibers easier) and deactivation of foodborne microbes (thus, lowering the body's energetic costs of an immune defense). On the other hand, dry heat methods result in caloric loss due to fat dripping, and protein digestibility can be reduced due to the Maillard reaction – chemical reaction during cooking responsible for the appetizing flavors and aromas of cooked foods. These flavors increase meat palatability and attract not only humans but also great apes (e.g., chimpanzees, gorillas) that spontaneously prefer cooked meat samples to raw ones (Wobber et al. 2008). Thus, while the Maillard reaction might decrease protein digestibility in some ways, it may increase the amount of meat eaten due to increased palatability.

Carmody et al. (2011) test cooked and raw meat diets on mice, once again contrasting the effects of cooking with a nonthermal alternative – pounding. Authors predicted weight loss on all three versions – raw, cooked, and pounded – since a 100% meat diet is not expected to be beneficial for an omnivorous species. While mice did lose weight on all three, only cooking (and not pounding) had a positive effect on energy gain as mice on the cooked version experienced the least body mass loss. Considering that intake on the cooked version was in fact lower than on the pounded diet, the higher energy gain with cooked meat is intriguing. This result can be attributed to decreased effort required for chewing as well as improved digestibility through heat's denaturation of proteins. Denaturation results in unwinding of proteins from their tight structures, making them more susceptible to digestive enzymes in the small intestine. This process increases the proportion of protein digested by the eater in the small intestine, compared to that digested by the gut bacteria in the large intestine – this is important for the animal's net energy gain, because very little energy is returned to the consumer from the microbial fermentation of protein.

Another potentially important mechanism behind the increased energy gain from cooked meat is the decrease in meat pathogens, which lowers the metabolic cost of an immune defense. Such cost can be substantial, as fever alone can increase resting energy expenditure by up to 13% for each degree celsius increase in body temperature.

Carmody and Wrangham (2009) calculate that, without customary cooking, the cost of bacterial infections for a US consumer would be substantial, as one would be expected to fall ill 42 times per year from foodborne bacteria in meat. The annual cost of immune upregulation due to fever would be almost 7 years worth of basal metabolism versus less than 1 day when customary cooking is employed. Thus, incidence of foodborne illness from meat eating is 99.98% lower due to cooking.

The ability of thermal processing to kill pathogens could have played an important role for early hominins, as some scholars propose that scavenging was the main strategy of obtaining meat in our evolutionary past (Smith et al. 2015). Considering that scavenged meat would likely accumulate pathogenic bacteria, it would have been a costly strategy before the adoption of cooking. Smith et al. (2015) examine bacterial loads on meat and bone marrow, demonstrating that open-flame roasting is highly effective at reducing bacteria or entirely eliminating it. Thus, a simple cooking method available to early humans – roasting over an open flame – would have decreased the risks associated with meat ingestion, facilitating increasing amounts of this high-quality food in the human diet.

Conclusion

Cooking leads to an increased caloric value of foods in several ways: by lowering the body's metabolic cost of digesting through decreased chewing effort; increasing digestibility of foods rich in starches, lipids, and possibly proteins; and reducing the metabolic cost of producing an immune defense against foodborne bacteria. These factors point to cooking as an evolutionarily important behavior, as increases in energy can be expected to have important effects on human evolution (e.g., expansion of the brain due to the rise in the energy value of the diet). This potential significance of cooking in our evolutionary past is challenged by alternative nonthermal processing methods: using tools to pound the foods also reduces their firmness, aiding in digestion. However, work with modern raw foodists, who heavily process their foods without heat, reveals caloric insufficiencies of even such high-quality diets. In addition, animal studies contrasting cooking and nonthermal alternatives show significant net energy increase only with cooking, demonstrating that tool use can not match the effectiveness of heat in increasing energetic intake from eating.

Cross-References

▶ Brain Evolution Resulting From Cooking

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