The ripening process in plants

Peter Kunz, Fonds für Kulturpflanzen-Entwicklung

Ripening and waving in the golden cornfield, tall, strong stalks bearing full, heavy, golden maturing ears: cereals are inseparably connected with human sedentism. And firmly embedded in our culture are pictures: the bluish-green sea of the cornfield in early summer; the gradual change to light green; then red lighting up on the stem followed by the yellow and gold tones that ring in high summer and announce the harvest. These pictures are vivid and live on in our songs and poems – and nowadays in advertising too. A culture of bread has arisen along with the culture of cereals. The traditional bread culture of a region is inseparably connected with the varieties and species grown there. Yet what does it look like in the fields? Out there, to meet the demands of the modern market, vast amounts of cereals are cultivated as our present source of food?

A quality indicator for our diet

Nobody has noticed, and nobody cares that wheat fields are greening the grey-brown earth in the autumn and through the winter. In the spring, the light green initially darkens, first becoming blue-green, then grey-green. At ripening time the straw changes to grey-yellow, often just to grey, and sometimes even to an unsightly grey-black – a veritable non-colour. Does our bread come from this, even though it has had all sorts of treatments such as growth regulators and fungicides? Vanished are the golden colours that can be seen on old pictures and in advertisements, and which are sung about in our harvest festival songs.

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Image 1: Lightening of the stalks, bright gold-yellow maturing wheat variety.

imes have changed. Agriculture has become something other. Even the wheat has changed through breeding. For over a hundred years it has become shorter and shorter, whilst at the same time the yield has increased. That was a justified goal, but it has side-effects. The change in the architecture and physiology of cereal varieties has unforeseen consequences. Shorter plants are more prone to fungal diseases. These spread to the ears endangering yield through highly poisonous and carcinogenic toxins that can find their way into our food. On account of the fact that the grains ripen closer to the ground and near the leaves, they taste more like grass. If the colours are missing, the taste is also lacking – just as with an unripe apple. Cereals too need maturation. It's just not as obvious as it is with other fruit. But it is no less important for the health of the plant and for the wholesomeness of the product. It is true that, through the skills of the baker, something can still be retrieved and improved in a longer dough process. But unless the wheat has already been properly ripened in the field, bakers will no longer be able to arrive at a really excellent bread.

What is ripening?

With fruit such as apples, the senses help us decide – we can actually taste ripeness. The ripening of a hard, green apple is not just a matter of it becoming sweet; it acquires a whole bouquet, an assortment of aromas characteristic of the variety, and typical of where it was grown. The texture and taste of the fruit's flesh gets pleasanter. And not least, a ripe fruit agrees with us better than an unripe one. Each fruit has its optimal ripeness for consumption. Ripeness is clearly recognisable as a fresh, frequently slightly brightened coloration together with a corresponding aroma profile. This is followed by spoiling. The fruit's structure disintegrates, taste and smell tend to one-sidedness and unpleasantness, eventually becoming intolerable. The colours once again approach the colours of the earth, i.e. those colours out of which the green plant grew originally. This applies to all cultivated plants. Even the special, prominent feature of a cultivated plant, one that distinguishes it from the wild plant, is a more pronounced development and species-specific ripening of one of its organs.

What happens during the ripening of cereals?

Cereals growth happens in three distinct developmental phases. Before winter, the germinating plant concentrates above all on developing its roots. Whereas above ground, only a few leaves appear, wherever the soil structure and conditions of light and warmth allow, the root already reaches to a depth of 30 to 50 cm. For almost six months the entire growth of cereals is oriented downwards. At low temperatures, the roots go almost vertically into the depths. Assimilate from the leaves is mainly transported downwards and there serves not only root development, but also a significant proportion is exuded into the surroundings of the roots. This involves a broad palette of substances: carbon dioxide and chelating agents influence the solubility of minerals; carbohydrates and amino acids 'nourish' the soil micro-organisms; and coumarin derivatives, phenolics, glycosides, alkaloids, vitamins, etheric oils and ethylene influence their growth and activity. Through all this the plant controls the soil life in the region of its roots. The plant enlivens and forms the soil. In the region of its roots, it builds up a potential available for its further development.

Biomass formation in spring and early summer

In early spring, new leaves and tillers are formed again. Each tiller forms a new generation of roots which increasingly spread horizontally with rising soil temperatures. In the still short tillers the leaf, stalk and ear are pre-structured in miniature before they turn upwards and grow in length. At this stage of development, during which the field looks no different from a green meadow, the whole plant that is later to appear is already completely formed. Only cereals show such a developmental dynamic. Within a brief period over the following weeks the plants stems grow in length. The stand grows tall and the ears are thrust out of the stalks. The completely inconspicuous flowers that briefly appear on the ears conclude the growth. Until this moment the wheat plants have not yet produced anything edible for humans, but have produced straw or roughage for animals that are especially adapted to digesting cellulose and lignified plant parts. Nevertheless, this biomass provides a valuable basis for the later swelling of the grains. And what remains on the ground as straw after the harvest is important for soil fertility, because it comes back to the field in a 'refined' form as livestock fodder and bedding together with their dung, and revitalises the soil anew.

Bild 2: Tengri Wheat with brown ears and red stalks.

Reversal of metabolism

At the time of flowering, grain formation and swelling begin. During the last six weeks of the vegetation cycle the physiology of a cereal plant is totally redirected to this. Previously, the assimilate was transported downwards into the roots and to the new leaves. Now the developing grains trigger a remobilization of assimilate, proteins and minerals accumulated in the leaves, stalk and roots. The metabolism is literally turned upside down. In healthy plants, this process proceeds slowly and steadily. But in diseased and weak plants it is chaotic or even interrupted prematurely. As a result, decomposing fungi spread wherever they can find a suitable medium to grow. In healthy plants the maturation process goes ahead in an orderly and slow manner. The leaves become lighter coloured from the tips, initially turning light green, then yellow, before they dry out. The stalks too become lighter in colour from the bottom upwards and can turn really translucent, whereby their colours brighten. As with broad-leaved trees in autumn, colour nuances appear in all shades from bright yellow to deep red. Thus, in their own way, cereal plants exhibit a flowering and ripening process; it is an expression immediately visible to the eye of a successful and balanced translocation from the green plant into the grain.

Image 3: Whole matured wheat grains

The transformation and re-deposition process is responsible for what minerals arrive in the grain and what can be formed there. Depending on conditions in the surroundings – temperature and water supply are above all decisive for that – and the predispositions of the variety, in the grain are produced structure-forming gluten proteins and starch compounds for dough development and the baking process, as well as a variety of aromatics and compounds influencing palatability. Thus, in the lower part of the plant, ripening means orderly breakdown, and, at the next higher level, equally orderly build-up of the fruit and food substance.

Conventional Breeding

To get high yields with cereals, plant stems are shortened to improve their stability. This is done either with the use of growth regulators that affect hormone metabolism, or genetically with so-called short straw genes that are based on a hormone receptor defect, or with a combination of both methods. As a result of shortening, the plants lack the required biomass that supplies the vitality necessary for ripening. In conventional farming this is provided by constantly oversupplying the plants with mineral nitrogen fertiliser. This indeed strongly stimulates growth in the first and second developmental phase, but the vitality remains 'stuck' at this vegetative level and hinders the ripening process. Conventional breeding has as its goal the stay-green trait. This is found in varieties that are intended to remain green for as long as possible. We can also describe this goal as a prevention of ripening. Prolonging the duration of assimilation in this way actually produces higher yields. However, the still green field of bread wheat has to be sprayed with glyphosate at an ever increasing frequency so that the thresher does not get blocked. Monsanto & Co. are looking forward to increasing sales. This trend is supported and intensified by the ever higher yield performance driven by the market, as well as by the 'quality criteria' prescribed by grain dealers, and it is visible in the non-colours in the fields. Besides the polluting farming, the shortened and over fertilised plants waste a not insignificant part of their resources: a large part of the fertiliser nitrogen remains behind unused in the straw, or it is leached out

Biodynamic plant breeding: a holistic approach embedded in the environment.

The biodynamic plant breeder's plants should grow in close association with the site and exploit its resources without tending to one-sidedness or becoming diseased. Its varieties mostly show a stronger leaf and biomass development, and are not dependent on nitrogen fertilisers to produce the high gluten content preferred by the processors. The stalks are longer and the ears, which ripen at a greater distance from the leaves, are consequently healthier. Finally the aforementioned ripening process is also taken into consideration as an essential characteristic for all cultivated plants. This is because it leads not only to an improved quality of the grains, but also to stable and good yields. Biodynamically bred cereal varieties are becoming increasingly popular. In Switzerland, almost 70% of organic wheat is grown with varieties from our cereal breeding. In southern Germany about half the bread wheat comes from biodynamically bred varieties. It is precisely that these varieties are reliable in difficult years, such as 2016 with its wet summer and 2018 with its hot summer, that confirms the high relevance of architecture, growth dynamics and ripening processes.

Our cultivated plants require a new aesthetics as a model: the beauty of the plants in their architecture and in their vivid expression is in no way a luxury, but central to developing quality and creating food security. Against a background of soaring diet-related health costs, it also makes economic sense to support and promote this holistic kind of plant breeding.

Bread-making as the completion of the ripening process

Well matured grain has a dormancy. Grain harvested at the right time is therefore storable for a very long time without losing its nutritional value. The one-sidednesses occur before and after, and certain culture techniques deliberately make use of these, e.g. sprouted grain and malt, as well as Grünkern (green spelt, green grains). In the case of Grünkern, dried unripe and then kilned, the seed has not yet become dormant. Grünkern is therefore powerful, but not nourishing in the fullest sense. With malt, which is produced by longer germination, the shoot grows again. The malt grain not only remobilizes sweetness from carbohydrates, but also produces new aromas. Its germination and digestive enzyme inhibitory substances are inactivated and the breakdown of proteins starts. This is partly connected with an increase in its valuable amino acids.

When preparing dough, the addition of water to the flour starts a transformation process that is related to the process of germination. Because the cereal grain represents a highly concentrated food, after milling and wetting it needs sufficient time for the digestion processes. Whereas the seedling bears within itself its developmental direction towards a new plant, and can control this development itself, the process of dough preparation is controlled from outside by the temperature or the addition of sour dough or yeast. Without sourdough or yeast, a change starts that can very easily end in chaos, i.e. in a butyric or acetic acid fermentation resulting in an unpalatable bread. In dough processing, bakers even speak of a ripening process that, like the ripening of the cereal plant in the field, is connected with decomposition and regeneration, and takes time. If the process is carried out too quickly, one-sidedly or incompletely, not only does the taste and aroma suffer, but also the wholesomeness. If the ripening process succeeds, a well structured, richly aromatic, wholesome bread is produced that retains its shape.

What is presented here is today being rediscovered by bakers and by many consumers. Even in large-scale industrial production attempts are being made to take this into account, at least to some extent. This is always connected with greater investment, and above all it takes more time. And nowadays time is money! Therefore at the same time there are those following a trend in the opposite direction: quicker, ever shorter processes, together with the addition of artificial aids and fragrances that lead to results hardly distinguishable by consumers in the shops. However, the determinant of quality is the ripening process that takes place between the breeding and the bakery. And consumers have it in their hands: with their purchasing decisions they can control what food is produced and how it is produced. It is not enough to make a conclusive judgement about quality immediately after your first sensorial impression. A holistic judgement results only against the background of a healthy, beautifully grown and ripened field of grain, as the result of a sustainable, carefully managed agriculture.

Image 4 and 5: Breadmaking: the completion of the ripening process.

Nourishment via the senses and the stomach.

Colour, aroma, taste and touch appeal to the senses, directly preparing the process of digestion and stimulating it to action. Whereas the germination of the seedling itself controls the accompanying breakdown of substances, and in grain formation and ripening in the ear the developing grain itself initiates and guides the breakdown in the green plant, in the case of human digestion this task of initiation and control to a large extent falls to sensory impressions and pleasurable experiences. When eating, the more powerful and differentiated the sensory stimulus, the more restful and complete is the ensuing digestion. The wholesomeness and palatability is also directly connected with it, despite our highly individual preferences and sensibilities. These are essential steps that teach us to approach bread or another food attentively before we consume it and digest it. Questions come before eating: what is it, and what does it look like? What is in it and how is it prepared? How appealing are the colours and the aroma? What taste and oral experiences are awakened? When eating, attention is directed wholly to the concrete encounter. What does it really taste like and what does it feel like? Are my expectations fulfilled? What was unexpected? And a few hours after eating, how did it agree with me? Do I feel strengthened and enlivened, or rather a heaviness? From breeding to loaf the ripening process features in all these questions.

The senses are part of eating, so we need them! But they carefully and prudently enrich our experience and deepen our understanding of and responsibility for the provenance and significance of food as the basis of our life. That too may be described as a ripening process.

Contact: Peter Kunz, Fonds für Kulturpflanzen-Entwicklung, www.kulturpflanze.ch, p.kunz@gzpk.ch, T +41 79 708 95 49