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Bread – innovation, serendipity, necessity – via hotspots of environmental degradation, gruel and sustainability!

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Many of us associate bread with agriculture; bread is one of the most typical products of agriculture, and, somehow, bread *is* agriculture. I was, therefore, very surprised to read in a recent article in *Nature* (Piperno *et al*., 2004) that barley, and possibly wheat, were routinely ground at the Ohalo II site (Israel) about 12 000 years before the advent of agriculture as we understand it. This would be 22 000 BP (years before present), during the Palaeolithic, 9 000 to 1 0000 years before the domestication of the main cereals during the Neolithic. The dates are, of course, indicative, but it is generally agreed (Toussaint-Samat, 1997) that cultivated cereals appeared 9 000 to 11 000 BP, in Palestine.

Grinders and pounders have been known from the upper Palaeolithic (between 45 000 and 18 000 BP); they were used for pigments and medicines of mineral, plant and animal origin. Toussaint-Samat lists the first grain mills as being from around 13 000 BP, but Piperno and her colleagues recovered starch from the stones; they were indeed millstones. The article also mentions that a *special alignment of burnt stones covered by ash suggests the presence of a hearth-like structure used as a simple oven.*

Jacob (1954) remains a classic on the history of bread. He wrote that bread is first known from ancient Egypt, and this is actually where the first proper ovens were discovered (from about 6 000 BP). Jacob stresses that barley was not very suitable for this bread, and that this is one of the reasons why barley has been worth less than wheat, starting in early times. There are, in fact, several passages in the Bible where barley is sold at half or one-third the price of wheat (2K 7:1, 16, 18). Jacob's view is that during the period *before* "bread", barley was used to prepare roasted flat cakes. It is quite possible that flour mixed with water was put directly onto the *burnt stones* mentioned by Piperno, and that the resulting griddle cakes would have been very different from what today we know as "bread".

There are good reasons for cooking cereals, as the amount of available energy increases in comparison with the raw, unprocessed grain and the food is more easily digested. The history of bread technology, including leavening the dough, and the relations between bread and beer, will not be discussed here; this has been addressed better by others, for instance by Toussaint-Samat (1997). It is interesting to note that the forerunner to cooking cereals (i.e. boiling with water) may have been roasting; this had the advantage of removing grain from spikelets and eliminating glumes. For cooking proper, earthenware cooking vessels were needed. The first evidence of pots that would resist heating dates from 10 000 or 9 000 BP; they were discovered in Mureybet (Syria), not far from the Ohalo sites.

Jacob quotes Plinius' opinion that, during most of their history, Romans used gruel, not bread (*pulte non pane*). Undoubtedly, this applies not only to Romans. It remains that bread did bring a change: it is durable (it can be stored over long periods of time), it is nutritious (the available energy content is greater that that of the unprocessed grain) and it is light (it can easily be carried in a bag).

The most interesting observation that I derive from the paper by Piperno *et al.* is that when man was forced into the Neolithic revolution, some of the fundamental innovations that were needed for the "invention" of bread were already to hand.

Was man "forced" into the Neolithic revolution? Experts naturally disagree about the details: which changes came first, and why. Mazoyer and Roudard (1998) note that, between 10 000 and 5 000 BP, human population increased tenfold, from 5 to 50 million; between 9 500 and 9 000 BP, small villages (0.2–0.3 ha) were replaced by large villages (2–3 ha) and, in general, many changes took place in living patterns. Competition for natural resources became acute and hotspots (Gommes *et al.*, 2004) of environmental degradation appeared, which in turn led to a drop in productivity. The time (and the energy) spent in collecting food increased; the old food production system became unsustainable.

Or did it? The old food production system may have become unsustainable, but as Mazoyer and Roudard note, the technical innovations required to survive the crisis had long been available. This includes tools, know-how, and, as we now know, "bread" as well.

As the pressure of environmental changes, population density and shortage of labour became excessive, the passage from hunting and gathering to a new system was a relatively obvious and fast one, though not necessarily easy. In other words, the food production system may have become unsustainable, but the society as a whole adapted to the new situation by resorting to exploitation of accumulated innovations, which in turn implies some kind of "leadership". Clearly, there is more to sustainability than adaptability, but not so much. Sustainability is a dynamic concept – the capacity to adopt innovations to turn a development bottleneck into a brighter future. This would be well worth examining from an ecological and energy perspective.

A final consideration is that extreme events frequently turn out to be the painful catalysts for innovation (Haberle and Chepstow-Lusty, 2000). *A priori*, what is

an innovation, or what innovation is important, is difficult to say. Cipolla (2003) confirms, in a completely different context, that innovations, when they first appear, are less important for their immediate advantages than for their potential to stimulate future developments, and that this second, intangible, attribute is always extremely difficult to value.

The chain extending from "neutral" innovations through environmental and societal stresses to the eventual adoption of innovations is one of the basic mechanisms of sustainability. In the same way as hotspots are characterized by an accumulation of environmental and societal stresses, an accumulation of innovations is required to precipitate development into a new direction.

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