# Negligible effect of cooking on nutritional value of Hadza tubers

Stephanie Schnorr[1], Koen Venema[2], Alyssa Crittenden[3], Frank Marlowe[4], and Amanda Henry[1]

1. Plant foods in hominin dietary ecology research group, Max Planck Institute for Evolutionary Anthropology; 2. Department of Pharmacokinetics & Human Studies, TNO Healthy Living; 3. Department of Anthropology, University of Nevada, Las Vegas; 4. Division of Biological Anthropology, University of Cambridge

## How much nutrition can humans obtain from wild plant foods and to what extent is cooking necessary in making these nutrients available during digestion?

Resource acquisition strategies of hunter gatherers involve obtaining sufficient calories that satisfy requirements of **essential nutrition**. Many models of human dietary ecology in evolution speculate on whether these needs could be met by human foragers in East Africa **from meat, plant foods or both** (1). A reliance on plant foods often implies the need for cooking to breakdown physical and chemical barriers in the plant so a human consumer can access the nutrition commensurate to what was expended in acquisition (2). **The Hadza hunter-gatherers** of East Africa offer a unique opportunity to test the **bioavailability** of nutrition in the **wild tubers** they consume year round (3).

## Introduction and Background

**Hadza ecology** (4)**:**

- The Hadza hunter-gatherers are modern foragers living in northern Tanzania along the eastern side of the Rift Valley

Photo by Mika Peterson

- Maintain a foraging subsistence lifestyle for >90% of diet
- Hadza women target tubers
- Available year round
- Consumed both raw and roasted

**Questions:**

- What is the bioavailability of nutrition?
- What is the relevance of brief roasting?

**Tuber properties** (5)**:**

- High fiber
- Moderate to low starch by fresh weight
- High moisture (70-90%)

**Roasting practices** (6)**:**

- 3-30 mins, average 5-7 mins
- Open high-flame fire
- Larger tubers roasted in sections

**Consumption** (5)**:**

- Peeled and bite-size sections cut
- Chewed up to 3 mins
- Wad or “quid” of fiber expectorated

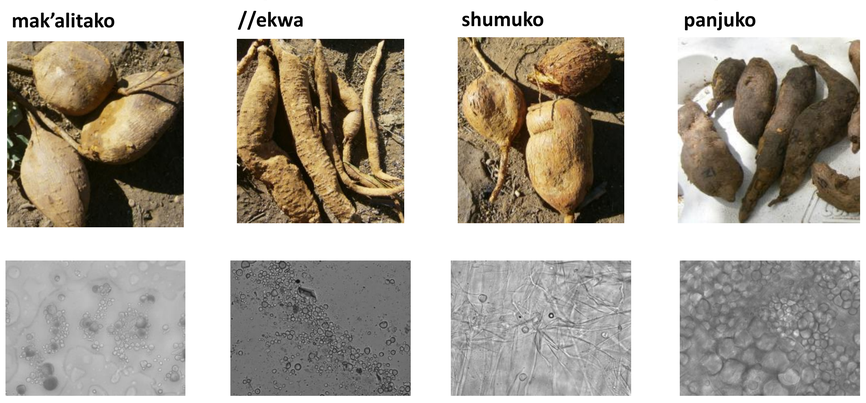
**Terminology:**

- Bioavailable- fraction of nutrition reaching circulation
- Gelatinization- loss of semi-crystalline structure in starch granules as water is absorbed during heating
- Quid- wad of fibers expectorated after chewing, inedible fraction

**How cooking alters food:**

- Gelatinizes starch
- Denatures protein
- Softens structural polysaccharides

### 4 tuber species collected for this study




Starch images give an impression of relative density of easily digestible carbohydrates in the form of starch grains (light microscopy, 400x magnification)

## Methods

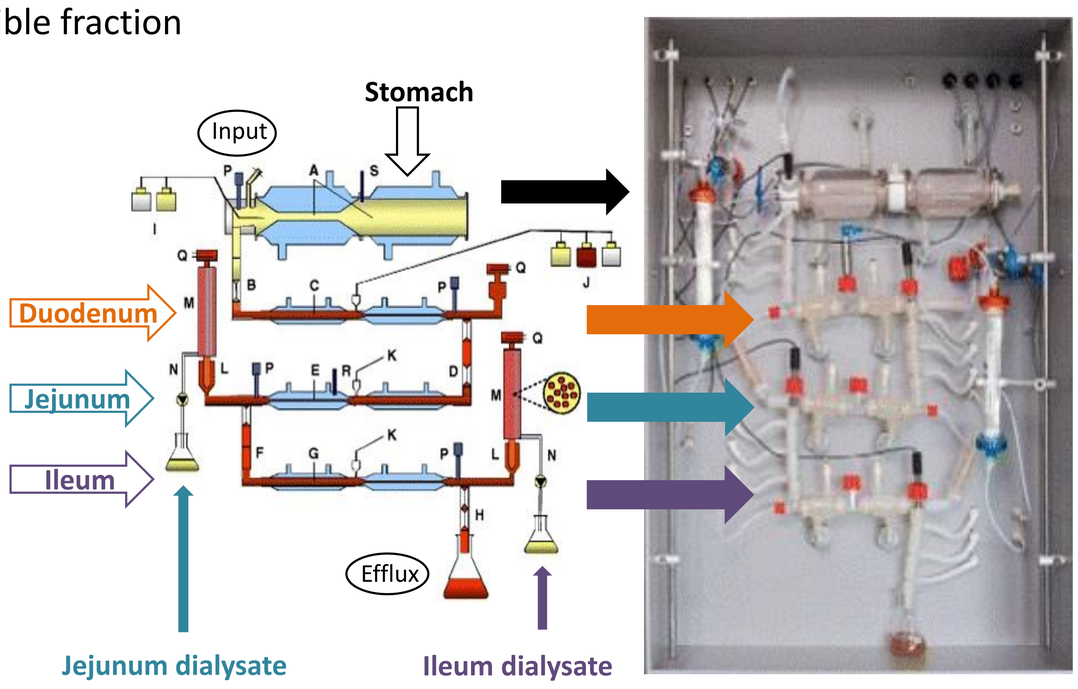
**Procedure:**

1. Simulate roasting: 5 mins on open fire
2. Peel and remove quids to extract edible fraction
3. Submit to *in-vitro* digestion
4. Dialysate analyzed for glucose

(amino acids (protein) below detection)

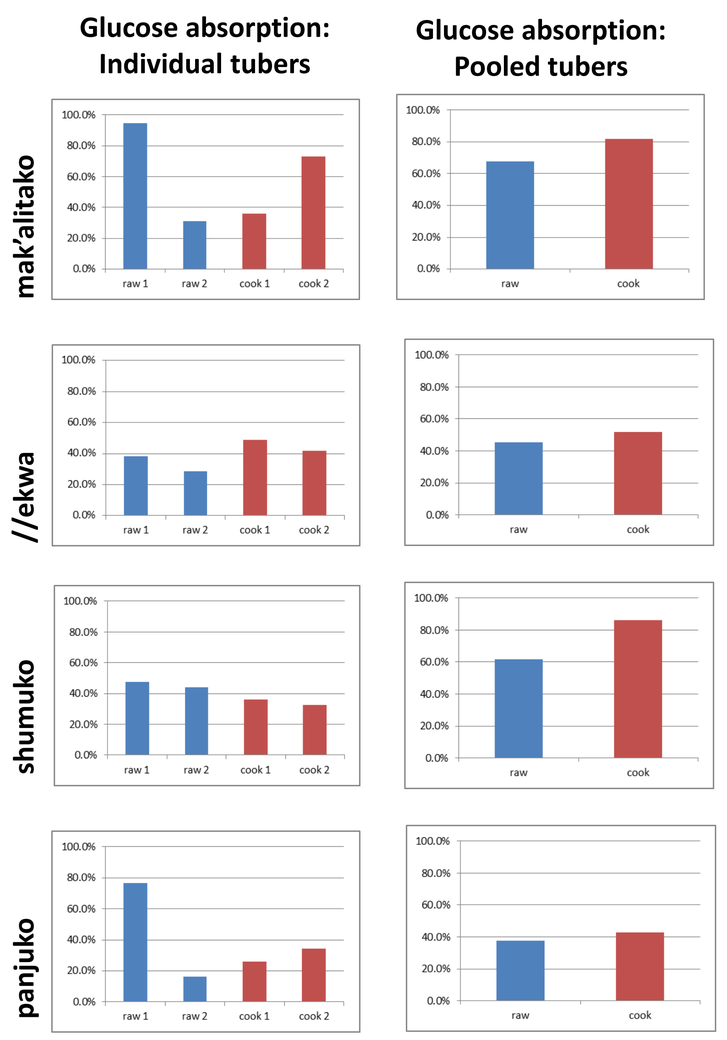
### TNO gastro-Intestinal Model (TIM)-1

stomach and small intestine




Full replica of the stomach and small intestine (7). The meal is inserted directly into the stomach and digested for 6 hours over a preset rate. Absorption of metabolic products (sugars and amino acids) through semi-permeable hollow-fiber membranes (5 kDa) are measured in the “dialysate”.

## Results




## Conclusions

**Notable observations**:

- Low starch by wet volume
- High simple sugars make raw consumption feasible and cooking unnecessary
- High fiber and pectin
- Fiber increases gut passage time
- Both upper and lower-gut digestion enabled

**Alternative reasons for brief roasting:**

- Softens food, faster peeling
- Ease of consumption for children
- Slower gut passage, longer satiation
- Preserve moisture in tubers
- Brief roasting may preserve vitamins (TBD)

**Summary:**

The results indicate high intra-species variation in nutrition availability with low impact from brief roasting.

**Two strategies emerge:**

1. **the forager must select the highest quality tuber**
2. **roasting gains a slight improvement but is not essential, raw consumption is reasonable in certain settings.**

We posit that roasting is a key communal activity, reinforces social bonding and distributes resource cost and therefore should be prioritized in mixed group settings. We also stress the importance of activating the whole gut in digestion. The upper gut digests and absorbs simple sugars and starch while the lower gut receives fermentable polysaccharides and provides further metabolic products to the host (SCFAs).

## References

1. Ungar P. et al. 2006. Diet in Early *Homo*: A Review of the Evidence and a New Model of Adaptive Versatility. *Annu. Rev. Anthropol.* 35, 209.
2. Stahl A. 1984. Hominid Dietary Selection Before Fire. *Current Anthropology*, 25(2).
3. Marlowe F. and Berbesque JC. 2009. Tubers as Fallback Foods and Their Impact on Hadza Hunter-Gatherers. *American Journal of Physical Anthropology*. 140:751-58.
4. Marlowe, F. The Hadza: Hunter-Gatherers of Tanzania. 1st ed. University of California Press, 2010.
5. Schoeninger M. et al. 2001. Composition of Tubers Used by Hadza Foragers of Tanzania. *Journal of Food Composition and Analysis*, 14:15-25.
6. Mallol C. et al. 2007. Earth, wind, and fire: ethnoarchaeological signals of Hadza fires. *Journal of Archaeological Science*, 34.
7. Minekus M. et al. 1995. A multicompartmental dynamic computer-controlled model simulating the stomach and small intestine. *Altern. Lab. Anim.* 23:197-209.

## Acknowledgments

We are grateful for the cooperation of the Hadza of Tanzania and the help of Mika Peterson, Shabaan, and Dorobo Safaris, without which this research would not be possible. We also wish to thank the Max Planck Plant Foods Research Group and the Department of Human Evolution for continual support, TNO Healthy Living technicians Mark Jelier, Tom Gorissen, Wendy Borst, and Azz-Edine Aynaou for TIM-1 support, Nick van Biezen of Bio-aNAlytiX for analysis and Audax Mabulla of University of Dar es Salaam for permit acquisition.