

## CONKERS FOR CORDITE

In 1914 the British government operated a single explosives works at the Royal Gunpowder Factory, Waltham Abbey, Essex, manufacturing cordite, a propellant explosive used to drive a shell or projectile from a gun. In addition, the government bought cordite from seven commercial works. Initially, to increase production, extensions were made to the existing factory at Waltham Abbey and private works, such as, those at Cliffe, Medway.

Also in 1914, Winston Churchill, First Lord of the Admiralty, gave approval for the construction of a new naval cordite factory at Holton Heath, Dorset, with a novel plant to produce and ferment acetone, essential in the manufacture of cordite. At first, maize was used, but later in the war a call went out for children to collect acorns and horse chestnuts.

When Britain's war effort was threatened by a shortage of shells, the government exhorted schoolchildren across the country to go on the hunt for horse chestnuts. The children knew it was for essential war work, but not its precise nature, and they collected hundreds of tons. The remains of this plant at Waltham Abbey are scheduled buildings now used as a visitors centre. Other new factories were built on a huge scale. At Gretna, Cumbria, the new cordite factory covered 3,600 hectares and by October 1917 employed nearly 20,000 people.

In the autumn of 1917, a notice appeared on the walls of classrooms and scout huts across Britain: "Groups of scholars and boy scouts are being organised to collect conkers... This collection is invaluable war work and is very urgent. Please encourage it."

It was never explained to schoolchildren exactly how conkers could help the war effort. Nor did they care. They were more interested in the War Office's bounty of 7s 6d (37.5p) for every hundred weight they handed in, and for weeks they scoured woods and lanes for the shiny brown objects they usually destroyed in the playground game.



*Willingdon Ratton Scout Troop of West Sussex 1916 – Image courtesy of Rosalind Hodges.*

Mr. Haylock, the Headmaster wrote an entry in the Willingdon School West Sussex Logbook for 30<sup>th</sup> January 1917. 'Sent off today three bushels of Horse Chestnuts gathered by children for the Minister of Munitions.'

Over the previous weeks there were notes in the Log that the children had been out in the parish during the school day collecting conkers as part of the war effort.

30<sup>th</sup> Sent off to-day 3 bushels of Horse-chestnuts gathered by children for the Minister of Munitions

Many of the schoolboys belonged to the 1<sup>st</sup> Ratton Scout Troup founded by Lord Willingdon and the scouts were also seen around the parish busily searching in the grass under the Horse Chestnut trees and filling boxes and baskets with conkers.

Once collected they brought them back to the schoolroom to remove the green shells, leaving just the nuts. These were bagged up in sacks, put on a hand cart and wheeled off to Hampden Park Station ready for collection and transportation by train to London and from there to secret locations.



The children's efforts were so successful that they collected more conkers than there were trains to transport them, and piles were seen rotting at railway stations. But a total of 3,000 tonnes of conkers did reach their destination – the Synthetic Products Company at King's Lynn – where they were used to make acetone, a vital component of the smokeless propellant for shells and bullets known as cordite.

In an otherwise tranquil Cambridge, the police were called out to defend horse chestnut trees from marauding bands of children who were energetically attacking them to collect horse chestnuts. 'Conkers' had always been subject to limited harvesting for use in contests where, strung on a string, they would be viciously scythed through the air as competitors tried to destroy their opponent's conker (and occasionally their knuckles!).

In 1917, as mentioned though, there was a new impetus to the harvest as conkers had now been identified as an important national resource. Behind this lies a milestone in the history of applied microbiology: acetone butanol fermentation – the first microbiological process to require asepsis on an industrial scale.

Cordite had been used by the British military since 1889, when it first replaced black gunpowder. It consisted chiefly of the high-explosives nitro-glycerine and nitro-cellulose (gun-cotton), with acetone playing the key role of solvent in the manufacturing process.

Prior to the First World War, the acetone used in British munitions was made almost entirely from the dry distillation (pyrolysis) of wood. As it required almost a hundred tonnes of birch, beech or maple to produce a tonne of acetone, the great timber-growing countries were the biggest producers of this vital commodity, and Britain was forced to import the vast majority of its acetone from the United States.

An attempt to produce our own acetone was made in 1913 when a modern factory was built in the Forest of Dean. But by the outbreak of war in 1914, the stocks for military use were just 3,200 tonnes, and it was soon obvious that an alternative domestic supply would be needed. This became even more pressing during the spring of 1915 when an acute shortage of shells – the so-called 'shell crisis' – reduced some British guns to firing just four times a day.

The British government's response was to create a dedicated Ministry of Munitions, run by the future Prime Minister David Lloyd George. One of Lloyd George's first initiatives was to ask the brilliant chemist Chaim Weizmann of Manchester University if there was an alternative way of making acetone in large quantities. Weizmann said yes.

The Royal Gunpowder Factory at Waltham Abbey dates back to the 1660's. From late in 1914, its capacity to produce cordite was greatly increased by the construction of new buildings and the expansion of its workforce and from 1916, the employment of women. The Explosives Factory here at the Wat Tyler Country Park is the subject of its own history in another booklet and graphic presentation.

Some of the buildings of the Royal Gunpowder Factory Waltham Abbey in Essex





Over 3000 women worked at 'The Powder Mills' during the First World War highlighting the vital and varied role women played during the First World War.



The picture of two of the ladies working at the factory showing the protective trousers and tunics that were somewhat of a novelty of the time. A Miss Kiddy is on the right wearing her Brass War Workers Badge for her service to the war effort.



### **Chaim Wiseman**

Developing the work of Louis Pasteur and others, Weizmann had perfected an anaerobic fermentation process that used a highly vigorous bacterium known as *Clostridium acetobutylicum* (also known as the Weizmann organism) to produce large quantities of acetone from a variety of starchy foodstuffs such as grain, maize and rice. He at once agreed to place his process at the disposal of the government.

In May 1915, after Weizmann had demonstrated to the Admiralty that he could convert 100 tonnes of grain to 12 tonnes of acetone, the government commandeered brewing and distillery equipment, and built factories to utilise the new process at Holton Heath in Dorset and King's Lynn in Norfolk.

A fermentation process using potatoes had been developed before the war by a consortium based in Manchester, London and Paris, centred around Strange & Graham, Technical Research Chemists in London's City Road, but it had not proved very successful in practice. Chaim Weizmann, a lecturer at the University of Manchester, was a member of the consortium but had been sacked in 1912 after disagreements about money and recognition. Following his dismissal, he continued to work on the project independently, going on to isolate the bacterium which could produce acetone reliably and in useful quantities from maize. He offered this to the government who, in 1915, provided him with pilot facilities to prove the process at Nicholson's Three Mills Gin Distillery on the River Lea in Bow, East London.

Nicholson's started in London during the 18th century 'gin craze' and produced the popular Lamplighter London Gin at distilleries in Clerkenwell and at Three Mills. The company enjoyed impeccable establishment connections through parliament and cricket. William Nicholson, the company chairman, was a Liberal Member of Parliament for Petersfield and his father, also an MP, had been an enthusiastic cricketer – so much so that he had loaned the Marylebone Cricket Club (MCC) the money to buy Lord's cricket ground in London. One reward for this generosity was that the MCC adopted Nicholson's colours – bright yellow and red – as their own. To this day, the same colours adorn the club's famously migraine-inducing tie in honour of Nicholson.

Successful gin production does not require strict asepsis and the facilities available at Bow meant that problems of contamination bedevilled acetone production there. Nonetheless, sufficient promise was shown for it to be rolled out to a distillery in Scotland, an existing (previously unsuccessful) acetone factory in King's Lynn and a large, newly built plant at the Admiralty cordite factory in Dorset. It was further proposed to take over all UK distilleries for this purpose: a plan that was greeted with some dismay when Lloyd George announced it to the distillers at a meeting in February 1916.

With peace, the distillery reverted to its former role until it was bombed during the Second World War – an event that occasioned one of the many tales of selfless bravery characteristic of the blitz when unnamed local heroes risked all to dive into the River Lea and save six barrels of spirits from being lost.

The possibility of using horse chestnuts was first mooted in April 1917 and Weizmann's advice sought. He was no longer working at Three Mills but had moved across London to laboratories, first at the Lister Institute in Chelsea and then across the river at Point Pleasant, Wandsworth. Test results showed horse chestnuts could be used, although pre-treatment was required to reduce levels of an inhibitory glycoside, aesculin, and the fermentation sometimes foamed excessively.



Royal and Generator House and Acetone Fermentation Tank      Naval Cordite Factory, Dorset - Boiler

Together they produced more than 90,000 gallons of acetone a year, enough to feed the war's seemingly insatiable demand for cordite. (The British army and Royal Navy, alone, fired 248 million shells from 1914 to 1918.)

Every rifle round made at the munitions factory at Quedgeley in Gloucestershire's Shell Filling Factory No. 5. contained 15grams of cordite propellant. If it takes 10 conkers to produce 1gram of cordite, how many conkers are needed for each round? In 1918, British factories made 2,800 million rifle rounds.

If the cordite in them had all made from conkers how many would have been needed?

1 round needs  $10 \times 15 = 150$  conkers,  $2,800,000,000 \times 150 = 420,000,000,000$  or 420 billion.

At the start of the War munition filling was carried out at Woolwich Arsenal, however it was soon realised that a massive increase in production of munitions was required created in England by the Ministry of Munitions in the early part of WW1 (covering 174 locations), among these were the National Filling Factories, including a National Fuse Factory, 5 Trench Warfare Filling Factories, and 3 National Factories for Filling and Assembling Chemical Shells.

Filling of small-bore ammunition was increased by the creation of 4 government cartridge factories. Most of the national filling factories followed similar designs with large sites with small lightweight buildings well separated and connected by raised walkways which had lightweight rail lines so materials could be wheeled between buildings on trolleys. Shells, fuses, packing cases, and explosives were brought in by rail to the edge of the factory, and completed munitions left by rail. All the filling work was carried out within the large 'clean area' by a large, mainly female, workforce. People entering the clean area had to change clothes and leave behind anything that could strike a spark, not just matches and lighters but all metal, even hairclips - one male worker being fined £5 for being in possession of 2 nails that he had used to replace a lost button on his trousers.



Fermentation VATS being erected at Rainham, Essex during the Autumn of 1912.

But by 1917, as grain and potatoes were needed to feed the British population, and German U-boat activity in the Atlantic was threatening to cut off the import of maize from the United States, Weizmann was tasked to find another supply of starch for his process that would not interfere with the already limited food supplies.

### ACETONE PRODUCTION DURING THE FIRST WORLD WAR

'You can have my distillery,' and with these words in 1915–16 Colonel Gooderham generated the second largest fermentation process in the world.

In 1909 in Germany, the pharmaceutical company Badische Anilin- und Soda-Fabrik (BASF) introduced synthetic indigo, dealing a severe blow to the Indian plantation industry. It was the British, however, that controlled the entire trade in indigo and a manufactured supply meant that an indigo monopoly no longer existed, and the price of indigo fell.

The German pharmaceutical industry, including BASF and Bayer, had also set its sights on synthetic rubber to replace natural rubber, caoutchouc. In order to avoid a repeat of the indigo disaster, the British scientific community, including Dr Francis Matthews, Nobel Prize winner Sir William Ramsey and Edward Strange, focused their attention on producing artificial rubber. On 17<sup>th</sup> December 1909, Matthews and Strange filed a patent describing a process that synthesised a natural rubber monomer, isoprene, from acetone and acetylene. Subsequently, by serendipity, Matthews left tubes on his bench while he went on holiday. On his return he saw that they had solidified as synthetic rubber. He managed to patent his discovery three months before the Germans independently discovered the process.