MERIEL JONES

Onions: sweet not smelly!

Imagine life without onions. We eat them with hotdogs and hamburgers; we add them to casseroles and curries; they make pizzas more mouth-watering; they give flavour to crisps and chutneys. We eat them fried, fresh and pickled. Take away the onion and many foods would be much less pleasurable. Onions are indispensable to the cuisine of every part of the world. No wonder they are the world's second most important horticultural crop (after tomatoes).

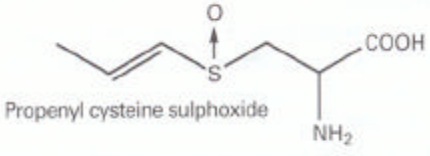
The reason for the interest in onions is their flavour. Intact onion bulbs have almost no smell, but the characteristic pungency that floods the air immediately they are cut can cause tears. It hangs around in the kitchen, and on hands and clothes, the smell changing subtly before its disappears. The taste of cooked onions is different again, with a sweetness underlying the distinct but much less pungent flavour. The sweetness is from sugars stored in the onion bulb, which can be detected once the onion flavour no longer overwhelms the palate.

What causes the smell?

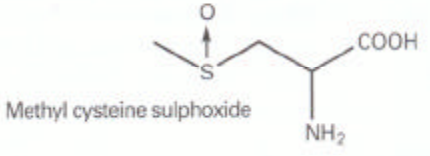
The flavour is produced by volatile sulphur compounds, which are released as soon as the onion cells are broken. These are unstable substances that react in the air and on surfaces. The compounds present, and their amounts, therefore depend on both time and the environment, and are the reason why the smell of onion changes as it lingers. Chemists have identified over 50 different sulphur-containing chemicals in volatile onion flavour.

Why do onions smell only after damage?

The source of onion flavour is enzyme activity on tasteless and odourless flavour precursors stored within onion cells. The flavour precursors are stable compounds that are converted into volatile onion flavours as soon as the cells are damaged. For all the complexity of the smell and taste of onions, there are only three precursors, all based on the sulphur-containing amino acid cysteine. The main one, propenyl cysteine sulphoxide, is unique to onions. Another, methyl cysteine sulphoxide, occurs in onions and all their relatives (such as leeks, chives, garlic, ornamental flowering onions), and also in cabbages, sprouts, cauliflowers and similar vegetables.



Propenyl cysteine sulphoxide



Methyl cysteine sulphoxide

The biological sciences play an important part in our everyday lives. *Interface* deals with the ways in which biological knowledge is being used in our society, for both the individual and the community.

The enzyme alliinase converts the precursors into volatile chemicals which give the onion flavour. Onions and their relatives all contain alliinase. All three flavour precursors are substrates for alliinase. The flavour precursors are present in the cytoplasm and alliinase is in the vacuole, so the enzyme comes in contact with its substrates only if the cells are damaged (see Figure 1). Once alliinase meets its substrates, the reaction is very fast, as anyone who has cut an onion knows! It breaks each flavour precursor into three chemical products. Two are unstable compounds liberated into the air, where they undergo chemical reactions, producing the many sulphur compounds that give onions their characteristic smell and flavour. The third product, pyruvate,

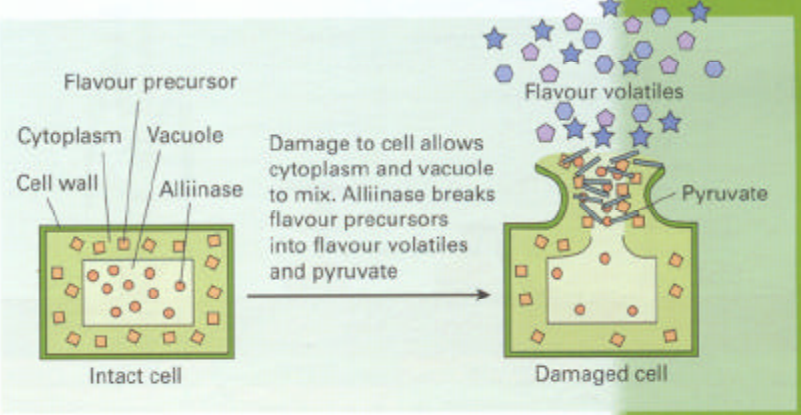


Figure 1 **Production of flavour compounds in onion through the action of the enzyme alliinase after cells are damaged.**

is much more stable and stays dissolved in the disrupted cells. It is an organic acid made in all cells during glycolysis but at much lower levels than in a damaged onion cell. The alliinase reaction is very different from glycolysis but one of its products is the same.

Alliinase was discovered in the late 1940s and scientists thought that it was the only enzyme needed to produce the volatile flavour compounds. However, in 2002, Japanese scientists used a combination of protein and DNA analysis to demonstrate that a second enzyme, lachrymatory factor synthase, is needed to produce the tear-inducing volatile sulphur compound from propenyl cysteine sulphoxide (see Figure 2).

Why do onions smell?

People often ask why onions contain flavour precursors and smell so pungent. There is no single answer to this question. The most important role of an onion bulb is to survive through the winter so that the plant can reproduce. Onion seeds germinate to produce a plant that forms a bulb at the end of the first year, and flowers and dies in the following year (see Figure 3). Growth at the start of the second spring is sustained by recycling the carbon, nitrogen and sulphur from stored substances in the bulb. These three elements are essential in all living cells. Carbon is normally obtained from carbon dioxide in the air through photosynthesis, but as dormancy breaks there are, as yet, no photosynthesising leaves. Nitrogen and sulphur have to come from the soil and can be at low enough concentrations to restrict

TERMS explained

Lachrymatory factor The tear-inducing component of onions.

plant growth, especially in non-agricultural soils. The store in the bulb therefore allows the onion to resume growth with advantageous supplies in the spring.

Of course, onion bulbs would also be a good food for hungry animals, so the pungent odours may have a secondary role as a deterrent to anything that bites the bulb. This protection extends to bacteria and fungi that would otherwise grow on the damaged onion. The liquid squeezed from fresh onions is surprisingly effective at killing many microorganisms. Another fact that supports this idea is that strong onions keep through the winter much better than onions with less flavour. This role for the flavour precursors could continue throughout the life of the plant, making animals wary of nibbling onion leaves.

The intense flavour of modern onions may reflect human intervention. Ancient Chinese, Egyptian and Roman pictures indicate that onions have been used in cooking for over 5000 years. Onions are thought to have originated in central Asia, although there are now no wild plants similar to cultivated onions. It is the same for many other agricultural plants. Either the wild ancestor has become extinct, or the cultivated plant is a rare variant that was selected by ancient people. Onion does not have the essential role in the human diet of a cereal like wheat, but it makes food much more enjoyable.

Onion varieties

There are many varieties of onion, differing in cultivation requirements, colour, shape and strength of flavour. The traditional British cooking onion has been selected to grow in the British climate and to keep well throughout the winter. The fleshy bulbs are surrounded by layers of shiny, yellow-brown skin and they have a very pungent flavour. Supermarkets stock this type throughout the year. Onions originated in a drier and sunnier region, and most other varieties do not grow so

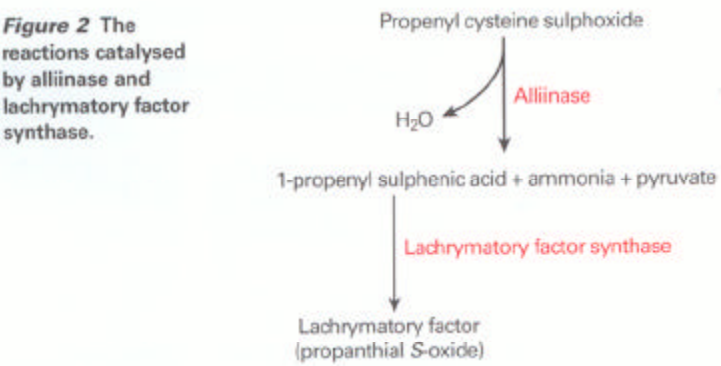


Figure 2 **The reactions catalysed by alliinase and lachrymatory factor synthase.**

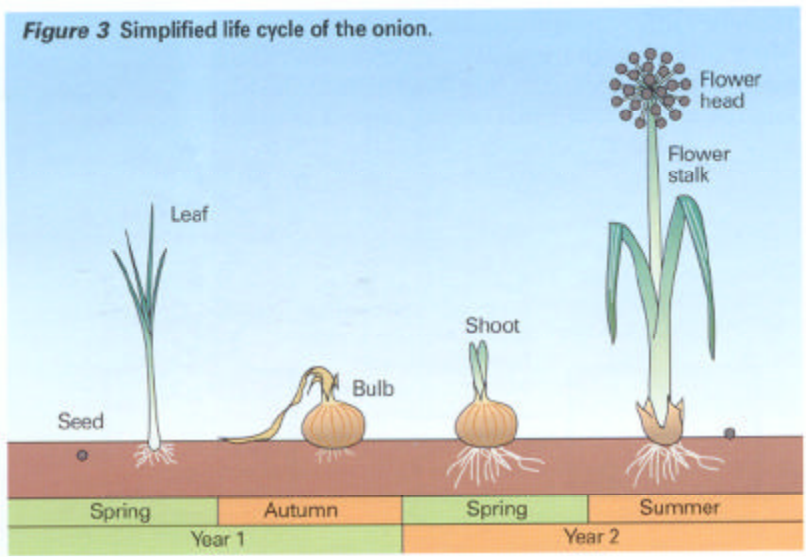


Figure 3 **Simplified life cycle of the onion.**

An onion flower.

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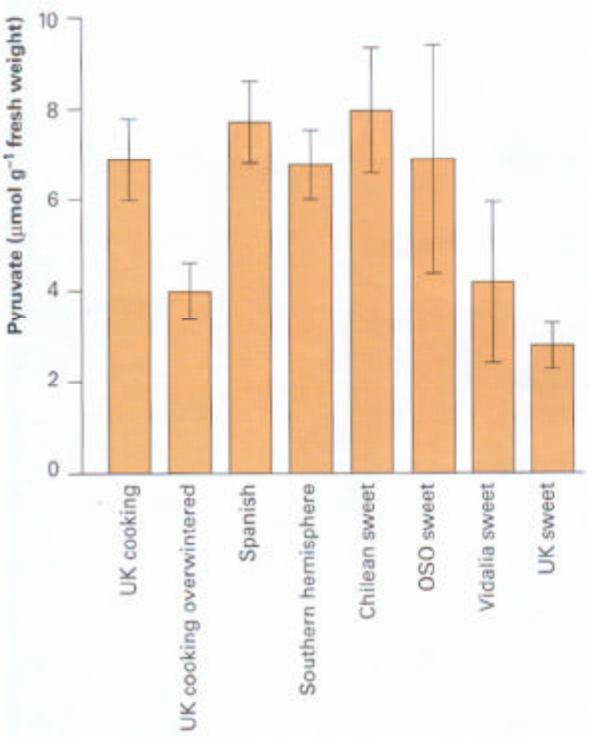

Figure 4 **Comparison of the pyruvate yield from several varieties of onion.**

well in the cool, wet and comparatively sunless British climate. However, plant breeders have produced white-skinned onions and others with red flesh and skins that grow reasonably well in Britain. Another popular variety — the large Spanish onion, with its attractive dark brown skin — cannot yet be grown commercially in Britain.

Developing new commercial plant varieties is as much an art as a science. Most of the important characteristics, like flavour, size and health, are controlled by many genes working together. New onion varieties are produced by crossing two varieties that each have desirable characteristics. The experienced eye of the plant breeder will look through the thousands of seedlings from such a cross, and pick out those that have the best combination of characteristics.

The Supasweet onion

A recent development is milder flavoured and sweet onions. A slice of fresh onion can improve the flavour of hamburgers and salads, but should not be from a strong onion. About 100 000 tonnes of mild onions are imported into Britain each year, a market worth about £30 million. However, their flavour is actually very variable. The label 'mild' comes more from the source of the onion, namely Spain or Chile, rather than an objective measurement of flavour. Many imported so-called mild onions are not mild at all.

Pyruvate concentration is one of the ways used to estimate the strength of onion flavour. Measurement of pyruvate shows that the average Spanish onion is as strongly flavoured as a UK cooking onion (see Figure 4). However, some other varieties are genuinely mild flavoured. Once the pungency is low enough, the sweet taste from the sugars mingles with the onion flavour to

Supasweet onions.

give the unusual taste of a crisp, sweet onion. Onions like this are produced in several parts of the world, through a combination of growing a suitable variety in soil that is low in sulphur. One of these is the Supasweet onion, grown in the UK and available from July to September. As well as its mild, sweet flavour, this onion has a distinctive thin, pale skin that is easy to peel.

Conclusion

The flavour compounds of onions are one example of the thousands of chemicals in plants that add colour, fragrance and taste to our food. The first farmers picked them out, but selection over centuries of cultivation has developed the many types of onion that exist today. Through applying science to understand the physiology of onion flavour in the twentieth century, it has become possible to select new varieties more easily. The Supasweet onion of the twenty-first century shows how a new type of onion can be selected to benefit both consumers and onion growers. Mealtimes and snacks would be less inviting without this versatile vegetable.

Further reading

Website of the National Onion Association (American):

http://www.onions-usa.org/

Things to do/topics for discussion

- Can you or your friends detect a difference in strength between onion varieties? Try this in summer or autumn, when sweet onion varieties are available. Think about how to do the testing so that people are not influenced by the appearance of the onion. How does the flavour change after cooking (frying or microwaving)? Is it the same for the flavour of related vegetables such as chives, leek, garlic and shallots?
- What are the differences between wild and cultivated plants? If you were asked to develop a new type of vegetable crop, which wild plant would you choose and how could you do it?

For information on the Supasweet onion, contact David O'Connor or Jo Topper, e-mail:
david@abcentre.co.uk or Joanne@abcentre.co.uk

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