Malt and beer, cures for scurvy afflicting European sailors

Christian Berger, 2016, 2022

1. Introduction 4
2. An old antiscorbutic recipe forgotten by Europeans 6
   2.1. The malt used by Viking sailors 8
   2.2. Oblivion of the antiscorbutic recipes inherited from the Vikings ...10
3. The transoceanic voyages from the 15th century 11
   3.1. The awful hardships endured by the crews 11
   3.2. Europe knows early on the disease and its cure 16
   3.3. Beer rations provided by the British navy in the 16th century 18
   3.4. Wine rations of the Spanish navy in the 16th century 19
4. The benefits of sweet wort rediscovered by MacBride and Cook.....21
   4.1. MacBride's method applied by Captain James Cook 21
   4.2. The 18th century searches for an antiscorbutic remedy.....24
   4.3. Cook's legacy and the missed adoption of his healthy method.....30
   4.4. The British navy turns to lemon juice in 1796.....32
   4.5. Scurvy plagues the merchant navy until the 20th century 36
   4.6. Maltsters and brewers render beer ineffective against scurvy 38
5. Some Chinese knowledge unknown to Europeans 43
6. The scientific rationale behind the benefits of malt infusion 46
7. The return of scurvy in the trenches of the First World War 47
   7.1. Sprouted grains are efficient against scurvy 48
   7.2. Kaffir beer is efficient against scurvy.....49
8. Conclusions 50
9. Bibliography 52

Abstract :

Scurvy has wreaked havoc among European sailors since the beginning of the great transoceanic sailings in the 14th century. A preventive remedy was known to the Vikings as early as the 9th century: the malt carried on their ships and its infusion prepared on board. This effective antiscorbutic was forgotten or ignored by naval authorities in both northern and southern Europe. Four centuries passed before trial and error led European navies to test the fresh malted infusion alongside lemon juice on board their ships. In the meantime, several million sailors of all nationalities died or were disabled by scurvy.

This dark side of the Great Discoveries is seldom studied. It highlights the sacrificial policy pursued by the European authorities to colonise the world beyond the oceans from the 14th century onwards and to generalise all-out naval war on Europe's coasts from the 18th century onwards. The health of the sailors, often recruited by force from among the poorest, was of no concern to the naval authorities. The bodies thrown overboard made this scourge of the seas invisible. Officers who fed on fresh produce rarely died of scurvy.

England, the world's leading maritime power, tested beer, malt, lemon juice, fresh produce and sauerkraut against scurvy. In 1793, England introduced a worldwide policy of maritime blockades and had to worry about the health of the crews of the navy who manned these blockades. In 1796, the Admiralty decided against malt infusion in favour of lemon or lime juice. The distribution of fresh or concentrated lemon juice became compulsory on-board British squadrons. By 1815, scurvy in the British warship fleet had almost vanished. This preventive measure proved highly effective.

However, at the end of the 19th century, scurvy was still rife among sailors in the English merchant fleets and those of other European countries. Lemon or lime juice was not distributed on a daily basis, or it was adulterated.

In the 20th century, the scourge of scurvy diminished thanks to technical progress in shipping: shorter voyages, more frequent provisioning, refrigerated holds for fresh produce, etc. In 1933, ascorbic acid was chemically synthesised. The commercial reign of vitamin C began. The old antiscorbutic remedies such as malt and lemon juice were gradually abandoned by sailors, except on Arctic and Antarctic expeditions.

Résumé :

Le scorbut a fait des ravages parmi les marins européens depuis le début des grandes navigations transocéaniques au 14ème siècle. Un remède préventif était connu des Vikings dès le 9ème siècle : le malt embarqué sur leurs bateaux et son infusion préparée à bord. Cet antiscorbutique efficace a été oublié ou ignoré des autorités navales du Nord comme du Sud de l'Europe. Quatre siècles se sont écoulés avant que des essais tâtonnants conduisent les marines européennes à tester à bord des navires l'infusion fraîche de malt en parallèle des jus d'agrumes. Entre temps, plusieurs millions de marins de toute nationalité ont péri ou sont devenus invalides à cause du scorbut.

Cette face sombre des Grandes Découvertes est rarement étudiée. Elle met en évidence la politique sacrificielle des autorités européennes menée pour coloniser le monde au-delà des océans à partir du 14ème siècle et généraliser la guerre à outrance sur les côtes de l'Europe à partir du 18ème siècle. La santé des marins recrutés souvent de force parmi les plus pauvres ne préoccupe pas les autorités navales. Les corps jetés par-dessus bord rendent *invisible* ce fléau des mers. Les officiers nourris de produits frais meurent rarement du scorbut.

L'Angleterre, première puissance maritime du monde, fait tester tour à tour la bière, le malt, les jus d'agrumes, les produits frais, ou la choucroute contre le scorbut. En 1793, elle mondialise sa politique de blocus maritimes et doit alors se soucier de la santé des équipages de sa marine de guerre qui assurent ces blocus. En 1796, l'amirauté tranche contre l'infusion de malt et en faveur des jus d'agrumes. La distribution de jus de citron frais ou concentré devient obligatoire à bord de ses escadres. En 1815, le scorbut au sein de la marine de guerre anglaise a presque disparu. Cette mesure préventive s'avère très efficace.

A la fin du 19ème siècle, le scorbut sévit toujours parmi les marins des flottes marchandes anglaises ou celles des autres pays européens. La distribution quotidienne des jus de citron n'est pas systématique ou ces jus sont frelatés.

Au 20ème siècle, les ravages du scorbut diminuent grâce aux progrès techniques de la navigation : voyages plus courts, ravitaillements plus fréquents, cales réfrigérées pour les produits frais, etc. En 1933, la synthèse chimique de l'acide ascorbique est réalisée. Le règne commercial de la vitamine C commence. Les anciens remèdes antiscorbutiques comme le malt ou le jus de citron sont peu à peu abandonnés par les marins, sauf lors des expéditions arctiques ou antarctiques.

1. Introduction

Scurvy has been known on land since ancient times, during periods of famine, war, siege, or simply malnutrition. Until the 14th century, scurvy had little effect on sailors. Most Europeans followed sea routes along known shores. This coastal trade ensured regular supplies of fresh produce. Scurvy threatened when sailors got lost on the high seas after storms or navigational mishaps.

The picture changed in the 14th century. Scurvy was feared by European sailors with the onset of transoceanic navigation and the Portuguese exploration of West Africa. Between 1415 and 1488, maritime exploration of the Atlantic shores of Africa as far as the Cape of Good Hope began. It was to cost the lives of many sailors, who were decimated by scurvy. Columbus's four voyages to America (1492-1504) ushered in the era of the great discoveries and long transoceanic voyages, and with them the era of the seaborne scurvy plaguing most European sailors.

Yet history tells us that Viking sailors knew of a cure for scurvy as early as the 9th century. Scurvy did not affect the Scandinavians who sailed to colonise Iceland in 940, who took malt on board their transport ships to cross the North Atlantic between Norway and Iceland. Sprouted barley and its vitamin C protected against scurvy.

Over the centuries, European navies overlooked the effectiveness of sprouted grains and malt against scurvy. Scurvy and a number of anti-scurvy remedies (fruit, lemon juice, fresh vegetables, herbs, beer) were described as early as the 13th century, but European maritime authorities hesitated as to whether they should be adopted and, above all, whether they should be used systematically aboard ships. Opinions continued to diverge until the practical ideas of Lind and MacBride, and the decisive experiments at sea done by James Cook and La Pérouse at the end of the 18th century.

Between the 14th and 18th centuries, this wrong-headed policy of the European naval authorities cost the lives of thousands of sailors, who were often forcibly enrolled in the ports. Scurvy was seen as the curse of sailors, a misfortune as inevitable as storms and shipwrecks. This lack of foresight did not prevent the use of citrus fruit or fresh vegetables on the coasts of Africa and Asia when scurvy struck. The effectiveness of citrus fruits and fresh vegetables had been well known in Europe since the 13th century. From the 17th century onwards, accounts of sea voyages describe the effectiveness of lemon juice or palm sap against scurvy. But exotic fruits and vegetables don't grow in European ports!

How could an effective antiscorbutic based on plants grown in Europe be found for crews leaving its shores? Or to put it another way, why was the use of malt, known and produced in Northern Europe since antiquity, not generalised on board ships at that time?

At the end of the 18th century, Captain Cook's three round-the-world voyages proved that malt infusion was a good antiscorbutic, alongside other recipes that had been tested in conjunction with it. Unfortunately, malt infusion was not widely

used by the English navy, which preferred lemon juice. Other European navies were no better.

In the meantime, English brewers altered their malting methods. They opted for final drying of the malt at a high temperature and prolonged cooking of the wort before fermentation, industrial techniques that made the beer more stable and denser but destroyed the sensitive vitamin C. English beer remained nutritious and rich in the amino acids produced by fermentation, but it had lost the original anti-scorbutic properties of the sprouted barley or wheat in the malt.

In the 19th century, beer was still taken on board ships, particularly those exploring the polar seas. It was known that fresh beer was a good antiscorbutic and the pasteurisation of beer had not yet been invented. But the results remained contradictory as to its effectiveness against scurvy because of the modified industrial methods of malting and brewing.

At the beginning of the 20th century, scientists successfully isolated L-ascorbic acid and understood its effects on the human metabolism. Chemists soon knew how to synthesise it. It would to be sold under the name "Vitamin C".

The intertwined history of scurvy and malt infusions highlights the close links between beer, its ingredients and the evolution of human societies. Ever since the first great voyages on the high seas, a remedy against scurvy was available to European naval authorities: malt infusions made on board ship. Rigid economic organisations, conservative attitudes in the Admiralty and, above all, a disregard for sailors' health prevented the widespread use of malt provisions on board ocean-going ships for centuries, and slowed it down during the 19th century. This blindness and ineptness on the part of the European naval authorities led to countless deaths and disabilities among sailors of every European nation.

By the end of the 19th century, hygiene was improving on the long transoceanic voyages that were becoming increasingly common. This progress stemmed from developments in shipbuilding, the colonial empires that controlled fresh produce supplying ports on all the shores of the globe, and finally the invention of artificial cooling and the installation of refrigerated holds to preserve fresh produce. These technologies consigned antiscorbutic remedies to oblivion. The technique of making fresh infusions of malt on demand on board ships would have been experimental and marginal, if not non-existent, in the lives and survival of sailors for six long and deadly centuries.

Europe is not the only maritime power in the world. China, South-East Asia and Indonesia have a long maritime tradition. Asian sailors have also endured scurvy. But unlike Europe, they recognised very early on that sprouted products or fruit and vegetables protected against scurvy and widely used them aboard their junks.

The Asian picture contrasts with that of a Europe that saw itself as being at the cutting edge of progress in every field, but which scorned the remedies against scurvy, not because of technical or scientific shortcomings, but because of the deeply unequal social management of the crews of its military or merchant fleets. The life of an ordinary sailor was not worth much to the European naval authorities. The Great Discoveries followed by the colonial epics celebrated by history books

hide a very dark side. The two main causes of death at sea during the classical era were scurvy and typhus. The death toll from maritime scurvy was estimated at over a million between 1600 and 1800. With the boom in colonial trade in the 19th and 20th centuries, this death toll increased, mainly affecting the crews of merchant navies, who worked and sailed in appalling conditions. Seafarers, like miners, paid with their lives and their health for the "miracle" of European prosperity.

Leaving the seas to come ashore, scurvy reappeared in the trenches of the Eastern Front during the 1914-18 war. Remedies were found: the sprouting of peas or beans followed by light cooking. They revived an ancient technique never forgotten by Asian sailors, known to the "barbarian" Vikings but forgotten or scorned in Europe.

The tragic world tour of scurvy comes to an end with this historic loop between West and East.

2. An old antiscorbutic recipe forgotten by Europeans

For most of its history, mankind has sailed the world's seas without losing sight of its shores. This coastal navigation to cross inland seas such as the Mediterranean, the Baltic, the Arabian Gulf, the Bay of Bengal or the China Sea commits sailors to eight to ten days between two ports of call and in good weather. Not long enough for scurvy to strike sailors or passengers. Symptoms of scurvy appear after one to three months of total vitamin C deficiency.

Coastal sailing allows crews to stock up regularly on fresh water and fresh produce. This way of sailing did not endanger the health of the sailors, who were more afraid of storms, shipwrecks and piracy.

The long seafaring voyages of the peoples of the Pacific and southern Indian Oceans several millennia ago must be set aside[1]. Little is known about these sailings except that they took Austronesian groups thousands of kilometres out to sea from their original homes in Taiwan and the archipelagos of South-East Asia. The techniques used and the question of food on board remain poorly documented. But we do know that in modern times, Chinese and Malay sailors took seeds on board to make them sprout during their voyages (5. The Chinese knowledge unknown to Europeans).

Seafaring techniques and ambitions changed at the dawn of the 15th century in Europe. From the 1420s onwards, the Portuguese explored the Atlantic coasts of Africa. Leaving the vicinity of Gibraltar, their ships avoided the coastal winds blowing from the south to find the favourable trade winds in the open sea and then set a south-easterly course towards the African coast. The caravels were able to sail upwind the Gibraltar headwinds towards the southern hemisphere. The

[1] The Indian Ocean, and even more so the Pacific, were explored and their islands and shores colonised by daring seafaring peoples (Austronesians) 6,000 years ago in the case of Oceania, and between the 5th and 15th centuries in the case of the Indian Ocean.

captains were able to calculate their latitudes using the nautical astrolabe[2]. In 1415, Henry the Navigator founded the Maritime University of Sagres and financed maritime expeditions along the west coast of Africa. The French (mainly Basque sailors) followed suit, then the Dutch.

In December 1487, Bartolomeu Dias de Novais' two caravels were sailing along the shores of present-day Namibia. A fierce storm carried them southwards for 13 days, far from the coast of southern Africa. On the high seas, the captain set a course to the north-north-east (thought to be around 28°), unknowingly round the southern tip of Africa, and again sailed within sight of its coast, which this time was to the west. He was sailing on a new ocean. Bartolomeu Dias was able to sail for a long time without seeing land, thanks to the nautical astrolabe, his navigational skills, his stubbornness and, as we shall see below, the sacrifice of his two crews decimated by scurvy, including his own brother. His navigation in the open ocean was a technical success with incalculable consequences. The nautical charts drawn up as the discoveries were made would do the rest. Reliable navigation on the high seas could begin.

Fig. 1: the *Erdapfel* (*terrestrial apple*), the oldest preserved globe, was made by Martin Behaim between 1491 and 1493 in Nuremberg. It does not show the American continent.

The Spanish reached the American coast in 1492, followed by the English to Labrador with Cabot (1497), then the French to Florida and Hudson Bay with Verrazano (1524) and to the St Lawrence with Cartier (1534)[3]. Reliable navigation on the high seas did not mean safe navigation. A new danger arose from these long transoceanic voyages. Scurvy hit the crews hard. Ships were unable to make port calls or stock up on fresh produce, sometimes for several months.

In the 16th century, it took one to two months to cross the Atlantic in ships each carrying 30 to 50 men. The holds were loaded with biscuits[4], grain, salted and dried meat and fish, beer, wine and barrels of fresh water. The narrowness of the ships, the rapidly putrifying water and the salty nature of the food wreaked havoc. After one or two months, scurvy set in, even if sea fish were caught. The disease was well known on the European continent, where famine and malnutrition were rife. Sailors recruited in European ports, often suffering from nutritional deficiencies before embarking, were all the more susceptible to scurvy.

---

[2] Around 1485, Martin Behaim, a German cosmographer who became Prince Henry the Navigator's astronomer, taught Portuguese captains to calculate their latitude on the high seas by day, using the astrolabe, the meridian height of the sun and declination tables. Previously, they had only calculated their latitude at night, far from the equator, by observing the North Star with a "Jacob's staff".

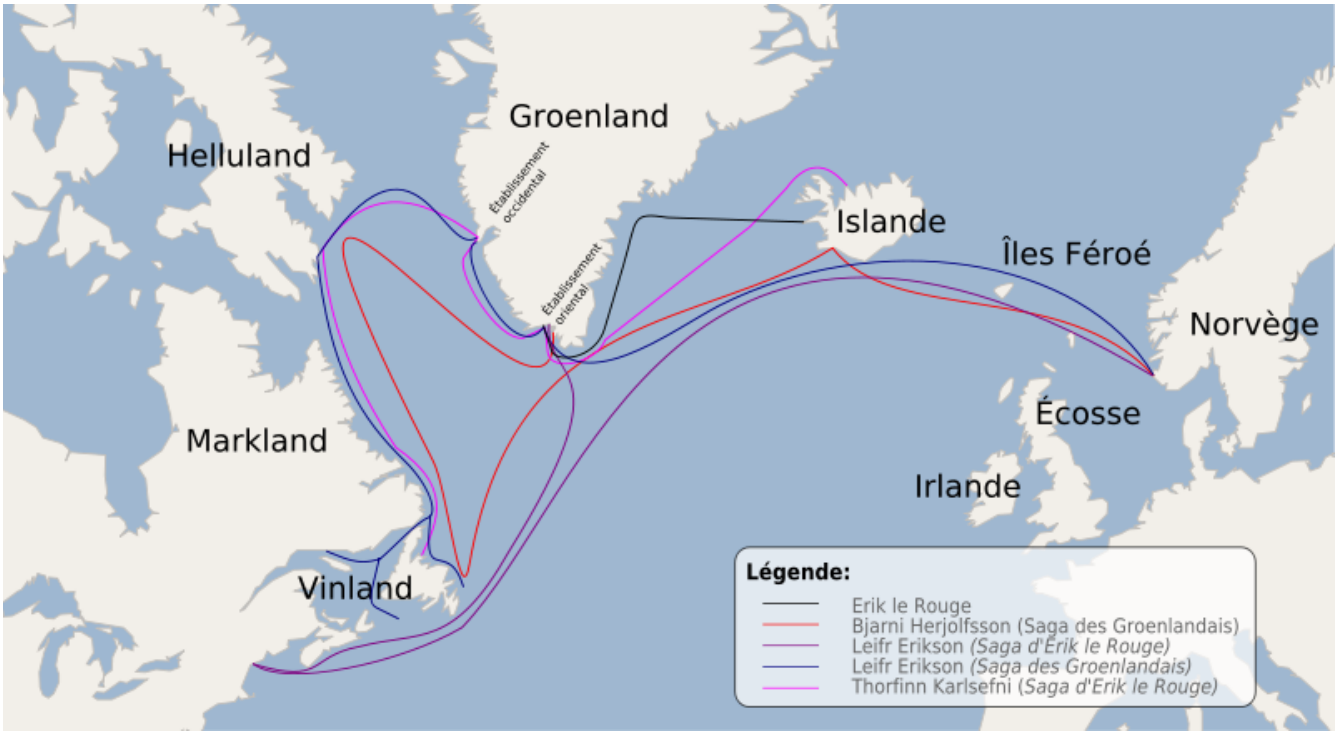
[3] Ships from the Basque Country, Saint Malo and Dieppe were already visiting the North American coasts and St Lawrence Bay around 1500, trading furs for metal tools with the North Amerindians. The North Atlantic route, which became commonplace in the 16th century, was very strenuous and dangerous for the health of sailors.

[4] Twice-baked (bis-cuits) breads resistant to mould and worms at sea for no more than four to five weeks.

2.1. *The malt used by Viking sailors*

The captains and sailors of the 15th and 16th centuries were not the first to cross the Atlantic. The Vikings had regularly sailed across the North Atlantic between Norway and Iceland since 874, when Iceland was first colonised, without being affected by scurvy. A genuine maritime bridge was established between Iceland, Ireland, the British Isles and Norway. The shorter voyage and the stopovers in the Faroe and Hebrides islands partly explain the good sailing of the merchants and warriors of the Viking era. However, the North Atlantic provided no fruit or vegetables, only fish and a few berries.

One habit of Viking sailors protected them from scurvy. They would not set sail without a supply of barley (or rye or oat) malt to make an infusion or brew beer on board. Their *knörir*, wide open ships adapted to the high seas, could carry goods, people and even livestock. Malt is nothing more than cereal seeds that have been germinated for a few days before being dried. Once dry, malt keeps for a long time and cannot re-sprout with humidity. Like all germinated seeds, malt is rich in vitamin C. The beneficial effects of malt certainly contributed to the success of the Icelanders' voyages to Greenland and North America. The Scandinavian sagas often mention the use of malt on board ship.



Map 1: Scandinavian sailors crossed the North Atlantic from the 10th century onwards.

Scurvy on land was known to the Nordic peoples who were deprived of fresh food during the long winter months. *Scorbutus* is a Latinisation of medieval Northern European vocabulary: Old Swedish *skorbjub*, Danish *scorbuck*, Old

Icelandic *skyrbjugr*, Middle Dutch *scheurbuik*. *Skyrbjurg* would mean "oedema (*bjugr*) from curdled milk (*skyr*)", and *scheurbuik* "to break, tear (*schoren*) the belly (*bük*)", one of the haemorrhagic effects of scurvy.

Eirikr Thorvaldson left Iceland, rediscovered Greenland around 985 and colonised it three years later by organising a new crossing with around thirty *knörir*, the Viking transport ship[5]. His son Leif Erikson sailed from the young Greenlandic colony to Newfoundland, which he named Vinland, around the year 1000. Shortly afterwards, Thorfinnr Karlsefni also attempted to colonise Newfoundland with three ships and 160 people. All these voyages on the high seas with men, women and livestock took place without any loss of life from scurvy. The *Saga of Thorfinn Karlsefni* (or *Saga of Eric the Red*) recounts the details of these discoveries and attests to the care taken by Norse sailors to sail with provisions of malt.

Fig. 2: a *knörir*, the Viking transport ship

The Scandinavian sagas tell us about this tradition, which was common to the peoples of Northern Europe at the time. Brewing beer on board was not a problem. Malt is made from grains that are germinated and then dried. Unlike raw grain, it cannot therefore (re)sprout when exposed to shipboard humidity. The liquid is supplied by the fresh water on board. The only technical issue is to make and keep a fire going on board in order to heat the water and infuse the malt. Vitamin C comes from malt, or more precisely from the sprouted grains (barley, wheat, rye) from which it is made. It alone provides the antiscorbutic. A simple infusion of malt, without alcoholic fermentation, provides an antiscorbutic drink. Alcoholic fermentation loads the beer with other vitamins and trace elements, but partially destroys vitamin C and therefore provides less protection against scurvy than malt infusion[6].

In 1010, Karlsefni sails from Iceland to Greenland with a convoy of boats to trade with Leif, son of Eric the Red settled in his Brattahlid colony. Leif offers them hospitality. But the feast of Yol, celebrated at the winter solstice, approaches and he is running out of beer. His guests with their berthed boats appease Leif's fears:
« *It shall not be so, Yeoman!, said Karlsefne; we have in our ship, both malt and corn; take as much as thou desirest thereof, and make ready a feast as grand as thou wilt! This Erik (Leif) accepted, and now preparation was made for the feast of Yule, and this feast was so grand that people thought they had hardly ever seen the like pomp in a poor land*'. » [Saga of Thorfinn Karlsefni]

This difference in the effectiveness of malt and beer was the cause of many misunderstandings over the centuries, and of countless scurvy-related deaths

[5] Gunnbjörn Ulfsson before him had set foot on Greenland between 876 and 932, or had glimpsed its shores, driven by a storm. The sagas are not accurate on this point. This discovery prompted Eirikr Thorvaldson, known as Eric the Red, to attempt to emigrate westwards. He was certain he would be banished from Iceland after killing a beer companion, and could not return to Norway from where he was already banished.

[6] In pure alcohol, ascorbic acid crystallizes, which protects vitamin C. But the alcohol content of beer is too low to achieve this effect.

among sailors. Sailors and naval authorities believed that beer automatically inherited the benefits of malt (**4.2**).

After the Viking period (8th-11th centuries), Nordic sailors did not seem to suffer from scurvy, despite the fact that they had forgotten to stock up on malt on board ship. Other fermented products such as sauerkraut provided the precious vitamin C. The Hanseatic League's maritime trade (1241-1630) in the Baltic and North Seas had made its benefits known to the Dutch and English.

However, at the dawn of the 15th century, this Nordic anti-scorbutic recipe was all but forgotten by European sailors, just like that of the Viking malt, except by the Dutch, who almost systematically took sauerkraut on board when sailing to their trading posts in Africa and later to their colonies in the Moluccas and Java from 1605, and in America from 1609.

Fig. 3: VOC ships arriving in Cape Town, their Southern Africa trading post

2.2. Oblivion of the antiscorbutic recipes inherited from the Vikings

Why in the 16th century did Spanish, Portuguese, French, English and Dutch captains forget that sprouted grains and malt were the best remedies against scurvy, in the absence of fermented vegetables?[7]

The explanation seems obvious to Mediterranean captains unfamiliar with Nordic brewing traditions. But the crews often came from all over Europe. German and Flemish merchants financed numerous maritime expeditions to America and brought on board their compatriots, lansquenets who were eager for gain and familiar with the farming world, and so with beer and malt.

Ignorance of the beneficial effects of sprouted grains was less of an issue for the French, English or Flemish. Sprouted grains, malt, beer, cider and perry were all part of their food culture.

Beer, or any other fermented product such as sauerkraut, was gradually identified in the 16th century as a remedy for scurvy. But the length of transoceanic voyages meant that its effectiveness could not be tested. Beer could never be kept on board ship for 12-13 weeks, the average time for the first symptoms of scurvy to appear. Packed in barrels, it was drunk quickly from the first days at sea. When scurvy struck sailors after several weeks at sea, only cooked wine, gin or rum remained drinkable in the holds. These alcoholic beverages were healthy compared to putrid water against cholera, dysentery, hepatitis, etc., but completely ineffective against scurvy.

[7] The Dutch, Danish and Swedish navies had lost the secret of the antiscorbutic malt of their Viking ancestors, but not the secret of the fermented cabbage, nor that of the infusion of pine buds or cruciferous plants of the *Cochlearia* botanical genus (see below).

As for the grains, they were the prey of rodents and worms. These reserves were protected by subjecting the loaves to a double baking process (bis-cuit) to harden them and make them more resistant to humidity and rotting in the holds.

There is no mention of raw grain being germinated on board European ships, or of malt being left to infuse, at least not until the end of the 18th century, nor of sailor's biscuits made from malt flour[8].

As early as the first crusades in the Near-East, Europeans identified certain antiscorbutic plants such as those of the *Cochlearia* genus (3.2) and crucifers. These "scurvy herbs" eclipsed the ancient Nordic remedies.

3. The transoceanic voyages from the 15th century

Right up until the end of the 18th century, ship's logs recount the litany of havoc wreaked by scurvy. Scurvy is seen as a fate, a misfortune or a divine curse that sailors have to endure, although some travellers recommended useful dietary measures as early as 1227[9]. Beer was recognised as a reliable antiscorbutic, alongside fresh fruit and vegetables. The vitamin C contained in beer comes from the sprouted grains from which the malt is made (Fig. 8). As long as malting and brewing in Europe followed traditional techniques, beer retained for sailors the benefits of vitamin C derived from germinating cereals. These techniques involved a slow, low-temperature drying of the germinated grains, a short cooking of the wort and no heating of the finished beer. From the 18th century onwards, malting techniques dried the germinated grains at high temperatures, destroying their vitamin C content. Modern malt is no longer anti-scorbutic (4.6). Furthermore, pasteurisation by heating bottled beer, which became widespread in the 20th century, definitively destroys vitamin C. But by this time, the role of fresh fruits and vegetables had already been grasped. For 150 years, beer had no longer been regarded as a natural antiscorbutic.

Attributing the merits of sprouted grains to beer, sailors and captains very rarely thought of stocking up on malt aboard ship. Sprouted grains were practically non-existent in the rations and provisions for sailors embarking for the high seas. Barrels of beer, cider, wine and brandy were used as insurance against scurvy (3.3 and 3.4). The ship's surgeons stocked up on medicinal herbs and *scurvy herbs*.

3.1. The awful hardships endured by the crews

Scurvy causes oedema, swollen and purulent gums, tooth and hair loss, severe haemorrhaging, exhaustion and finally death. Sailors who survive are toothless, very weak and prematurely aged. Symptoms of scurvy appear after

[8] In any case, the single or double baking would have destroyed the vitamin C.

[9] Unavoidable for the sailors and cabin boys, but the officers guarded against scurvy by taking on board fresh food (poultry, pigs, vegetables, etc.), good water and quality spirits for themselves. The two social categories cohabited on board and did not mix. The sailors lived and slept in the forecastle at the bow, the officers in the forecastle at the stern.

three to six months of poor nutrition. For malnourished sailors of this era, scurvy appeared more quickly, often after 40 to 60 days at sea. This invisible progression of scurvy made it difficult to prevent. It was difficult for the naval authorities of the time to agree on a preventive diet after Nordic recipes (malt, sauerkraut) had been forgotten. What's more, fresh fruit and vegetables could not be kept on board for very long, except for the officers. Scurvy, seen as an unavoidable illness, was a matter for curative treatments, not preventive diets.

One of the most appalling descriptions of scurvy can be found in the account of Jacques Cartier's second voyage to Canada in 1535:

"… began the illness all around us with a marvellous force, & the most incongruous: for some lost their substance, & from then on, their legs became fat & swollen & the nerves receded & blackened like charcoal, & for some they were all strewn with drops of blood like purple: then the said illness rose to the hips, thighs & shoulders, to the arms & neck. And to all of them came a mouth so foul & rotten from the gums, that all the flesh fell out down to the root of the teeth, which almost all fell out. And the disease took hold of our three ships so much that by mid-February, out of a hundred and ten men, not ten were healthy, so that one could not help the other, which was a pitiful thing to see, considering where we were." [Cartier 1535, 35-35, Beer-Studies translation]

Fig. 4: the Micmac Amerindians of the St Lawrence Bay make an infusion of *annedda* (pin buds)

Fig. 5: symptoms of scurvy drawn by marine surgeon Henry W. Mahon in 1841. National Archives.

When Vasco da Gama returned to Portugal in 1499 after his first voyage around Africa, half his sailors, including his own brother, had died, most of them from scurvy. Magellan's circumnavigation (1519-1522) was tragic for the crews of his three ships: 247 sailors out of 275 died of scurvy during the three years of this voyage[10]. In April 1529, Jehan and Raoul Parmentier left Dieppe (France) to trade spices in the Indian Ocean with two ships and 150 sailors. They reached the Maldives and then Sumatra, but died at the end of 1529. During the outward and return voyages, the sailors died of scurvy. In June 1530, only some forty returned to Dieppe. In his diary, Jacques Cartier states that scurvy killed 25 of the 110 sailors on his 1534 expedition to Canada. Willem Barentsz died of scurvy in 1597 on the island of New Zealand, in what is now Russia, while searching for the North-East Passage. In 1606, the crew of the Portuguese Pedro Fernandez de Quiros discovered the New Hebrides archipelago (now Vanuatu), but returned decimated during their two voyages. William Bradford wrote in January and February 1621 that the colonists who landed at Cape Cod (Massachusetts) died on land of scurvy, deprived of the beer that the sailors kept on board the Mayflower for their own use, until they themselves were decimated by scurvy. The Dane Vitus Bering, leader of a Russian expedition, was shipwrecked in Kamchatka in 1741 after reaching the coast of Alaska and discovering the strait that bears his name. The crew was struck down by scurvy. Bougainville's round-the-world expedition between 1767 and 1769 was badly struck twice by scurvy in the Pacific.

These are just a few famous examples of explorations or maritime voyages decimated by scurvy.

The military naval expeditions of the various European fleets wreaked even more terrible havoc on crews recruited, often by force, from among the poor, the prisoners and the malnourished. As soon as they set sail, the poor health of these "sailors" made them a target for scurvy. Table 1 gives an idea of how many sailors died from scurvy during lengthy transoceanic voyages. The examples chosen fall

---

[10] Antonio Pigafetta's logbook, secretary on board of Magellan's admiral vessel: "*Wednesday November 28, 1520, we emerged from the said strait [that of Magellan] and entered into the Pacific Ocean, where we stayed three months, and twenty days without taking food or other refreshments. We ate only old biscuit turned to powder, full of worms and stinking, because of the scum of urine that rats had let on it, and ate the good part, and drank a fouled yellow water. We also ate beef hides, which were the major mast (so it should not break the shrouds) and were very harsh because of the sun, rain and wind. And we let them four to five days in the sea, then put them a little on the embers, and then eat them. And still have enough of sawdust and rats which cost half a crown one, let no one could find enough. In addition to the above said evils, this evil that I will tell was the worst.*
It is that the gums of the greater part of our crew were growing above and below, so hard they could not eat and so they died, as much as nine people died ... But besides those who died, twenty-five or thirty became sickened, of various diseases on arms as well legs and other places, so very few have remained healthy." (Le voyage de Magellan, 114-115. translation is mine)

In the Strait, Magellan's sailors had made provision of wild celery (austral *Apium*) they have preserved in vinegar. This powerful antiscorbutic had limited the ravages of malnutrition and scurvy. The second crossing of the Pacific, undertaken by Jofre de Loaísa, would be a hecatomb. Between May 26, 1526 (coming out of the Magellan Strait) and September 4 (arriving at Guam island in the Marianas), 40 sailors died on the sole admiral ship (op. cit., 378, 380-381).

into the category of both voyages of discovery and naval military expeditions. In both cases, the mortality rate is appalling.

	Destination	Navigators	Mortality	Causes
1227	Palestine	Gilbertus Anglicus	Great	Scurvy
1492	West Indies	Columbus	**1** man out of **87**, in the crews of the 3 caravels	Start in good season kept scurvy away
1497-99	Portugal-India-Portugal	Vasco da Gama	**120** sailors out of **160** in 11 months	Scurvy
1519	Circumnavigation	Magellan	**247** sailors out of **275** in 3 years	Scurvy
1529	Indian Ocean	Parmentier	**110** sailors out of **150**	Scurvy
1535	Canada	Jacques Cartier	**25** sailors out of **110**	Scurvy
1545	English Navy	English Navy	**3,512** men out of **1,000** in 10 days	Scurvy, plague [Keevil 1957]
1585-86	Cape Verde Islands	Drake	**800** out of **2,300 men**	Malaria, scurvy (?)
1606	New Hebrides, Pacific Ocean	Fernandez de Quiros	Crews decimated during 2 voyages	Scurvy
1712	Swedish Navy	Swedish Navy	In October **274** among **4,552** men. In November **489** among **4,245** men	Scurvy, infection, poor health on embarkation
1732-1806	Africa, India	Swedish East India Co.	**132** expeditions with crews of 110-150 men, around **2,000** deaths	Scurvy, infections, drowning
1737-39	China	Vessel "Stockholm"	**26** out of **100** men	Scurvy, infections
1741	Swedish Navy	Swedish Navy	in August **729** out of **1,976** men	Scurvy, infection, poor health on embarkation
1743-45	China	Vessel "Riddarhuset"	**32** out of **100** men	drownings, starvation
1740-44	Circumnavigation	Georges Anson	**+4/5** of the crews. **1,812** sailors out of **2,000**	Scurvy
1767-69	Circumnavigation	Bougainville	**2** out of **213** & **3** out of **120**	Scurvy under control
1768-71	Circumnavigation	James Cook	**30** among **85** men	Scurvy
1772-75	Circumnavigation	James Cook	**1** death ("not at sea") among **112** men	Malt and lemon juice have prevented scurvy
1770	Netherlands - Cape Town	Carl P. Thunberg on a ship owned by the Dutch East India Co.	**136** among around **250** men	Digestive infections, scurvy, syphilis
1780-81	Many destinations	Navy anglaise	**1** out of **27** sailors per month	Scurvy
1804	English Navy	Admiral Nelson	**9/10** of all deaths	Tuberculosis. Scurvy avoided by lemon juice
1780	English Navy		Overall death rate **125/1000**	All causes combined
1811	English Navy		Overall death rate **40/1000**	idem
1830	English Navy		Overall death rate **20/1000**	idem
1913-14	English Navy		Overall death rate **3,25/1000**	idem

Table 1: after Anon. 1960, *Historical notes*, p. 10 and other examples added

The expedition of Commodore Georges Anson to the Pacific is an example of a true health disaster. More than 2,000 men embarked at Plymouth in 1740 on eight of his majesty's ships. Only 188 returned in 1744, after a pirate race in the Pacific to plunder gold and silver from Spanish galleons. The keen observations of the chaplain Walter who accompanied Anson highlighted the effectiveness of diets based on fruit and vegetables in treating scurvy. When the ships called at the islands of the South Pacific and at Juan Fernandez and Tinian, the sailors whose gums had swollen recovered within a few weeks.

Mortality was even higher on-board warships (overcrowding of sailors and soldiers, endless sailing, stays in harbours, blockade cruises, etc.). During the Elizabethan era, the British navy suffered hecatombs (10,000 deaths from scurvy

in 20 years, according to Richard Hawkins). The most tragic period was the 18th century. Naval wars escalated on all the world's seas. The *Royal Navy* alone, the main player in this strategy, lost 75,000 men to disease (scurvy, typhus, etc.) during the Seven Years' War between 1756 and 1763 [Masson 1985, 23, 28].

A classical account of this kind is contained in the book of Carl Peter Thunberg (1743-1828), the Swedish physician and biologist, *"Resa uti Europa, Afrika och Asien"* (*Journey to Europe, Africa, and Asia*) given out in four volumes between 1788 and 1793. Describing his journey to Africa, Thunberg wrote : "*One hundred and fifty men lay sick nearly the whole time until we crossed the Equator and the weakest of them - 136 men - had died off.*"

The Swedish Commander-in-Chief at the time, General Lewenhaupt, said in a report to the King of Sweden in 1742 that these losses were caused by epidemics and scurvy on board. In 1741, almost 20% of Swedish naval personnel died (Table 2).

	October 1712	November 1712	August 1741
Healthy	4,552	4,245	1,967
Ill	2,409	2,267	2,282
Dead	274	489	729

Table 2: after Anon. 1960, *Historical notes*, p. 15

The usual crew of a ship in those days was no more than 150 men, but a larger number probably embarked at the start of the voyage to anticipate this mortality [Anon. 1960, Historical notes, p. 15].

After the Seven Years' War (1756-1763), the European powers resumed their voyages of exploration around the globe. None of the captains allowed scurvy to decimate their crews, because there were scientists on board who were aware of the research into anti-scurvy treatments, and officers, such as La Pérouse and James Cook, who had become concerned about the health of their crews (cf. **4**).

It was a different matter for the military armadas of these same European states, subject to the goodwill of the navy's suppliers and a conservative administration. These suppliers negotiated contracts that the navy sets at very low prices, for one naval campaign or for several years. The economic equation and the quest for profit alone governed the quality of provisions. The health of the officers, the chief officers, the ship's secretary, the bursar and the chaplain were taken care of. But the crew, assembled by professional recruiters who scoured port taverns and prisons, were not considered experienced personnel. Their lives and health were of little importance to the Admiralty, which regarded sailors as renewable resources.

The death toll from maritime scurvy was estimated at over a million victims between 1600 and 1800 [Hughes 2000: 989; Roddis 1951: 72]. This estimate is based on the testimony of Richard Hawkins (1562-1622), who, like Francis Drake, was an official pirate for Queen Elizabeth I. He put the number of scurvy deaths he knew of during his 20 years at sea at 10,000 men, an average of 500 per year

for the English navy alone [Roddis 1951: 48][11]. Extrapolated over two centuries, this gives a figure of 100,000 'English' deaths, and one million for all the European navies and merchant navies between 1600 and 1800. This figure is underestimated because the ravages of scurvy peaked in the 18th century. They continued to decimate sailors on merchant ships in the 19th century[12]. Historians point out that scurvy caused more deaths worldwide than all the naval battles, shipwrecks and other tragedies at sea put together.

A nagging question arises: why were the well-known anti-scorbutic remedies (citrus juice, fresh vegetables, malt infusions, sauerkraut, scurvy herbs) not systematised on board the warships equipped by the European naval authorities?

3.2. Europe knows early on the disease and its cure

Jacques de Vitry and Jean de Joinville, in their respective accounts of the 5th Crusade to Palestine in 1218, describe the symptoms of scurvy during the siege of Damietta [Joinville 1309, chap. LVII, p. 103].

In 1227, Gilbertus de Aguila described the symptoms of scurvy in his *Compendium Medicinae*, and recommended taking apples, pears, lemons, muscatels and other fresh fruits and vegetables on board after his voyage to Palestine, to prevent scurvy [Keevil 1957].

In 1578, R. Dodoens wrote in his history of plants about scurvy herb: "Spoonworte [*Cochlearia* sp.] … a singular remedie against the disease of the mouth … called by the Hollanders and Friselanders Scuerbuyck, against which evil it hath been lately proved to be very good and is in great estimation and much used of the Hollanders and Friesans." [Dodoens 1578, 117-118].

In 1633, one of the first descriptions of scurvy in England describes a remedy consisting of the juice of scurvy herb (spoonwort, Cochlearia officinalis) drunk in beer:

"The juice of Spoonwort [*Cochlearia officinalis*] given to drinke in Ale of Beere … perfectly cureth the disease called … of the later writers *Scorbutum*, of the Hollanders and Frisians *Scuerbuyck*, in English the scurvie …" [Version by Thomas Johnson of the J. Gerarde's *Herbal*, entry *scurvy grass*].

Between 1601 and 1603, François Martin travelled to the East Indies. On his return, his account of the voyage contained a special chapter dedicated to scurvy and addressed to Monsieur du Laurent, physician to King Henri IV and Chancellor of the University of Medicine in Montpellier: "A treatise on scurvy, which is a strange disease that occurs to those who travel to these lands".

This title relates scurvy to faraway lands and makes no link with the seafarers' diet. For the author, these countries generate the disease and also provide its cure:

---

[11] *The Observations of Sir Richard Hawkins, Knight, in his Voyage into the South Sea*, was published after his death in 1622.

[12] It is also underestimated because European national navies lagged behind the British navy in scurvy prevention in the 19th century. The French navy systematically used lemon juice only around 1860, following the military doctor René Ernest Gallerand's report, and adopting his recipe: 14 grams lemon juice + 28 grams sugar in 112 grams of water.

"there is nothing better to preserve oneself from this disease than to take Lemon or Orange juice often, or to eat fruit often, or else to stock up on Syrups of lime, sorrel, barberry and a herb called *Coclearia*, which seems to contain the real antidote, and to use it often." [Martin 1604, 128].

This *scurvy-herb* refers to plants of the genus *Cochlearia*, common throughout Europe, from Scandinavia to the shores of the Mediterranean. Sailors drink them as infusions or pressed into juice, and officers drink them as distillates. An effective remedy has been known in Europe since scurvy first appeared.

Scurvy was combated in the 16th and 17th centuries by introducing foods rich in vitamin C, such as sauerkraut and citrus fruits, into sailors' diets. But lemons and oranges were not available to the navies of northern Europe, and even less so when the wars with Charles V (r. 1519-1558) and Philip II (r. 1580-1598) in the 16th century cut off trade routes between Spain-Portugal and the Mediterranean world on the one hand, and England and northern Europe on the other.

On their homeward voyage from Canada, the sailors took spruce beer on board to combat scurvy. The Amerindians of St Lawrence Bay had taught the colonists how to prepare a decoction made from young spruce or white cedar thorns as early as 1534, when they first came into contact with Jacques Cartier. This decoction, mistakenly called spruce-beer in English, is rich in vitamin C as long as it is not boiled.

Fig. 6: pine buds

In northern Europe, the countries around the Baltic Sea had known for centuries how to prepare a type of beer containing a decoction of young fir thorns, a variant of the Canadian spruce 'beer'. In 1594-97, Willem Barentsz shipped barrels of this 'beer', known in Dutch as *jopen-bier* or *sprossen-bier*, before exploring the Arctic Ocean and the northern shores of Europe. He knew that this beer, in which young fir shoots replace hops, had antiscorbutic properties, but like all his contemporaries, he was unaware of the reasons for its effectiveness (De Veer 1609, 114-115].

On 11 December 1621, Edward Winslow wrote from the new colony of Massachusetts to his friend George Morton, who was still in London, with advice for his forthcoming crossing by boat to the colony. Edward Winslow was one of the first 102 Pilgrims to land on Cape Cod in 1620, exactly half of whom died of scurvy in January-February 1621. He advised taking with him lemon juice and beer in a metal-reinforced cask and aniseed-flavoured water:

"I thought good to advertise you of a few things needful; be careful to have a very good bread-room to put your Biskets [biscuits] in; let your Cask for Beer and Water be Ironbound for the first tier if not more ; let not your meat be dried salted, none can better doe it then the Sailors; let your meal be to hard trodden in your cask that ou shall need an Ads or Hatchet to work it out with; … bring juice of Lemmons, and take it fasting, it is of good use; for hot waters, aniseed water is the best, but use it sparingly …" [Mourt 1865, 141-142].

The anti-scurvy recipes are known to the civil population, not just to the sailors and their captains.

The evils of scurvy were well known. So were the remedies. But the economic organisation that governed naval expeditions and the conditions under which sailors were recruited and embarked stayed under the control of merchant companies, commercial leagues and investment banks, whose were not concerned with preserving the lives of sailors. Whatever the country, the principle was the same: subcontract the supply of food for ships to merchants or specialised suppliers, negotiate a low price per sailor/day, authorise a special regime for captains and officers whose know-how and loyalty are sought after. This type of management precluded any concern for seafarers, who were seen as a renewable workforce, and prevented any improvement in their diet and hygiene on board.

In addition, the often brutal and forced recruitment of sailors drew on a population of landlubbers who were ignorant of the sea, scurvy and its remedies.

The financial logic behind equipping and feeding naval forces is highlighted by the rations provided by the two most powerful European fleets of the 16th and 17th centuries, the Spanish and English navies. They left no room for vegetables and fresh produce, except for those officers who could afford them.

3.3. Beer rations provided by the British navy in the 16th century

Allowing British sailors to use fermented beverages on a regular basis is an ancient practice. Ale was part of the standard ration for sailors as early as the 14th century under the reign of Edward III (1327 to 1377). Henry VII (r. 1485-1509) set up a naval brewery in Portsmouth in 1492 to supply his ships with beer, a drink considered healthier than water at the time. English royalty had already realised the geostrategic advantages offered by a powerful fleet. The year 1492 marked the first Atlantic crossing in the service of the Spanish crown and the entry of the English navy into the fray.

In 1565, Edward Baeske agreed to supply Queen Elizabeth's navy at the rate of 5 pence per sailor per day. His surviving account books provide an insight into the quantity and quality of rations allocated to English sailors (Table 3).

English rations per sailor allocated in the 16th century			
Pounds per week	Average/day (grams)	Av./day (calories)	Calculated calorific values
Biscuit 7	455g	908	2 cal. per gr.
Salted beef 8	148g	1,036	2 cal. per gr.
Fish 3/4	48.5g	68	1.4 cal. per gr. (can)
Butter 3/8	24g	192	8 cal. per gr.
Cheese 3/4	48.5g	121	2.5 cal. per gr.
Beer 7 gallons	4.6 litres	1,932	420 cal. per litre
Total		4,257	

Table 3: after Davies C. S. 1963, *Les rations alimentaires de l'armée et de la marine anglaise au XVIe siècle*

The biscuits were wheat-based. These rations were supplemented with peas or beans, and rye. The barley supplied by the navy's suppliers was used exclusively for brewing beer. The high consumption of beer is characteristic of the country, if

we compare these rations with those of Spanish sailors, who drank a litre of wine every day. The daily ale gallon (4.62 litres) given to English sailors was the same as that given to the servants of the English nobility. Two centuries later, in James Cook's time, a gallon of beer per sailor per day became the standard.

The daily calorie count is sufficient, although a little low for the hard work required of sailors at sea. But the quality is lacking. The total absence of vegetables is noteworthy. Scurvy was almost unavoidable in a fleet at sea for more than three or four months. Apart from the addition of peas, no effort was made in the Navy until the 19th century to add vegetables to sailors' diets. After 1795, the Navy decided to use fresh lemon juice on its ships. At first, it was given as a medicine to treat sailors already suffering from the symptoms of scurvy. After several years, its use on board was generalised as a compulsory and preventive ration throughout the whole navigation.

3.4. Wine rations of the Spanish navy in the 16th century

The House of Trade (*Casa de la Contratación*) was founded in Seville on 14th February 1503 to better control the *Convoys of Treasures* and to regulate trade and sea travels between Spain and the Americas (Spanish_treasure_fleet).

Its documents, in the *Archivo General de Indias* in Seville, provide information on the wages and subsistence of the sailors and officers on board the ships that brought gold, silver and precious gems from Mexico and Peru to Spain (Table 4).

Spanish rations per sailor allocated in the 16th century (1560)			
	Food material	Quantity	Approximate caloric value
Sundays, Tuesdays, Thursdays	Bread	680g	1,695
	Wine	1 litre	1,066
	Salt beef	230g	395
	Beans or chick-peas	110g	361
	Olive oil	12ml	100
	Vinegar	…	…
	TOTAL		3,617
Mondays, Wednesdays	Bread	680g	1,695
	Wine	1 litre	1,066
	Cheese	170g	667
	Beans or chick-peas	110g	361
	Olive oil	12ml	100
	Vinegar	…	…
	TOTAL		3,889
Fridays, Saturdays	Bread	680g	1,695
	Wine	1litre	1,066
	Salt cod	230g	163
	Beans or chick-peas	110g	361
	Olive oil	12ml	100
	Vinegar	…	…
	TOTAL		3,385

Table 4: diet of soldiers and sailors in 1560, after J. Hamilton 1929, *Wages and Subsistence on Spanish Treasure Ships, 1503-1660*

Like the English rations, these diets show a total lack of fruit and vegetables. Given that vegetables could be grown in all seasons in the fertile Guadalquivir valley on the outskirts of Seville, their absence from the rations indicates that they were not much in demand as food at the time. With the exception of a small jar (*Bote*) of lemons in 1530, no trace of fresh fruit has ever been found in a ship's provisions. These lemons were not intended for sailors or soldiers, but for the three nuns (*Beatas*) transported as very privileged passengers. The Spanish already knew about the benefits of lemons, but reserved them for women and men from the better-off social classes. The officers obtained them on their own.

As the pound-and-a-half daily ration on the Treasury ships shows, bread was the staple food. Olive oil was the main source of fat. Cheese was more widely consumed than it is today. Neither milk nor butter was ever taken on board a Treasury ship. Each sailor was usually entitled to just over a litre of wine a day. In 1560, the manager of the *House of Trade* was instructed to replace each quarter of wine with two litres of cider in case the supply of wine proved insufficient. In 1503, the crown ordered the *House of Trade* to buy an annual supply of wine and flour to send to the agricultural settlers of Hispaniola (the island of St Domingue). The wine cost 117,221 maravedis and the flour 93,732[13]. According to the estimate of the manager of the *House of Trade*, wine from the fleets sailing in 1563, 1564 and 1573 cost 2,263,592 maravedis and bread 1,305,930. In 1642, a sailor's daily ration of wine cost 25½ maravedis, while his bread cost just 14.39 maravedis.

A full supply of spices was always provided: cinnamon, cloves, mustard, parsley, pepper and saffron. Onions were included less frequently than might be expected, but every two years from 1503 to 1660, garlic was omitted only three times in 1507, 1511, and 1605. Since condiments, with the exception of vinegar, were never included in rations, they were apparently not rationed.

As far as we know, rations did not tend to deteriorate. Even after 1642, when Spain entered a period of economic decline, rations remained as good in quantity and quality as before.

Not surprisingly, the mortality rate on the Treasury's ships was appalling. And judging by the medicines they carried, the infirmaries on these ships must have been very busy. In four centuries, Spain lost more cargo on its Manila galleons and those of its Treasure Fleet to scurvy (due to crews decimated and unmanoeuvrable ships) than it did to piracy and storms.

[13] The maravedi is the common copper currency, the Spanish unit of trade and account. 1 silver real = 34 maravedis; 1 escudo = 350 maravedis; 1 gold ducado = 375 maravedis. There is also a unit of account, the silver maravedi = 1/34 of the silver real.

4. The benefits of sweet wort rediscovered by MacBride and Cook

After his first voyage to the Pacific between 1768 and 1771, during which scurvy killed 30 of the 85 sailors, James Cook (1728-1779) undertook a second maritime expedition to the Southern Ocean. He was commissioned by the Royal Society of London to discover the southern continent, the 6th continent that geographers suspected existed. Cook knew that in this cold, hostile world, there were virtually no opportunities to buy fresh fruit and vegetables. The only options were fishing and hunting marine mammals. The risk of a scurvy epidemic on board was very high. Yet the ships landed in Plymouth three years later with only one accidental death. Not a single case of scurvy!

What is the secret of such a miracle?

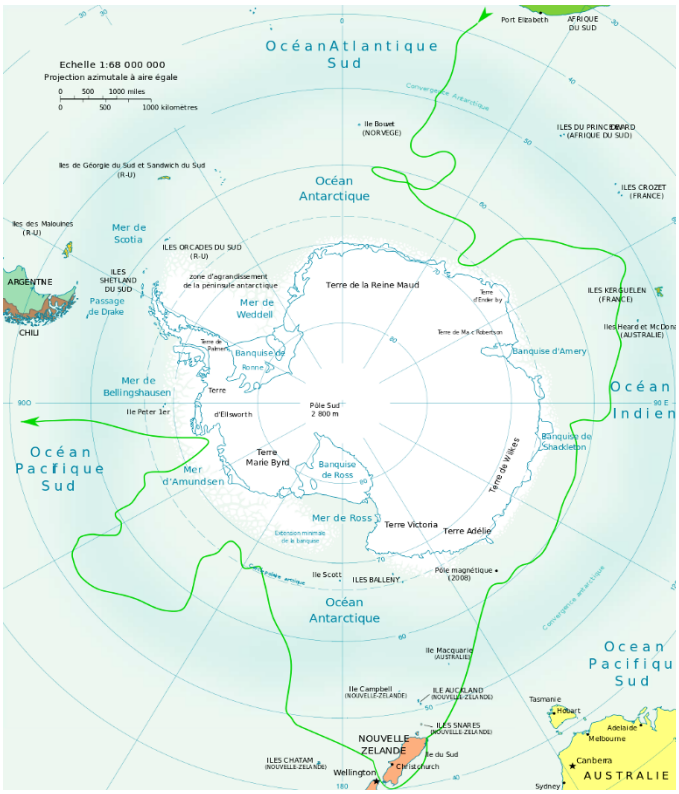


Fig. 7: the 2nd expedition of James Cook around the Antarctic continent (1768-1771)

4.1. *MacBride's method applied by Captain James Cook*

On 30 November 1776, Captain Cook received the highest award from the Royal Society of London, which commissioned his second voyage, not for the success of his exploration, but for preserving the lives of his sailors in the Southern Ocean between July 1772 and July 1774. Here is the citation that earned him this honour:

> "*Now what inquiry can be so useful as that which hath for its object the saving the lives of men? And when shall we find one more successful than that before us? Here are no vain boastings of the empiric, nor ingenious and delusive theories of the dogmatist; but a concise, an artless, and an incontested relation of the means, by which, under the Divine favour, Captain Cook, with a company of an hundred and eighteen men, performed a voyage of three years and eighteen days, throughout all the climates, from fifty-two degrees north, to seventy-one degrees south, with the loss of only one man by a distemper. What must enhance to us the value of these salutary observations, is to see the practice hath been no less simple than efficacious.*" [quoted by Smith 1918, 814]

What is this *simple and efficacious practice* used by Cook to fight against scurvy?

Captain Cook provided a beverage he called "Sweet-Wort" for his men to drink. Everyone on both HMS *Resolution* and HMS *Adventure* received a pint a day, and anyone with slight symptoms of scurvy was immediately raised to five or six pints. This "Wort" was unfermented beer, an infusion of malted grains, made up fresh to his order every day from a supply of ground malt (dried sprouted barley). The preparation of wort was very easy. Each day on board ship, the infusion was freshly prepared following MacBride's instructions:

> "*… the method in which it is proposed to prepare the wort, is to take one measure of the ground malt, and pour it on three measures of boiling water; stir them well, and let the mixture stand, close covered up, for three or four hours; after which, strain off the liquor. It must be brewed, in hot weather especially, fresh every day, for if it be allowed to grow vapid, or sourish, it will not only be unpleasant, but useless, as it would then not run easily into fermentation; but when perfectly fresh, there cannot well be a more palatable kind of drink; and I dare say, that, in general, it will sit light and easy on the stomach.*" [MacBride 1768]

MacBride described how to make a 100% malt wort (with no added sugars, molasses or raw grains) that could, depending on the circumstances, go on to the alcoholic fermentation stage. MacBride had these two drinks in mind – the unfermented beer wort (*sweet wort*) and the diluted fermented beer (*inspissated juice*) – in order to test their effect on scurvy.

Captain Cook has tried both *sweetwort* and *inspissated juice*, beside spruce beer when this beverage could be brewed ashore in New Zealand (1772, his first voyage in Pacific) with leaves of a tree similar to the American black spruce. We shall explain further what was called an *inspissated juice*.

This is a classic example of a long voyage without serious loss due to scurvy, at a time when great suffering and loss due to illness at sea, mainly the scurvy, were a common fate. *Sweetwort* was the prophylactic to which Cook attributed much of the credit of the immunity. After his ship, the *Resolution*, had been at sea non-stop from Nov. 22nd, 1772, until March 26th, 1773, we read:

> "*After such a long continuance at sea in a high southern latitude, it is but reasonable to think that many of the people must be ill of the scurvy. The contrary, however, happened. Sweetwort had been given to such as were scorbutic. This had so far the desired effect, that they had only one man on board that could be called very ill of this disease, occasioned chiefly by a bad habit of body and a complication of other disorders.*" [Cook 1777 Vol. I, 68]

Patten, surgeon on the *Resolution,* recorded his own observations in his medical journal:

> "*I have found the wort of the utmost service in the scorbutic cases during the voyage. As many took it by way of prevention, few cases occurred where it had a fair trial; but these, however, I flatter myself, will be sufficient to convince every impartial person, that it is the best remedy hitherto found out for the cure of the sea scurvy; and I am well convinced from what I have seen the wort perform, and from its mode of operation, that if aided by portable soup, sour krout, sugar, sago*[14]*, and courants, the scurvy, that*

[14] Sago refers to the starchy pith of the sago palm, a tree quite common in warm southern regions. The people of the Philippines and Pacific islands make a traditional beer from it. Their know-how used by Cook had certainly saved the crew from scurvy. The sago-beer has been given to the crew instead of the unavailable infusion of malt. As for the "courants" (currants/berries), their vitamin C content had the same effect.

maritime pestilence, will seldom or never make its alarming appearance among a ship's crew, on the longest voyages ..." [Cook 1777 Vol. II, 379-380, note ‡ of a *Discourse upon Some Late Improvements of the Means for Preserving the Health of Mariners. Delivered at the Anniversary Meeting of the Royal Society, November 30, 1776 by Sir John Pringle, Baronet, President*]

Sir Joseph Banks, the official botanist on the *Endeavour,* records :

"*I received great benefit from the use of this mess, it totaly banish'd in me that troublesome costiveness [constipation] which I believe most people are subject to when at sea.*" [Beaglehole, 1962].

Constipation was an early symptom of scurvy.

This sweetwort is described as "*one of the best antiscorbutic sea-medicines then discovered when used in time.*" Other antiscorbutics that Captain Cook had with him were sauerkraut and a "rob" or concentrate of lemon and orange juices. He also brewed malt or spruce-beer whenever opportunity offered.

Malt, however, appears not to have been used for brewing during Cook's first voyage, its use being restricted to the preparation of wort for administration as an antiscorbutic, hence after the occurrence of scurvy among sailors. This is confirmed by Pringle who said that:

"the wort, and the acid juices of lemons and oranges, were dispensed only as medicine". [Stubbs 2003, 132]

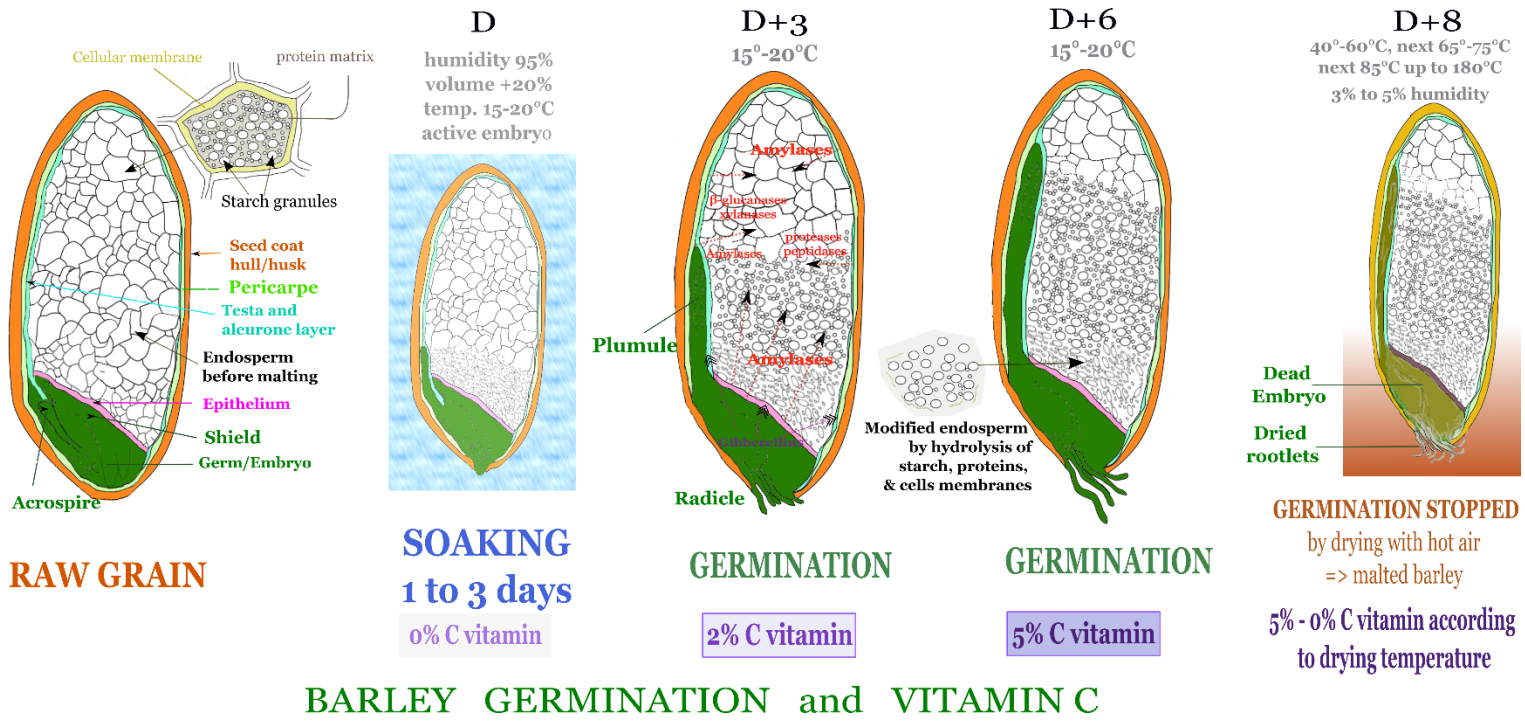


Fig. 8: the vitamin C content of sprouted barley (or other grains) depends on the drying temperature during the final malting stage. Before the 18th century, malt dried at low temperature was rich in vitamin C because it was used quickly to brew domestic or farmhouse beers. Afterwards, maltsters increased the temperature and drying time as they supplied a burgeoning brewing industry. Malting and brewing became two distinct crafts. Over the course of 18th and 19th centuries, malts became increasingly depleted in vitamin C.

Before Cook's first voyage, malt has been used to prepare a sweet wort on Wallis's *Dolphin* in 1766-68, again as a medicine post-scurvy, not as a preventive beverage. Captain Cook's real innovation was to systematically distribute malt

wort to his crews every day before any symptoms of scurvy appeared, and to follow the recipes suggested by MacBride. MacBride simply described the method of preparing beer wort used by all English brewers. MacBride rightly insisted on the quality of the malt, particularly its drying temperature (Fig. 8). We shall see later that this technical detail had an incalculable impact on the real anti-scorbutic qualities of malt infusions and beer, and consequently on the health of sailors.

Another explicit statement of the value of the sweetwort occurs in a letter from Admiral Graves to the Victualling Board of the Admiralty in 1794, in which he says:

> "*On the American voyage of the London, essence of wort* [the same malt infusion apparently, from the context] *had been given, with such vegetable acids* [lemon or orange juices] *as the surgeon had. Scurvy gradually gave way, and they sent only four* [sailors] *to hospital instead of thirty or forty, as other ships did at New York.*" [Henderson Smith 1918 b, 814].

At the end of the 18th century, knowledge of the effectiveness of the malt infusion against scurvy seems to have been acquired amongst the British navy. Concerned about the health of his crew, Cook had the merit of having scrupulously followed the requirements of MacBride. Very pragmatic, Captain Cook, during his voyages in 1772 and 1774, tested almost all beverages deemed antiscorbutic that the Navy wanted to experiment with in actual severe conditions of high seas and lengthy navigations.

We shall see that this reputation and these practical successes were not enough to ensure that malt was definitively added to the list of compulsory provisions for ocean voyages. Captain Cook's voyages and his successes against scurvy came under the heading of maritime exploration and its special organisation. The provisioning of regular naval forces and the rations of English sailors remained unchanged despite Captain Cook's achievements.

By contrast, the English captains learnt from Cook's successes and sought out vitamin-rich native foods and drinks during their sailings far from European lands and plants. This was the case for Captain Nathaniel Portlock in May 1786 on his two-year voyage from Hawaii to the Alaskan coast to trade in furs. On the Hawaiian Islands, Portlock stocked up on the *Ti* plant (*Cordyline fruticosa*, also known as Hawaiian spinach). In 1791, Portlock accompanied Bligh on his second voyage to transport and transplant breadfruit (*Artocarpus altilis*) from Tahiti to the island of Jamaica via Cape Horn. The roots of *Ti* and the fruit of the breadfruit tree were used to brew beer in the Pacific islands before the arrival of Europeans, and are rich in vitamin C.

4.2. The 18th century searches for an antiscorbutic remedy

In the second half of the 18th century, research into antiscorbutic treatments identified a wide range of food sources. These included all fermented drinks, beers with infusions of fresh buds or other herbs reputed to be antiscorbutic, malt and

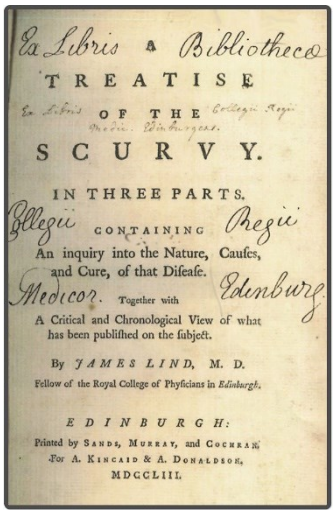
its unfermented infusions, citrus juices (lemon, orange), vegetables and fresh fruits. But the actual nature of the active ingredients wad unknown. No distinction was made between the nutritional qualities of beer, which in some cases helped sailors to regain their health, and the specifically antiscorbutic qualities of malt infusion. Citrus juices had the same efficiency, which did not help to isolate an antiscorbutic active principle common to all these foods and drinks.

On 20 May 1747, James Lind, as ship's doctor, carried out a now famous clinical experiment on board the Salisbury. He divided 12 scorbutic sailors into six groups of two, and administered a different substance to each group, with solid food being the same for everyone. Per day and according to each group: a quart of cider, 35 drops of vitriol elixir, 6 spoons of vinegar, ½ pint of sea water, a special concoction (garlic + mustard seeds + Peruvian horseradish + myrrh gum + barley water boiled with tamarind + cream of tartar = a tartaric acid powder), 2 oranges + 1 lemon. The orange and lemon group quickly cured scurvy, just behind the cider group.

Fig. 9: James Lind experiments with various antiscorbutics on board the Salisbury.

In 1757, Dr James Lind published a treatise on scurvy in which he writes:

> "*A simple decoction of the tops, cones, or even bark and wood of these trees is antiscorbutic, but it becomes much more so when fermented, as in making spruce-beer. Spruce should be carried to sea; if not, the common fir-tops used for fuel should be first boiled in water and the decoction afterwards fermented with mollasses, in the common method of making spruce-beer.*" [Lind 1757, 178]



Ex Libris Bibliotheca

TREATISE

OF THE

SCURVY.

IN THREE PARTS.

CONTAINING

An inquiry into the Nature, Causes, and Cure, of that Disease.

Together with

A Critical and Chronological View of what has been published on the subject.

By JAMES LIND, M. D.

Fellow of the Royal College of Physicians in Edinburgh.

EDINBURGH:

Printed by Sands, Murray, and Cochran, For A. Kincaid & A. Donaldson,

MDCCLIII.

James Lind also says that beer, wine and other fermented beverages are all antiscorbutic. The range of antiscorbutic remedies therefore remains very wide because the scientific concepts are not firmly grounded. Marine doctors attributed the effectiveness of their remedies to a number of phenomena: germination, alcoholic fermentation, acidity, fruit flavours, purity of air, purity of water and so on. The clinical picture of scurvy is confusing: anaemia, haemorrhage, ulcers, loss of appetite, loss of consciousness, etc. The treatments in use only treat certain symptoms, never all of them, and even less the real cause, the vitamin C deficiency.

The end of the 18th century is notable for the amount of research carried out in England to test various antiscorbutic drinks, in addition to vegetables and fruits,

which were deliberately not included in sailors' standard rations (**3.3**). Here are the main ones:

Fig. 10: James Lind (1716-1794)

- Fresh beer, in particular Porter and India Pale Ale, strong density beers brewed since the early 18th century to withstand long sea voyages while retaining their nutritional quality.
- Unfermented malt infusion, in other words the ancient Viking recipe rediscovered by MacBride. MacBride is very precise about the quality of the malt and how to prepare this infusion.
- Inspissated juice of malt, a beer extract obtained by boiling for several days and then diluted on board ship at a rate of one part extract to 3 parts water. This beer concentrate does not retain any anti-scorbutic properties due to the prolonged boiling of the malt juice, which destroys the vitamin C, a process that the doctors and scientists of the time were unaware of.
- Lemon juice in fresh form or concentrated in a bain-marie according to Lind's recipe. The same remark applies to the concentrated form and the destruction of vitamin C. These concentrates of malt, lemon or orange could be kept for several years, allowing them to be stored to buffer against irregular supplies, and halving the volume to be transported in the holds of ships.
- *Portable soup*, a concentrated, dehydrated vegetable broth prepared ashore and re-diluted on board. The process was perfected in France around 1690 and reinvented in London around 1750 before being adopted by the Navy in 1756.
- Sauerkraut or "four cabbage": cabbage cut into four pieces, salted in barrels and preserved on board in its brine.

Put to the test throughout the 19th century, each of these drinks proved to be defective on board, for reasons relating either to its preparation or to the quality of its ingredients (e.g. Mediterranean lemon vs. lime with only ¼ of vitamin C, or malt dried at high temperature). Malt infusion was the best candidate, given the proportion of vitamin C contained in barley after a week's germination. Unfortunately, the rise of English industrial breweries compromised the intrinsic quality of germinated grains by favouring high-temperature drying of malts (> 200°C), which destroys vitamin C (**4.6**).

In France, Antoine Poissonnier-Desperriéres published his *Traité des maladies des gens de mer* (*Treatise on seafarers' diseases*) in 1767. He quoted Lind extensively, while proposing, as Lind had done, that the ultimate cause of scurvy was cold, damp air, and that the seafarers' diet was merely an aggravating factor. At the time, medicine was still locked into a theory of bodily humours. When it came to remedies, like his English colleagues, he listed fermented drinks, fruit, vegetables and herbs in no particular order, since a nutritional deficiency was unthinkable at the time.

> "Well-made beer, loaded with hops, is a fermented liquor, which fortifies, nourishes, & which at the same time contains principles very likely to prevent & combat scurvy; to make its action even more effective, one can add to it, when it is weak, a small quantity of the juices of the fruits of which I spoke before [juice of currant, lemon, oranges, acid berries], & enliven it with a little brandy drawn from sugar, grain or wine. It is only when prepared in this

way that this latter liquor should be permitted; by associating it with a mucous body, with which it combines easily, one restores to it that it had given up in distillation; it then increases the antiscorbutic virtue of the substances with which it is combined. On this point, experience agrees with theory." [Poissonnier-Desperriéres 1767, 105-106].

The other countries may or may not have been conducting more discreet research. The Dutch navy remained adept with sauerkraut and scurvy herbs (*Cochlearia*), while Mediterranean countries had no shortage of lemons and oranges.

Let's pick up the thread of the story with Commodore James Cook and Dr MacBride. James Cook follows the recommendations of Dr David MacBride, who is conducting research at the Royal Hospital Haslar in Portsmouth, the main port for the English Navy at the time.

In 1762, MacBride proposed the malt infusion to the Navy. MacBride agreed with Lind's conclusions, but recommended a "malt infusion" (called wort) that would have the same effect as condensed citrus juice, but would be made fresh on board and on demand using malt from English maltsters loaded in the ships' holds. For MacBride, this would be a more effective solution for the health of sailors and less costly for the Navy.

In 1762, Dr MacBride's preliminary trials at the Navy hospitals in Plymouth and Portsmouth were unsuccessful, as he demanded that all fresh meat and vegetables be excluded from the sailors' diet for the sake of a better demonstration. The patients were very reluctant to comply. When a man died of scurvy during MacBride's treatment, the experiment was stopped. The Admiralty then suggested that it could be used on board ships where fresh food was not available, and ordered malt to be carried on board a few test ships.

In 1764, David MacBride publishes in London *On the scurvy, with a proposal for trying new methods to prevent or cure the same at sea. Experimental essays on medical and philosophical subjects*.

In his book published in 1767, MacBride reiterated his proposal and gave the public his explanations, accompanied by ten trials carried out at sea by two doctors, one from the Navy and the other from the East India Company, in 1766-67 and 1766 respectively. They summarised the situation, which for the Navy pitted concentrated citrus juice against malt infusion:

"As a Confirmation of the Justness of this Charge, I may fairly be allowed to allege the small Degree of Attention, that, in the Course of more than five Years, I have been able to procure to my Proposal for trying fresh Wort, or Infusion of Malt, as a Substitute for the Juices of fresh Vegetables, in the Cure of the Scurvy at Sea.

For as Wort is a Liquor perfectly similar, in all its Qualities, to the recent juices of the sweet Vegetables, which are known, from repeated Experience, most certainly to cure the Scurvy ; I naturally inferred, that if taken like them in a Quantity sufficient, it would, in all human Probability, produce the same salutary Effects.

Now as Malt, if well dried, and carefully kept in a proper Part of the Ship, may be preserved sound for a great Length of Time, I proposed that it should be carried to Sea, in Order to be brewed into Wort as often as it might chance to be wanted and thus prove a Remedy always in readiness against a most fatal Disease." [MacBride 1767, 2-3].

MacBride's main argument is economic: "but as the material [the malt] for making this liquor [the wort] may be so cheaply purchased, and is capable of being much longer preserved than oranges, lemons, or indeed any other Kind of Fruit, there can be no hesitation in giving it the preference for general use." [MacBride 1767, 60].

MacBride anticipates two objections. Does malt keep well in the holds of ships, and can malt be replenished in India?

> "Whether Malt will keep during the whole time of an East India Voyage is a Query ; but it might be made at several of the Company's Settlements, in India, where there is no Want of good Barley to make it of." [MacBride 1767, 53].

Unfortunately, the peace of 1763 and the victorious Navy on all the seas of the world no longer encouraged the Admiralty to test MacBride's preventive cure[15]. It was still on an experimental basis that in 1770 it was ordered that "barrels of well-dried malt" be taken on board Her Majesty's ships to test the malt infusion against scurvy.

The following year, an "*inspissated juice of malt*" was tested. The Admiralty's interest in brewing at sea has been stimulated in October 1771 when it received reports of an inspissated juice of malt. Instructions were given for this product to be prepared and for a trial of brewing at sea to be carried out on board James Cook's ships *Resolution* and *Adventure*.

Two types of *thickened malt juice* were made before the departure. One of wort and the other of beer. Both contained hops, to avoid having to carry them at sea. The second was fermented to avoid the necessity of available yeast throughout the voyage. The thickened juice was prepared by evaporating most of the water from the wort or beer in a water bath until it became thick and viscous, a week-long process. The resulting concentrate could then be turned into beer by simply mixing it with the required amount of water, with or without yeast if necessary, and leaving it to stand for a few days. Nowadays we know that these malt or beer concentrates contained only a negligible amount of ascorbic acid [Stubbs 2003, 132], but English and Scottish scientists were unaware of its existence in the 18th century. Tests at sea were not very conclusive. On the other hand, James Cook obtained good results against scurvy by using malt turned on board into fresh wort, drunk on its own or mixed with the thickened wort or beer concentrate prepared before his departure.

Unknowingly, MacBride, a doctor of Irish origin, had rediscovered the recipe of his past Viking cousins. He knew that beer had long contributed to the health of sailors when it was fresh, and therefore was healthy when brewed on demand on board ship rather than being heated and concentrated when ashore. He was also guided by the vitalist ideas of the scientists of his time, who saw germination and its biochemical phenomena as the source of life. MacBride lacked the analytical chemistry and biochemistry that would emerge a century later. He was not yet

[15] The Treaty of Paris between England, France, Spain and Portugal was signed in 1763. It put an end to the Seven Years' War, in which England emerged victorious thanks primarily to its naval power.

able to make a full and clear scientific difference between germination and alcoholic fermentation[16].

He extended Pringle's ideas, published in 1750, that fermentation, by producing fixed air (CO_2), inhibits putrefaction. MacBride believed that food that ferments rapidly in the digestive tract is effective in treating or preventing putrefactive diseases, including scurvy, by producing fixed air that penetrates the digestive tract and other living tissues. At the time, scurvy was considered a disease of putrefaction of human flesh, as evidenced by purulent gums, and festering legs, arms and flesh of the body.

But his focus on sprouted grains and the resulting beer malt indicates that, even in his time, people were ignorant of the presence of specific nutrients created during the natural processes of grain germination. In support of his thesis, MacBride quoted the opinion of Mr. Pelham, Secretary to the Commissioners of the Supply Office. The latter's conclusions (fresh wort, a simple infusion without heating, inherits the nutritional qualities of malt) were based on a sound reasoning, albeit obtained with the approximate chemical notions of the time:

> "*GRAIN, after it is malted, differs widely from grain in the crude state; by the germination, drying, and slight torrefaction, its natural viscidity is destroyed, it acquires an agreeable, saccharine taste, and the farinaceous part is so attenuated as to be rendered soluble in water.*
> *FRESH Wort, or infusion of malt, is a liquor similar to the recent juices of the sweet vegetables, fermenting readily like them, and being precisely of the same mild, saponaceous and aperient nature.*" [MacBride 1764, 190]

It should be noted that Pelham, like MacBride, insists on the drying of germinated grain being gentle, guessing that high temperatures could destroy the active principles that make malt effective against scurvy. James Cook writes:

> "*For the Inspissated Juice of Wort, and Beer, we were indebted to Mr. Pelham, Secretary to the Commissioners of the Victualling Office. This Gentleman, some years ago, considered that if the juice of malt, either as beer or wort, was inspissated by evaporation, it was probable this inspissated juice would keep good at sea; and, if so, a supply of beer might be had, at any time, by mixing it with water.*" [Cook 1777, xxxii]

The opinion of Sir Gilbert Blane (1749-1834), a Scottish physician, on the '*extremely beneficial and antiscorbutic*' nature of the malt liquor, is instructive:

> "*The common quantity of small beer allowed (in the Navy) is so liberal that few men make use of their whole allowance; and there is I no objection to the constant use of it except that it is apt to spoil in the course of a few weeks, and that upon foreign stations the stock can, seldom be renewed. One of the greatest improvements that could be made in the victualling of the Navy would be the introduction of porter, which can be preserved in any climate for any length of time that may be necessary.*" [*Observations on the*

[16] In 1762 MacBride communicated his views on the treatment of scurvy to his friend Dr. George Cleghorn [q. v.], through whom they reached William Hunter and Henry Tone, one of the commissioners for taking care of sick and wounded seamen. MacBride advised the use of fresh wort, or infusion of malt, and the lords of the Admiralty gave orders that the method should be tried at Portsmouth and Plymouth. Nothing further, however, seems to have been done officially, and MacBride's specific was eventually quite superseded by lemon-juice, which had been recommended by James Lind [q. v.] in his 'Treatise on the Scurvy' in 1754. But John MacBride, a brother of David, who was commander of H.M.S. Jason, made a successful experiment with the cure in a voyage taken in 1765–7, and the ship's surgeon, Alexander Young, sent his journal to David MacBride, who published it as an appendix to his 'Historical Account'. wikisource.org/wiki/Macbride,_David_%28DNB0

Diseases of Seamen, 1795, quoted by Henderson Smith 1918 b, 813, underlined by me].

When war was declared between Spain and England in 1796, the price of lemon juice rose as sources of supply in the Mediterranean and the Caribbean were partially cut off for the English navy. The Sick and Wounded Council wrote to the Lords Commissioners that:

"*though they do not consider strong beer a substitute for lime juice and sugar for scurvy, yet as it is conducive, they recommend* that the experiment be made of substituting it (lime juice) on some ships" [quoted by Henderson Smith 1918 b, 814].

The expression *strong beer* refers here to Porter or India (Pale) Ale.

Porter was a type of beer brewed in London from the 1720s onwards, which kept well and was often one of the drinks carried by English officers on ships. At the time, porter was highly regarded for its medicinal properties.

Gilbert Blane reports on the benefits of beer against scurvy during the American War of Independence (1775-1783), when the English fleet was constantly cruising the Atlantic to transport munitions and soldiers to the American front, and when they blockaded the ports of the Confederates, particularly New York and Charleston:

"*In the beginning of the war two storeships called Tortoise and Grampus sailed for America under convoy of Daedalus, a frigate. Grampus happened to be supplied with sufficient quantities of porter to serve the whole passage, which proved very long. The other two ships were furnished with the common allowance of spirits. The weather being unfavourable the passage drew out to fourteen weeks, and upon their arrival at New York the Daedalus sent to hospital a hundred and twelve men, the Tortoise sixtv-two, the greater part of whom were in the last stage of the scurvy. The Grampus sent only thirteen, none of whom had the scurvy.*" [*Observations on the Diseases of Seamen*, 1795, quoted by Henderson Smith 1918 b, 813]

Thomas Trotter (1760-1832), physician to the Channel Fleet in 1794-1795 and a pupil of MacBride, introduced the practice of giving malt liquor (another name for strong ale) at the Royal Hospital Haslar when he officiated there. He found the strong beer called Porter "*one of the best ingredients in the diet of a convalescent*"; it "*never failed to strengthen them quickly for duty*" [Trotter 1797]. But this was a curative, not a preventive, treatment for scurvy. The same Trotter, who became physician at the Royal Hospital Haslar after MacBride, advocated lemon juice rather than malt infusion as a preventive treatment for scurvy.

4.3. Cook's legacy and the missed adoption of his healthy method

Shortly after James Cook's last famous voyage in 1779, malt infusion is one of the Royal Navy's requisitions. It is listed among several antiscorbutics. Captain Cook's successes and the publicity that followed should have guaranteed the eradication of scurvy at sea through the widespread adoption of malted grains as compulsory provisions for long-distance sailors. But this was not to be. The anti-scurvy power of sprouted grains would have to be rediscovered, again and again,

with each new political crisis, right up to the dawn of the 20th century. News of Cook's victorious battle against scurvy during his second voyage to Antarctica spread to France before the French Revolution. Louis XVI sponsored an ambitious round-the-world expedition led by La Pérouse.

To prepare for this expedition, Paul Monneron set off for London in March 1785 to buy instruments and collect information and maps on Cook's voyages. He met John Webber, an artist on the Resolution and a survivor of the 3rd voyage, who advised him on antiscorbutic remedies and insisted on the effectiveness of the malt taken on board by Cook[17].

Reaching Botany Bay (Australia) in February 1788, two weeks before Cook, La Pérouse proclaimed that his crew had suffered no more from scurvy than those of the British captain on his 2nd voyage[18]. These two illustrious navigators were concerned about the health of their crews and tested new methods, this time preventive. They differed from the vast majority of officers in the navies and merchant navies, who counted the dead thrown overboard and disembarked the dying, but rarely attempted to prevent scurvy on board. James Cook tested malt infusions and other enriched drinks and broths. La Pérouse focused his attention on the quality of the water on board, which was a vector for typhus. Experiments were planned during the expedition [Tessier 1787]. Like Cook, La Pérouse also took on board a good supply of malt and pine essence:

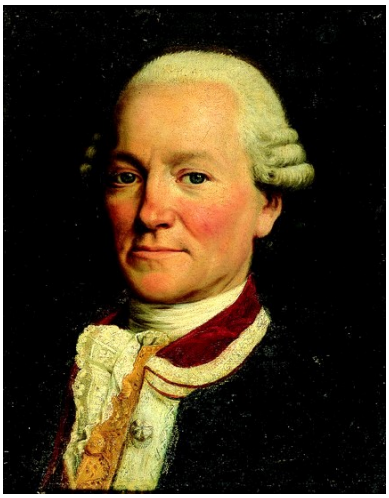


Fig. 11: La Pérouse

[17] The archives of the French Navy contain an interesting series of letters sent by Monneron to La Pérouse and Marshal de Castries during his mission to England. In England, Monneron sought out men who had known Cook, albeit of a lower rank. He had the good fortune to make the acquaintance of John Webber, the artist of the *Resolution* and of a famous painting depicting Cook, as well as numerous drawings of the North-West coast of America. Webber provided him with a wealth of information on how to deal with the natives and the prices charged in England for the supplies he needed for the voyage. Above all, he advised him on antiscorbutic recipes, emphasising malt. Monneron sent several barrels of malt and beer to Paris, and had antiscorbutic specific foods cooked for the purpose (fr.wikipedia.org/wiki/Exp%C3%A9dition_de_La_P%C3%A9rouse#Pr%C3%A9paratifs). Astonishing! Nobody knew how to make malt in Paris in 1785, or more plausibly how to dry pale malt properly so that it retained as much of its amylase as possible. At the same time, the archives of General Santerre (1752-1809), a brewer by trade in the Faubourg Saint Antoine in Paris, contain plans to build a kiln for drying malt using a process borrowed from English maltsters: cold germination, drying by air heated with coke oven (instead of wood) + fresh air, horsehair mesh, etc. (Monnier 1989, 110-113). At the end of the 18th century, the advanced techniques of English maltsters and brewers are renowned throughout the continent.

[18] Last letter from La Pérouse to Fleuriot de L'Angle on 17 February 1788 sent from Botany Bay: "You will find in my logbook that I saw Plistard Island, Norfolk Island, and finally arrived at Botany-Bay without a single sick man on the two ships: the minor symptoms of scurvy gave way to the use of the fresh food I had obtained from the Navigators' Islands. I am sure that the sea air is not the main cause of this disease, and that it is rather to be attributed to the bad air of the warehouses, when it is not frequently renewed, or even more to the poor quality of the victuals." la%20perouse%20derniere%20lettre

"Moreover, a considerable supply of spruce oil, beer malt and other preservatives against scurvy was taken on board. Ammunition of this kind, and other items intended to preserve the health of the crews, can be valued at 30,000 pounds." [La Pérouse 1797, 246].

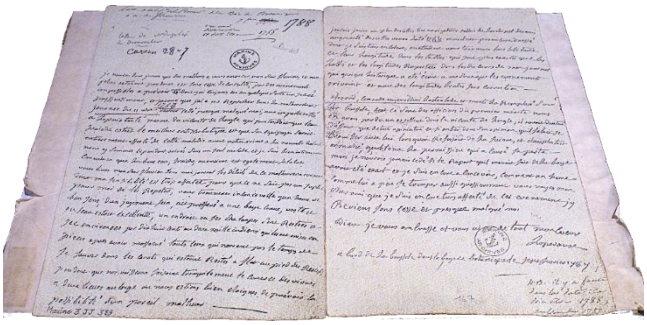


Fig. 12: last letter from La Pérouse in January 1788 at Botany Bay

At the end of the 18th century, the prevention of scurvy using malt infusion was well known in France. However, the experience acquired by sailors seems to have come from England, as shown by Monneron's preparatory voyage to London in 1785 (**note 17**).

The commercial navy followed more eclectic rules. Malt was also carried by whaling ships. Their activity took them further north than the others, apart from the explorers, and like them they were liable to be held up by the ice for long periods and to suffer from scurvy [Henderson Smith 1918 b, 814].

4.4. The British navy turns to lemon juice in 1796

In 1781, one man in seven still died of scurvy in the English navy and other navies. After dithering for many decades, which proved fatal for English sailors, the Admiralty decided in 1796 to systematise scurvy prevention by making it compulsory for their warships to be supplied with lemon juice. The merchant navy sailors would wait another 40 years for this policy to be granted to them.

Is this decision motivated by a concern for the health of sailors? In fact, it is based on strategic considerations. Between 1793 and 1815, England implemented its policy of blockading the European mainland and colonial ports of countries deemed to be enemies. The effectiveness of this naval blockade or embargo would depend on its fleet and its domination of the world's seas. After various maritime disasters caused by scurvy during this continental blockade, particularly among the Channel's Fleet, the Admiralty turned the health of sailors into a military objective. The maritime embargos undertaken by effectively blockading ports or by cruising required crews to be at sea for long months while keeping in a relatively good health[19]. What was really at stake was the British supremacy over the world's seas. This blockade or naval embargo policy became an integral part of the official British policy and, de facto, a part of the international maritime law in the 19th century [Battesti 2021, 35, 37-41]. At the same time, the Navy tightened its disciplinary policy towards crews after the mutinies at Spithead and Nore in 1797, and other mutinies in India and at the Cape of Good Hope. The adoption of lemon juice had nothing to do with humanitarian considerations.

In 1795-96, the Navy gave up malt infusion in favour of lemon juice alone, either fresh or concentrated. Why lemon juice rather than malt infusion? The British Isles produced an abundance of malt, but no lemon juice. A seemingly

[19] The English war fleet blocked maritime traffic from foreign ports by permanently cruising off the French, Dutch and Spanish coasts and boarding all ships, even those from neutral countries, forcing its own crews to remain at sea for months on end with minimal supplies and maximum risk of scurvy.

paradoxical choice[20]. The answer lies in British naval military strategy. The dispersal of the British war fleets across all the world's seas and in all the ports of the English colonies meant that lemon juice was the preferred choice. Malt was not available everywhere, or it was in too small quantities, even in the colonised ports of India such as Calcutta where barley was grown. It was a straightforward solution to a problem of global naval logistics.

Before 1795, Gilbert Blane recommended various ways of preventing scurvy: beer, fruit, fresh citrus juice, but rarely malt alone. He and his contemporaries were unable to distinguish between the nutrients derived from germinating barley or wheat and those derived from alcoholic fermentation. The British studies on scurvy were published and known to doctors in the continental seas. But as we have pointed out, their conclusions were often contradictory, alternating between preventive and curative approaches, recommending infusions of malt or citrus juice, or concentrates of beer, malt or lemon juice.

In 1786, Thomas Trotter published his *Observations on Scurvy*, based on his voyage as surgeon on board the *Liverpool Guineaman* slave ship in 1783-1784. He treated African slaves for scurvy with lemons and guavas during the slave trade [Trotter 1786, 29-43].

In April 1794, the *Suffolk* left India for England on a 23-week voyage. Every day, the sailors were given 20ml of lemon juice mixed with toddy and sugar. There were no cases of scurvy.

In 1796, Gilbert Blane, who had become Commissioner of the *Navy Sick and Hurt Board*, convinced the Admiralty Board to adopt lemon juice as the official and regular antiscorbutic for the British Navy. The use of malt infusion rapidly declined in the supply of English war fleets. The decision taken by the Navy did not apply to the merchant navy [Anderson Smith, 1918]. Blane regulated a daily ration of lemon juice for each sailor: three-quarters of an ounce (around 22ml), with 10% brandy added[21]. Unwittingly, Blane and the naval doctors caused ascorbic acid to crystallise in the presence of alcohol, which ensured its effective preservation [Adrien 1997: 388-389].

The manufacture of this lemon concentrate preserved with alcohol was a military secret jealously guarded by the Admiralty for over 50 years[22]. It was disclosed in 1840 because England wanted to extend the benefits to its own merchant navy, from whom it could not demand the same confidentiality. Lemon concentrate was made compulsory for the British merchant navy in 1844 [Roddis 1951: 68-69]. In the meantime, scurvy had struck many sailors.

---

[20] We might wonder about this odd commercial circuit. Malt was produced in large quantities on English soil. Concentrated lime juice had to be shipped from faraway places (first Mediterranean countries, a little later on from the Caribbean English colonies)! The English Admiralty remained faithful to the primary vocation of its navy: trade, exchanges and the traffic of the financial intermediaries.

[21] There were 2 official preparations. 1) 1/10th brandy added to a volume of lemon juice; 2) Boiled lemon juice! Both were kept in bottles under a thin layer of 1cm olive oil. The Mediterranean lemons (*Citrus limonia*) came from Sicily, Malta, Lisbon, Madeira, etc. before inconclusive trials with limes (*Citrus acida*) from the Caribbean (Roddis 1951, 69-70).

[22] The secret lies in the preparation and preservation of lemon juice concentrates (note 21), not in the efficacy of citrus juices, which have been known to everyone for centuries.

This is one of the paradoxes of this long affair. The contractors responsible for supplying the crews of the English navy could make or buy malt at will in England, Ireland or Scotland. However, the naval authorities promoted the use of lemon juice, which England obtained from the Mediterranean and the South Seas. The preventive and curative treatment of scurvy with lemon juice was to suffer setbacks throughout the 19th century.

The replacement of Spanish or Portuguese lemons with West Indian limes is the root of the problem. Lemons (*Citrus medica*, var. *limonum*) were brought from Lisbon. Until 1803, supplies were uncertain, insufficient and costly when contracts were first signed with the naval representative in Malta. Subsequently, and for many years, an annual contract ensured a sufficient quantity of lemon juice grown in Malta and Sicily. This enabled the Admiralty to use lemon juice more widely. For some years, its use was not confined as before to the sick and crews of ships abroad [Henderson Smith 1918 a, 737]. With the improvement of supplies and general living conditions on board warships, the widespread use of lemon juice succeeded in expelling scurvy from the Navy in a very few years. In 1815, Sir Gilbert Blane showed that scurvy had almost disappeared from the war fleet, according to figures provided by Dr John Lind, James Lind's son and successor at Haslar Hospital. Only two cases were sent to this military hospital in Plymouth during the last four years of the Napoleonic Wars [Tröhler 2005, 522]. In 1810, cases of scurvy ceased to be recorded by the navy. After this period, the disease mainly affected the merchant navy sailors.

Around 1812, the development of colonial plantations in the West Indies, mainly Jamaica, made large quantities of lime (*Citrus medica*, var. *acida*) available[23]. The Admiralty transferred its Mediterranean contracts to Jamaica and had lime juice delivered instead of Mediterranean lemon juice. No one suspected the essential inferiority of the antiscorbutic power of lime over that of Mediterranean lemon (Table 5). This new supply, which was supposed to be better than the old one, was produced by English companies under conditions that ensured its quality and purity. The juice was supplied to the ships under regulations that precisely set the quantity consumed by each member of the crew. The daily ration of 30ml was given to each man individually and drunk by him in front of an officer [Henderson Smith 1918 a, 737].

Source	Average amount of L-ascorbic acid/100g of fresh material
Lemon	53mg/100g
Lime, grapefruit	30mg/100g
Brussels sprouts	80mg/100g
Cabbage raw green	30mg/100g
Potato	20mg/100g
Sprouted Mung (*mungo*) beans	5mg when raw, 80mg/100g after sprouting for 4 days
Sprouted barley (green malt)	30mg/100g after sprouting for 4 days

Table 5: vitamin C content of the main foods discussed in this article (wikipedia.org/wiki/Vitamin_C)

[23] In Florida, Barbados, Jamaica, the Bahamas, St Vincent, Dominica, Grenada and Tobago, Bermuda, British Guiana, etc., most of which were ceded to England by Spain and France under the terms of the Treaty of Paris in 1763.

Twenty-five years apart, two major expeditions to the North Pole meet opposite fates from a medical point of view and highlight the weakness of limes.

In 1875, Sir George Nares's ships *Alert* and *Discovery* set sail to discover the North Pole. Sir Alexander Armstrong, former medical officer on the *Investigator* in 1850 and now Chief Medical Officer of the Navy, was so pleased with the results of Mediterranean lemon juice during his voyage that he instructed the *Alert* and the *Discovery* to be supplied with lemon juice. The juice must be given to the sailors in exactly the same way as during his expedition, in identical quantities and with the same controls to avoid variations in consumption. However, the juice supplied to Georges Nares' two ships came from the West Indian lime (*Citrus acida*) and not from the Mediterranean lemon (*Citrus limonum*).

These two expeditions were close enough in time that the general diet of the sailors remained very similar. The only difference was that the more recent Nares voyage benefited from certain dietary improvements dictated by accumulated experience. These included double rations of vegetables and fruit, the addition of meat and sugar and a reduction in the amount of alcohol allowed. There were no notable differences in terms of occasional supplies of game and spices. In theory, these improvements favoured the Nares polar expedition. The results and their comparison speak for themselves [Henderson Smith 1918 a, 737].

The *Investigator*, stocked with Mediterranean lemon juice, left England in January 1850 and remained in the ice for the following summer. Throughout the following winter and the summer of sleighing, there was no scurvy. In autumn 1851, rations were reduced by a third and lemon juice by half, but no cases of scurvy appeared during the following winter and spring. Only in May 1852 did the first case develop, after seven months of reduced rations and lemon juice. Over a period of three and a half years, there were only three deaths from scurvy.

The *Alert* and *Discovery* left in May 1875 with lime juice from the West Indies. The first case of scurvy occurred in January 1876. The first symptoms of scurvy appeared among a larger number of sailors in early spring. With the start of the sledge expeditions in April 1876, scurvy developed severely and three deaths occurred. At the same time, scurvy developed no less seriously among the men who remained on board the ships [Chick, Hume, Skelton 1918, 737].

Preventing and treating scurvy with lime juice from the West Indies did not guarantee perfect protection.

4.5. Scurvy plagues the merchant navy until the 20th century

The health of the sailors aboard British warships improved after 1815. The health of seamen in the English merchant navy, like that of other European navies, had to wait until the second half of the 19th century.

In the Port of London, a report covering 1841, for example, records:

> "Out of the number of Asiatic Seamen ['Lascars'] introduced to this port, many most pitiable objects have been brought to the Dreadnought [one hospital-ship in the port of London], afflicted with scurvy in its most aggravated form" [Cook 2004, 224].

Fig. 13: leg of a scurvy patient in a London hospital ship (1887)

The Medical Officer to the Privy Council comments:

> "… of the entire number of men received into the Sailors' Home at Poplar [in London's dockland], nearly half are, at the time of their admission, suffering more or less from scurvy, and … perhaps a twentieth part seriously diseased with it …". He continues: "Apart from the not insignificant question … of cruelty from master to servant … the security of this country has on several occasions been imperilled by the disablement of the [Royal Navy] through scurvy, it may be presumed that the same cause will imperil the safety of our merchant ships".

Reports and doctors point out that the persistence of scurvy in the merchant fleet is unacceptable: lemon juice is a reliable preventive cure that has been tried and tested by the navy for half a century. The Merchant Shipping Act of 1854 requires merchant captains to use it. The causes of these plagues are soon discovered: lemon juice is not being distributed, it is adulterated or, worse still, falsified with citric acid and lemon essence [Cook 2004, 225-226]. A Deputy Inspector-General of the Royal Navy (R. Armstrong), based at Chatham, but with extensive experience in "nearly all parts of the world", also gives his view; he too contrasts the health of "seamen in our merchant service" with those in the Royal Navy, and emphasises the outstanding value of lime juice which *must* be consumed under observation!

Fig. 14: *"The scourge of India captains. He takes his usual regale, a pint of beer"* (1781).

The objection to the exclusive use of lemon juice comes from W. D. Stone, a Fellow of the Royal College of Surgeons. In 1866, Stone is still of the opinion that cooking does not diminish the antiscorbutic quality of the potato: "… this vegetable is equally effective when cooked, and certainly much more palatable …" [Cook 2004, 227]

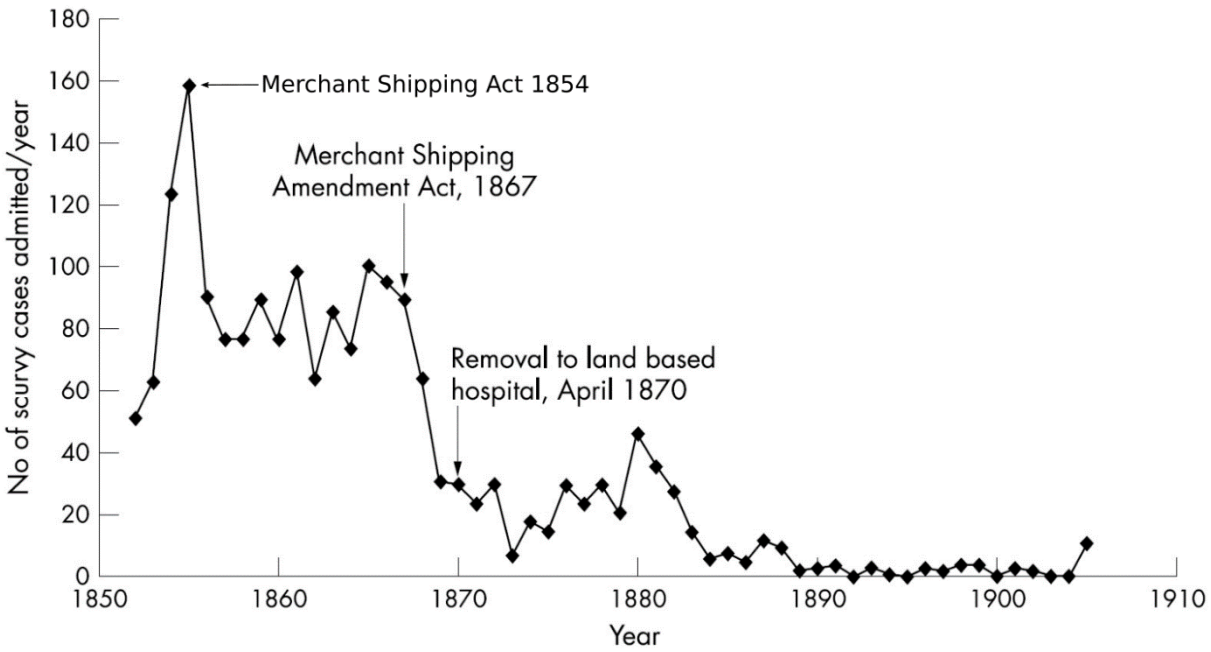


Fig. 15: annual number of cases of scurvy reported by the hospital ships *Dreadnought* and *Albert Dock* between 1852 and 1905 (Cook Gordon 2004, fig. 3, p. 226)

The progress of preserved food in glass or metal jars is no more convincing in the case of scurvy.

Naval explorers, often naval officers, continued to source beer, malt and lemon juice throughout the 19th century. This eclecticism reflects a concern to find the best way(s) to resist scurvy.

In 1815, the end of the long continental and naval wars allowed the search for the North-West Passage to resume in 1818[24]. Malt and yeast were taken on board the exploration ships and a kind of 'small beer' was brewed. Admiral Edward Parry of the Navy, and other explorers of his time, ascribed great importance to them.

Edward Parry (1790-1855) pioneered the use of tinned food during his Arctic voyages of 1819, 1821 and 1824 to discover the Northwest Passage (North America). The technique of preserving food in metal, poorly mastered at the time, presented as many dangers as advantages. The maritime polar expedition led by Captain John Franklin remains the most famous example.

This expedition left England in 1845 and made its way through the dangerous North-West Passage to explore the Arctic. An officer in the Royal Navy, Franklin was by the age of 59 an experienced and renowned explorer, having taken part in three Arctic expeditions. Franklin and his 128 men died near their ships stuck in the ice of the Victoria Strait, close to King William Island in the Canadian Arctic Archipelago. Several international rescue expeditions set out to find them.

[24] The North-West Passage is a maritime route bypassing the American continent from the north. In the 19th century, its exploration was supported by the British, Canadian and American governments in the hope of reaching the North Pacific and trading there without bypassing Africa or America from the south. It was crossed by Roald Amundsen in 1906. The Suez Canal (1867) and the Panama Canal (1914) put a stop to the economic interest in this passage, which is also icebound, right up to the present day.

Malt was also supplied on some ships as an additional guarantee against scurvy for a certain period of time. When Sir John Franklin set sail in 1845, a brewing apparatus was taken on board and beer was brewed. Barrels of pale ale supplied by the Allsopp brewery were also shipped. The crews drank it as long as the stock lasted during the first winter. Confidence in the beer was firmly established, and it was always given first to the men on the expeditions' sick lists.

According to Francis Leopold McClintock, malt was sometimes given as an alternative to lemon juice. In 1848, he and James Clark Ross joined the search for John Franklin's missing expedition. In 1857, McClintock led a new expedition on a steam yacht with a 25-man crew. The Allsopp brewery supplied a strong beer, Arctic Ale, which could withstand extremely low temperatures without freezing. In 1875, Sir George Nares asked for a similar beer to be provided for a new Arctic exploration.

Fig. 16: Allsopp advertising for its Arctic Ale brewed in 1875

In the 1980s, a team of scientists led by Owen Beattie, Professor of Anthropology at the University of Alberta, began a series of scientific studies of the graves, human remains and other material evidence left by the members of Franklin's crew on Beechey Island and King William Island. Beattie concluded that pneumonia, tuberculosis and scurvy, diseases aggravated by lead poisoning from poorly soldered tin cans, had decimated the members of the expedition.

To sum up, approaches to scurvy by European navies in the 19th century were tentative. Depending on the circumstances and the regulations, the old tried and tested remedies of the 18th century were retained, namely beer and malt plus lemon juice, or lemon juice alone in the case of the English navy. Vegetables and fruit kept their place, but were marginalised for long voyages. Preventive cures and remedies were known, tried and tested, and effective, but in fine, the causes of sailors' deaths were their appalling living conditions on board. Maritime transport had to cost as little as possible in order to increase goods traffic between the colonies and their metropolises, as is the case today. The result was low wages, often unpaid, precarious contracts, intensive and dangerous work seven days a week, young and poorly trained crews, corporal punishment at the captains' discretion, floating wrecks, unscrupulous recruitment agencies and a mortality rate among sailors higher than that of miners. This system of over-exploitation of seafarers was established in the 19th century, expanded in the 20th century and persists today [Quinlan 2013, 288-303]. The scurvy issue is just one revealing of the dreadful social rules that govern the maritime global economy.

4.6. Maltsters and brewers render beer ineffective against scurvy

Unfortunately for sailors, a parallel development took shape in the 19th century. While the Admiralty was testing various formulas to combat scurvy on board its warships, English maltsters and brewers were radically changing their grain malting and beer brewing techniques. The burgeoning brewing industry

made the various qualities of malt very low in vitamin C and ineffective against scurvy at sea and on land. The reputation of beer remained unaffected, however, as sailors still saw it as beneficial. This partially explains the contradictory results obtained by malt infusion and beer as an anti-scurvy remedy, and the debates within the maritime authorities of the time.

As we have seen, sailors and naval officers had complete confidence in the antiscorbutic properties of beer in the 18th and 19th centuries. A number of British beers, such as Porter and India Pale Ale, were renowned in this respect, as they were brewed to last longer aboard ship. Unfortunately, developments in malting and brewing methods at the end of the 18th century were to destroy once and for all the precious but fragile vitamin C metabolised during barley germination. Porter is a case in point.

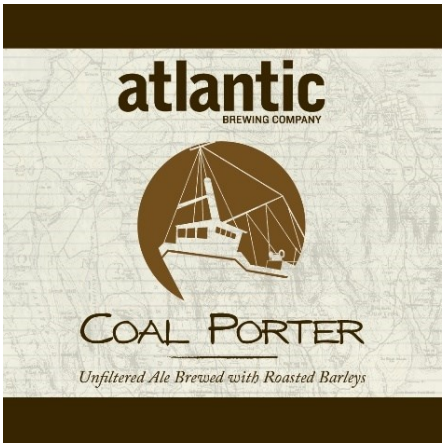


Fig. 17: modern beer label evoking the use of coke to dry the malt for brewing *Porter* beer

Dark, with a high density and alcohol content (6-7%), Porter beer was originally brewed with brown malt around 1720. The browning of sprouted barley was achieved by drying it for longer than pale malt and using warmer air. At the end of the 18th century, English brewers began using the saccharometer to gauge the proportion of sugars diluted in the wort after the malt had been mashed into hot water[25]. Malts could then be classified according to their potential fermentable sugar content. The London brewers gradually replaced brown malt with pale malt, which provided a higher proportion of fermentable sugars extract for the same volume of grain, and was therefore more profitable.

The naval wars and Napoleon's blockade of England after the break of the peace in 1805 by the Third Coalition against France prompted the English government to tax malt more heavily in order to force brewers to finance the war. This was the period when molasses, caramel sugars and colouring substances were added to porter to save on malt. But once peace returned, the law of 1816 required them to use only malt and hops, thereby increasing the cost of beer.

The technical solution was quickly found in 1817 by Daniel Wheeler, who developed a roasted malt capable of giving porter its traditional dark brown colour while retaining the rich fermentable extracts of pale malt. The *Porter* beer could now be brewed with 95% pale malt and just 5% black malt, although most London brewers still used brown malt for its flavour. This *Black malt*, also known as *patent malt* or *black patent malt*, is a malted barley roasted to the point of carbonation, at around 200°C. This black malt gave *Porter* its colour and some of its flavour, giving it a pungent taste with a hint of ashes or smoke. In small quantities, *black malt* is also used to darken beer to a desired colour, sometimes as a substitute for

[25] In 1762, Michael Combrune published *The Theory and Practice of Brewing* in London, advocating the widespread use of thermometers in brewing. This work, which was translated in Europe and America, was to have a major influence. In 1780, the brewer John Richardson (1743~1815) used a hydrometer to measure the sugar content of wort. In 1788, he published in York The Philosophical Principles of the Science of Brewing; Containing Theoretic Hints on an Improved Practice of Brewing Malt-Liquors …. The thermometer and saccharometer were to become two highly useful scientific tools in the hands of maltsters and brewers.

caramel colouring. However, because of its high drying temperature, it contained no enzymes or vitamins. A technical development with no detriment to countrymen, a tragedy for seamen.

The competition between London brewers to make a cheap brown malt was having repercussions on the quality of Porter and, indirectly, on the health of English sailors. Initially low, the proportion of black malt in Porter increased. On the other hand, the technique of drying at higher temperatures was gradually applied to pale malt to speed up drying times without colouring it, by better controlling the moisture content of the germinated grains during their drying phase. Here again, this general increase in drying temperatures practised by maltsters and brewers would deplete the vitamin C content of pale malts.

On a wider scale, the industrialisation of brewing was profoundly changing malting and brewing techniques. Beer was no longer a domestic, rural beverage, but an industrial product brewed on the scale of multimillion litres for urban markets each year. Some of its nutritional qualities were lost, particularly vitamin C. The beer supplied to the British Admiralty by concessionaires was an increasingly weak antiscorbutic. The new malting and brewing methods developed by the English brewing industry were soon imitated on the continent at the dawn of the 19th century (note 17).

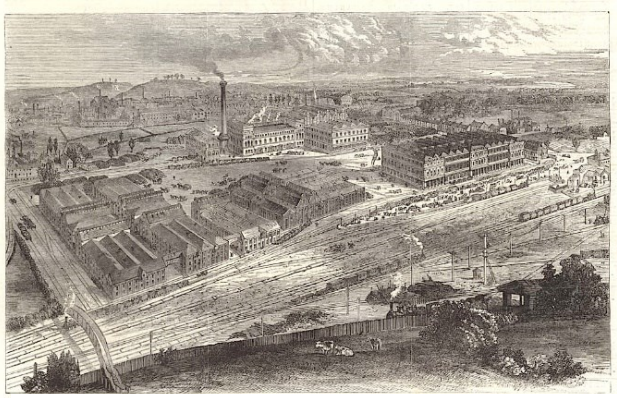


Fig. 18: the Allsopp & Sons pale ale brewery around 1862 at Burton-on-Trent

India Pale Ale originates in another technical development dating from the middle of the 18th century. In England, hot air produced by a coke or coal fire was gradually used to dry germinated barley, replacing wood fires. The process produced less smoke and ashy flavours in the beer. The malt obtained remained pale in colour, making it possible to brew a pale ale with no smoky taste. Stronger hops compensated for its slightly bland sweetness. This type of beer was becoming popular. It could be matured in barrels for a year or two.

The Bow Brewery was located on the River Lea near Bow Bridge on the outskirts of East London, next to the *East India Company* docks. Taken over by the Hodgson family in 1752, the brewery initially produced a *porter* for the local market. In 1787, Mark Hodgson decided to brew a beer for export. His brother Thomas was a captain in the East India Company. Hodgson developed a very hoppy beer based on pale malt, and added dry hop cones to the barrels to preserve the beer loaded onto ships bound for India. Hodgson Pale Ale was a quick success. It was sold exclusively to British nationals in the colony by agencies in Calcutta. Every autumn, the *East India Company* fleet unloaded its goods in Calcutta, where its officers and those of the British Army of India sold the *Hodgson October Beer*, which the *Company*

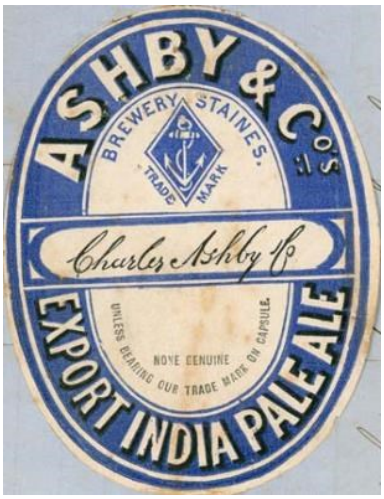
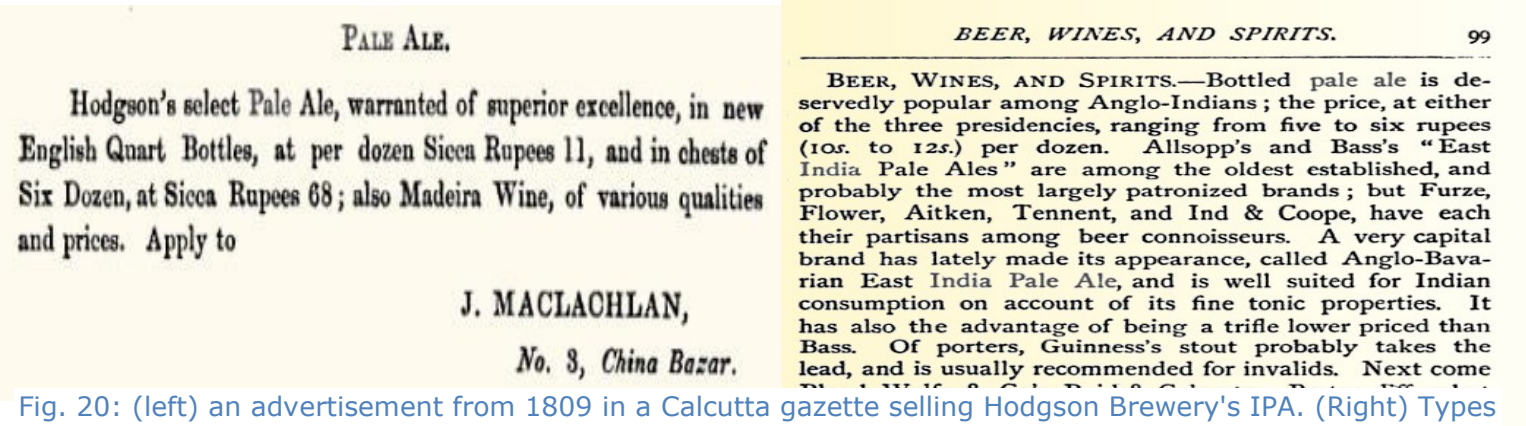


Fig. 19: Ashby & Co.'s export India Pale Ale, 1876

allowed to be shipped in the holds of its ships at the officers' own expense and for fees of shipping [Alan Pryor 2009, 3-4].



PALE ALE.

Hodgson's select Pale Ale, warranted of superior excellence, in new English Quart Bottles, at per dozen Sicca Rupees 11, and in chests of Six Dozen, at Sicca Rupees 68; also Madeira Wine, of various qualities and prices. Apply to

J. MACLACHLAN,

No. 3, China Bazar.

BEER, WINES, AND SPIRITS. 99

BEER, WINES, AND SPIRITS.—Bottled pale ale is deservedly popular among Anglo-Indians; the price, at either of the three presidencies, ranging from five to six rupees (10*s.* to 12*s.*) per dozen. Allsopp's and Bass's "East India Pale Ales" are among the oldest established, and probably the most largely patronized brands; but Furze, Flower, Aitken, Tennent, and Ind & Coope, have each their partisans among beer connoisseurs. A very capital brand has lately made its appearance, called Anglo-Bavarian East India Pale Ale, and is well suited for Indian consumption on account of its fine tonic properties. It has also the advantage of being a trifle lower priced than Bass. Of porters, Guinness's stout probably takes the lead, and is usually recommended for invalids. Next come

Fig. 20: (left) an advertisement from 1809 in a Calcutta gazette selling Hodgson Brewery's IPA. (Right) Types of India Pale Ale published by 'The European in India', Delhi, 1878.

In the same period, the brewers of Burton-on-Trent were losing their monopoly on exports to Russia, particularly that of the *porter* beer, and were looking for new outlets. At the request of the *East India Company*, which had lost its monopoly on trade with India in 1813, they started brewing a beer similar to Hodgson's, although with Burton-on-Trent water rich in calcium and magnesium sulphate, which accentuated the bitterness and fostered a complete fermentation. What's more, Burton's brewers had developed a maturation method that enhanced the attenuation of the beer without increasing its alcohol content too much[26]. This ensured that the beer could be well preserved during the 120-day shipping to India in the 1820s (against 160 days in the 1770s) [Solar & Hens 2013].

The success of this beer with merchants and their English customers in the colony ensured the prosperity of the Allsopp brewery and other brewers in Burton-on-Trent (Bass & Ratcliff, Ind & Smith, Charringtons, Salt). *India Pale Ale* was also shipped and later brewed in other British colonies, such as Australia[27]. *India Pale Ale* was born, and so was its legend. Around 1860, a number of English brewers began offering *India Pale Ale*, this time for sale in England.

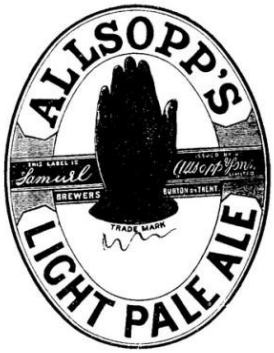


Fig. 21: Allsopp Pale Ale Trade Mark registered at the Patent Office in 1876 specifically for 'India Pale Ale'

[26] Attenuation measures the percentage conversion of fermentable sugars into alcohol. The less residual sugar there is after alcoholic fermentation, the more stable the beer. By maximising attenuation and maintaining the same final alcohol density, Burton's brewers saved on malt.

[27] In 1836, the *Stirling Castle* left Sydney for Singapore and was wrecked on the reefs off the northern coast of Australia. Deprived of drinkable water, the survivors drank one 18-gallon (≈80 litre) cask of India Pale Ale before being rescued by Aborigines (Mehle 2021).

India Pale Ale was a light, refreshing, well-hopped beer suited to hot climates[28]. For a long time, sailors were confused, interpreting its undeniable preservative qualities as protection against scurvy. In truth, the vitamin C contained in that beer could not survive such long transport in the holds of ships. The legend of an IPA that could withstand the ravages of the tropical climate of Bengal and the Indian monsoon long sustained the myth of an anti-scurvy India Pale Ale.

When the Franklin scientific expedition to the Arctic left in 1845, the kilned malt on board was deliberately very dry. Once again, the essential element (vitamin C) was destroyed without its importance being observed. Belief and tradition then attributed the anti-scorbutic qualities of germinated malt to beer. But these qualities were unintentionally destroyed by the industrial transformation of traditional malting processes in the 18th century.

Fig. 22: HMS Erebus and HMS Terror of the scientific expedition of Franklin to the Arctic in 1845

In addition, and whatever the malt used, the unstable nature of vitamin C means that the antiscorbutic quality of beer is superior in a freshly brewed beer that is consumed quickly than in beers made for export and kept for several months in casks before being drunk. This is the case with *Porter*, *India Pale Ale*, *Pale Ales*, *Stout* and other English export beers from the mid-19th century, the time when the Franklin expedition was organised. That expedition was decimated by scurvy and food poisoning caused by poorly prepared preserves[29].

The American ships in the expeditions financed by Henry Grinnell to search for Franklin's traces in the Arctic did not make use lemon juice. They relied mainly on raw potatoes, molasses and beer brewed on board the ship, which was expected to provide a defence against scurvy. The first expedition left the United States in May 1850, and scurvy appeared in September. A diet that allowed scurvy to appear in such a short space of time had little anti-scurvy value, although the ships had fresh meat in summer [Henderson Smith 1918 b, 814-815].

[28] The contemporary attempts to define an *India Pale Ale* style and to freeze its technical formula have no historical grounds. Like the *porter* beer, *India Pale Ale* has never stopped evolving. It was first and foremost a commercial product whose success depended on the British colonial empire. The "India Pale Ale" style (IPA) is a modern marketing invention.

[29] The two ships and their 129-man crew took three years' worth of canned food with them. Some 8,000 tins were hastily made in the seven weeks before departure. Poorly soldered with lead, they were as much to blame for the disaster as scurvy.

5. The Chinese knowledge unknown to Europeans

Fig. 23: Chinese war junk (Zheng Ruozeng's *Chouhai tubian* 1562)

The Chinese were well aware of the outstanding qualities of bean sprouts. Bean sprouts have been known in China since ancient times. The first reference to the use of bean sprouts as a medicinal food appears in the pharmacological classic *Shennong bencaojing*, compiled towards the end of the Han dynasty (220 B.C. to 210 A.D.), which contains recipes from the Zhou and Qin dynasties [Torck 2009, 133].

In the oldest treatises on Chinese medicine, sprouted grains are listed alongside seeds, and the ailments they cure are mentioned. Four diseases caused by nutritional deficiencies receive particular attention: goitre, beriberi, twilight blindness and rickets. Scurvy is not mentioned.

In 406, the Buddhist monk FaXian returned to China by sea from Ceylon after a journey lasting several months, which his friend Buddhabhadra recorded in writing. Both embarked on merchant ships that could carry around 200 people and their provisions for 50 days[30]. After a storm, the boat reached the Shandong peninsula (Northern China):

> "After twelve days they reached the southern shore of Mountain Lao bordering the county of Changguang. Subsequently, they obtained fresh water and vegetables." [Torck 2005, 60]

These vegetables were part of the provisions that Asian sailors took on board. The text makes no link with scurvy. The *Tang Yulin* (*Collection of Tang Discourses*) in 1107, describes life on board a type of giant boat (compared to their Western counterparts) and gives a clue with the practice of gardening on board:

> "The large ships do not exceed 8,000-9,000 *shi* (…). Among them there are the *Yu Da Niang* ships, which are the largest. Those living [on them] spend their whole lives and marry on board. All [ships] have [dwellings] lanes in their sections and they have gardens. There are several hundreds of boatmen and technicians [on board]" [quoted by Torck 2005, 62. Underlined by me]

We do not know whether Chinese sailors brought supplies of grain to germinate on board their ships. Chinese maritime expeditions were generally coastal voyages[31]. Torck mentions the miraculously preserved logbook of Jian Zhen's voyage to Japan in 753-54 with 17 Buddhist monks and 85 crewmen. The list of provisions on board is very detailed and contains no vegetables or fruit [Torck 2005, 63].

---

[30] By comparison, the European caravels in the 16th century carried 50 to 60 sailors.

[31] Even crossing the China Sea to Japan and Korea, or island hopping in the South Seas and to Taiwan, involves sailing quite close to the coast.

The seven expeditions undertaken between 1405 and 1437 by Admiral *Zheng-He* sailed along the coasts of South-East Asia, moving from island to island in Borneo, sailing along Malaysia and Sumatra to Ceylon and then the Straits of Hormuz. The sheer size of the squadron could only have caused supply problems[32]. With so many ports of call and so many supplies, there was little chance of scurvy taking its toll. Mortality was nevertheless high [Ma-Huan, 32].

According to Ma-Huan, the scribe of these naval expeditions, the Chinese-supplied junks carried soya, wheat, millet and rice, which could be stored for long periods without losing their nutritional value. These could be cooked fresh on board the junks at sea. The ships also carried chickens fed on the cereals, for fresh eggs and meat [Ma-Huan].

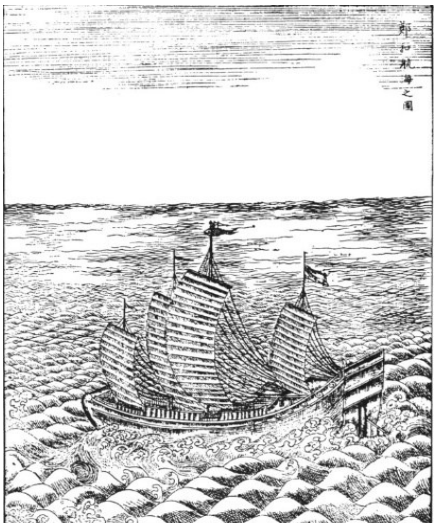
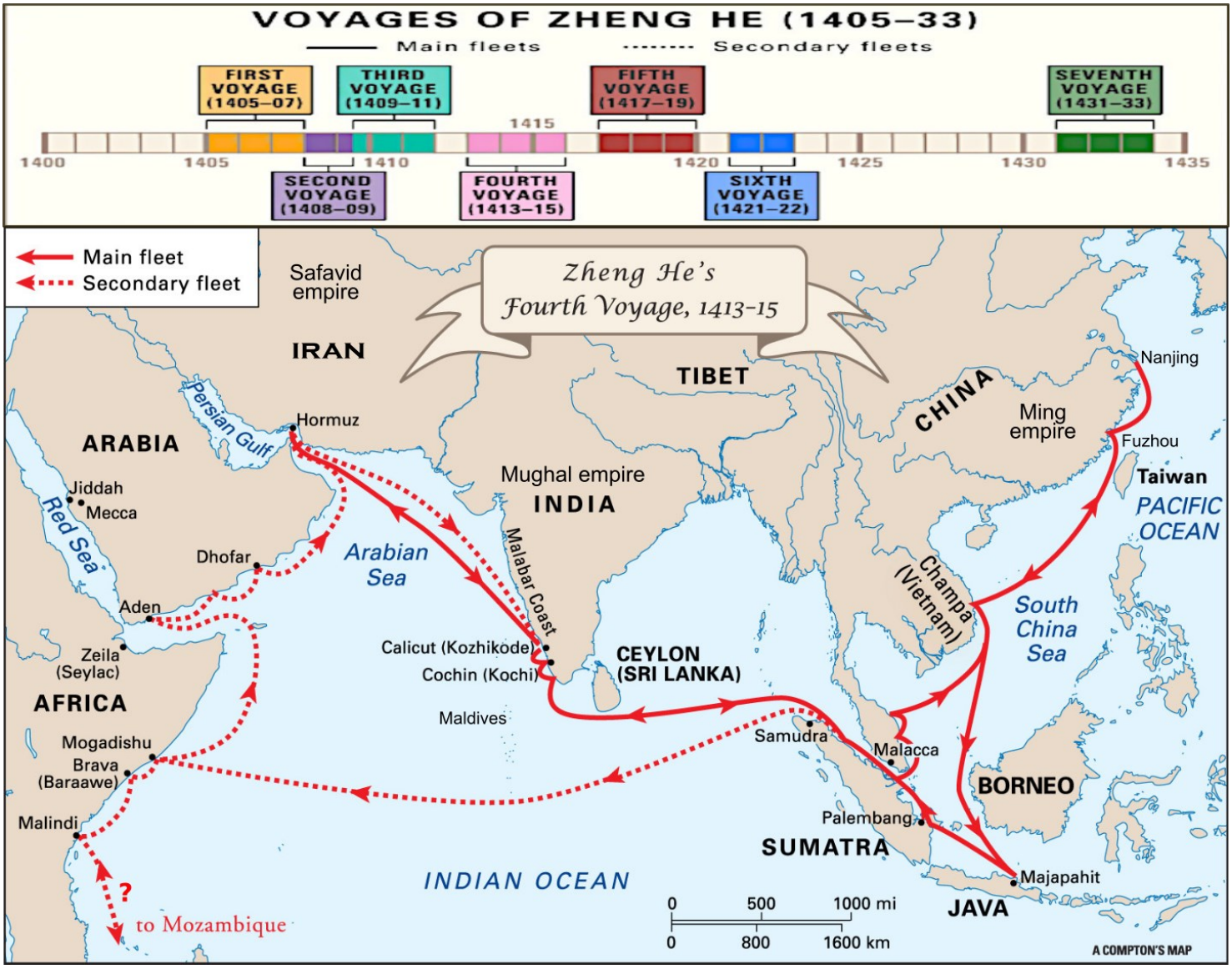


Fig. 24: Cheng Ho's admiral junk (1431)



Map 2: reconstruct Zheng He's 4th sea voyage described by Ma Huan

[32] The 7th expedition brought together 300 boats and almost 28,000 men (Ma-Huan, 15).

Bean sprouts were of particular importance[33]. All ships carried open tubes in which bean sprouts could germinate in sunlight, developing large quantities of riboflavin, niacin and vitamin C. Daily consumption of the bean sprouts provided enough vitamin C to prevent scurvy. In 1346, Ibn Baṭṭūṭa reported that sailors in the Indian Ocean "have their children living on board ship, and they cultivate green stuffs, vegetables and ginger in wooden tanks."[34]

Torck reports the story of Samuel Bowen, an American adventurer who went to China in 1758, who while in Canton noticed the technique of bean sprouting, which was done on land and at sea [Torck 2005, 65 n. 35].

Very early on, the Chinese navy had acquired a mastery of feeding themselves on the high seas that European navies sorely lacked.

This does not imply that scurvy was unknown in the Chinese world. In 1742, the medical classic *Yizong Jinjiang* described, as did Western medicine, the symptoms of scurvy (*qingtui yagan* lit. *green-legs stinking-teeth*) affecting soldiers in the armies of the northern frontier. Tao Qilin, quoted in this medical treatise, attributed the causes of scurvy to a lack of the Five Grains (rice, millet, *adzuki* beans, wheat/barley and soya) providing the basic Chinese diet, and to the cold and dampness of northern regions [Torck 2009, 65-66].

This medical treatise is illustrated with a drawing showing a Qing soldier affected by the blue putrefaction of the skin typical of scurvy. This means that scurvy on land was a scourge in the armies of the Qing dynasty [Torck 2009, pp. 62-63]. The same medical treatise suggests several treatments: rice or millet beer (*huangjiu*), mare's milk, various herbal and spice tonics, *ephedra sinica*, ginger, areca nut and aromatic plants [Torck 2009, 69-87]. Beer, this time made from rice or millet, was therefore used in China as an anti-scorbutic remedy, as it was in the West at the same time.

Fig. 25: Qing dynasty (1622-1942) soldier with typical blue scurvy stains on both legs

Sprouts were also a staple food in much of South-East Asia. Their use against scurvy is not in doubt. Although it dates from the 19th century, this anecdote may prove it. An American skipper named Edmund Fanning, engaged in the seal fur trade between the Antarctic Sea and China, learned from the Malays how to sprout peas on board and use them to ward off scurvy[35].

Comparing the eating habits of Asian and Western sailors, Matthieu Torck concludes that the former, whether Chinese, Korean or Japanese, eat the same

[33] *Soybean* is a faulty translation. Soybeans in this text are not soya bean sprouts, but mung bean sprouts.

[34] Testimonies gathered from Muslim merchants and excerpts from Ibn Baṭṭūṭa's fictional journey to China. The many implausibilities in this account have made it suspect. But Ibn Baṭṭūṭa's journey to India is genuine (Fauvelle-Aymar & Hirsch 2003, 85-93).

[35] Nixon J.A. 1944, *Health and Sickness*, p. 511. Quoted by Torck 2009, 146 n. 515.

fruit and vegetables at sea as they do ashore, but in a fermented and pickled version that can be preserved for longer.

In short, Asian sailors on long crossings took on board provisions that had proved effective on land against scurvy, namely sprouting grains and beans, fermented foods, and possibly rice or millet beer. Western sailors on the other hand, who were deprived of vegetables and fruit, waited for scurvy to appear after several weeks at sea before treating its symptoms when they could, i.e. when they were lucky enough to stop over in a place that provided fruit or plants rich in vitamin C. Asian sailors practised prevention, while their Western counterparts accepted the inevitability of illness at sea.

Eating techniques and habits do not explain everything. Fermented vegetables and marinades also existed in the West, but were rarely taken on board, except by Baltic Sea fleets. As we have seen, sprouted grains, especially barley malt, were identified as an effective antiscorbutic remedy as early as the middle of the 18th century and were successfully tested by MacBride and Cook.

Success without a future. The disregard of maritime authorities and merchant companies for the lives of seamen hampered the adoption of beneficial sanitary measures. The ultimate cause of the hecatomb of several million European seafarers since 1700 lies in the highly unequal social structures of the old regimes in Europe and their dynastic struggles for supremacy. Preventive remedies had been known for a long time but had never really been implemented (**4.5**).

The answer of the 20th century is scientific, commercial and technical. Ascorbic acid is synthesised. The industrial production of vitamin C proves a worldwide commercial success. Ships equipped with cold rooms keep food fresh. In contrast, the social issue of the precarious living conditions of seafarers in the globalised mercantile world remains topical.

6. The scientific rationale behind the benefits of malt infusion

Despite the undeniable merits of fresh citrus juice, research continued in laboratories at the end of the 19th century. They explored the properties of sprouted grains of all kinds (peas, lentils, beans, etc.), including barley. The value of freshly sprouted barley was demonstrated again by Valentin Fürst in 1912, and current experience of its use seems to suggest that malt that is not 'highly dried', as is the case today, probably retains much of its potency. Even in a simple brewing process, beer can still retain some of the virtues of barley, regardless of what fermentation or added ingredients may impart.

The circle is closed with MacBride's experiments on malt and its infusion a century earlier. But this time, scientific methods and tools would finally unlock the mystery of vitamins, particularly vitamin C.

In 1907, Axel Holst and Theodor Frølich, two Norwegian doctors studying beriberi on board the Norwegian fishing fleet, requested a small mammal guinea pig to replace the pigeons then used in beriberi research. They fed a guinea pig with the same test diet of grain and flour that had previously caused beriberi in

the pigeons, and were surprised when the classic symptoms of scurvy resulted[36]. The choice of this animal was a happy coincidence. Until then, scurvy had not been observed in any living organism other than humans, and had been considered an exclusively human disease. A laboratory animal model that could help identify and isolate the anti-scurvy factor had just been discovered.

The mystery of the benefits of vitamin C was revealed in 1919 by Jack Cecil Drummond. He realised that the antiscorbutic factor was one of the "water-soluble B" substances already discovered in rats. He first called it "water-soluble C", then recommended that it be named vitamin C. At the time, the chemical structure of vitamin C was not yet known.

Fig. 26: Albert Szent-Gyorgyi in 1948

In 1928, Albert Szent-Gyorgyi isolated a reducing agent from the adrenal glands of animals, from orange juices and from cabbage. He named it "hexuronic acid" because of its 6 carbons and 6 oxygens. He immediately drew a parallel with the famous vitamin C known to be an antioxidant. In 1931, he definitively identified it as vitamin C. Tests on guinea pigs were carried out jointly in 1932 by Charles Glen King at the University of Pittsburgh. In 1933, Albert Szent-Gyorgyi and Walter Norman Haworth decided to adopt the name a-scorbic acid (contraction of anti-scorbutic).

The L-ascorbic acid molecule was synthesised from glucose by Tadeusz Reichstein in 1933, then in 1934 by Walter Norman Haworth. The patent for the Reichstein process was sold in 1935 to Hoffmann-La Roche with a view to industrial production. Today, more than 80,000 tonnes of vitamin C are produced worldwide every year[37].

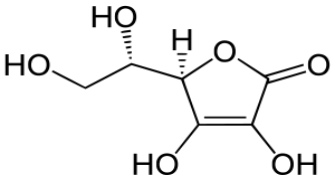


Fig. 27: ascorbic acid molecule

7. The return of scurvy in the trenches of the First World War

The 19th century witnessed the advent of preserves, inspired by the techniques developed by the Frenchman Nicolas Appert in 1795. Appert kept his preserves in glass jars tested by the French Navy. He chose to publish his discoveries in 1810, instead of taking out a patent[38]. With little encouragement in

---

[36] Guinea pigs must ingest ascorbic acid, and cannot synthetise it endogenously, as must humans, some monkeys and bats.

[37] The Reichstein process began with the hydrogenation of glucose to produce sorbitol and then an acetic fermentation of sorbitol, a biochemical process using *acetobacter*. It continues with a second, purely chemical operating phase.

[38] Nicolas Appert, *L'art de conserver, pendant plusieurs années, toutes les substances animales et végétales, Paris juin 1810* (*The art of preserving all animal and vegetable substances for several years*). Published at his own expense in an edition of 6,000 copies, this work was to eat up part of the prize of 12,000 francs awarded by the French Imperial Government. Humanity owes Nicolas Appert many discoveries, including "pasteurised" milk, condensed milk, bouillon in dried tablet form and the clarification of fermented beverages. wikipedia.org/wiki/Nicolas_Appert

France, his inventions were copied in England by Peter Durand, who took out a patent to make the process his own. The process was modified by the use of tin cans. England, always keen to support its powerful navy, became one of the main customers for this invention.

The technical progress made at the end of the 19th century improved the supply of food to ships, and the health of sailors at sea. They no longer suffered from scurvy, except during maritime expeditions across unknown seas.

7.1. Sprouted grains are efficient against scurvy

However, the annals of the 20th century record the reappearance of scurvy, this time on land. The disease spread in the trenches of the 1914-18 war, on the Italian-Austrian front in the Dalmatian mountains and among Serbian troops fighting along the Black Sea. Soldiers and doctors were looking into ways of combating and curing scurvy. Wiltshire, a doctor at King's College Hospital, described the benefits of sprouted beans prepared in this way:

> "*They [haricot beans] were first soaked in clean water for 24 hours and then placed in tin trays for 48 hours to germinate. Old ration biscuit tins, cut in half longitudinally and freely perforated with holes, were found serviceable for this purpose ; they were easy to make, clean, and handle, and each half held 7 pounds of beans-a day's dose for 28 patients. Since germination takes about 48 hours at a temperature of 60° F., it can easily be carried out in this country in May, when the mean temperature is 67°. The whole process is very simple, the only essentials being that the seeds must be kept moist, but not shut off from free circulation of air. After germination ten minutes boiling was ample to fit the beans for eating.*" [Whiltshire 1918, 811]

The procedure followed was straightforward. Soldiers suffering from scurvy were admitted to two wards with 27 and 30 beds respectively. In one ward, they were given 115ml of freshly squeezed lime juice every day, in the other ward 115g of sprouted beans. After four weeks, 70% of the soldiers treated with the sprouted beans saw their scurvy symptoms disappear, compared with 53% of those treated with the lime juice. Wiltshire proposed supplying Serbian troops with sprouted beans for the coming winter of 1918:

> "*The advantages of these dry seeds over all other forms of fruit and vegetables, both for storage and transport, are obvious. Since they double in weight and bulk and require to be kept moist when germinated, this process should be carried out as near the site of consumption as possible. In stationary trench warfare it should not be necessary to attempt germination in the actual front line, because the supply of vitamine by this method is so generous that it would suffice for preventive purposes if given every other week, or every other fortnight, when the troops were in rest. Should, however, a battalion be compelled to stay in the front line for longer than a fortnight it would not be difficult to supply it with pulses already germinated, since at most two hundredweight (100 kg.) per day would be needed for a thousand men, and this weight represents so much food transported as well as so much vitamine.*" [Whiltshire 1918, 812-813]

The First World War unleashed an overwhelming wave of misfortune in Europe. The resurgence of scurvy on the many battlefronts attracted the attention of military doctors. They tested various treatments, some of which proved the

spectacular effectiveness of sprouted beans against the disease. It was no longer a matter of barley or wheat malt only, as with MacBride's treatments 150 years earlier, but of all the grains, peas and beans that can germinate quickly (2 to 3 days) in the trenches. European military medicine rediscovered one of the anti-scorbutic remedies used by Asian sailors for more than a thousand years (**5**).

7.2. Kaffir beer is efficient against scurvy

Another crucial observation led to a parallel being drawn in 1918 with the beer of Viking sailors and its anti-scorbutic effect. Not the industrial beer of the early 20th century, but the domestic beer brewed in the villages of South Africa. During the winter of 1918 on the battle front in France, the military doctor Dyke Hamilton noticed some surprising cases of scurvy among Africans from South Africa (Basuto, Bavenda, Xosas, Zulus and other ethnic groups). The British Army had forcibly recruited hundreds of them to work on the lines of communication behind the military fronts in Europe. They belonged to the *South African Native Labour Corps*. Why are these cases so surprising? Because scurvy is unknown to these same Africans, who spend the southern winter in their homeland without vegetables or fruit for 5-6 months. What was the source of the vitamins that protected them from scurvy during the austral winter time?

After investigating, Dyke Hamilton observed that these African populations drank a type of African beer throughout the winter, a beer called kaffir beer by the European colonists. This traditional beer made from sorghum malt is part of the domestic economy in South Africa [Berger 2021]. The sprouted sorghum is dried in the sun, avoiding the high drying temperatures used by English Porter and IPA brewers. The infusion of the sorghum malt is not followed by prolonged boiling of the wort. Kaffir beer is brewed in small quantities and consumed fresh. These three techniques protect the vitamin C contained in the sorghum malt. In France, the South African forced labourers did not drink kaffir beer during the winter of 1917-18. Dr Hamilton had his explanation for the scourge of scurvy affecting the Africans workers deprived of their traditional beer [Hamilton W. Dyke 1918, 514]. We also have ours. It confirms that in Europe, industrial malting and brewing techniques have profoundly altered the original antiscorbutic qualities of domestic beers.

The end of the First World War in 1918 heralded a new era. A year after the armistice, scientists began to understand the nature and effects of vitamins on human health. The notion of a vitamin was now part of scientific thinking. The actions of vitamin C on human metabolism were the focus of recent research. Genetics show that the world's population can be divided into three groups that are more or less dependent on the antioxidant properties of vitamin C. The onset of scurvy is not determined solely by nutritional factors. Scurvy prevention on European ships in recent centuries did not depend solely on the uniform volume of lemon juice or malt infusion drunk by sailors. Their susceptibility to scurvy depended on the two alleles of the gene that controls the haptoglobin generation[39].

[39] Haptoglobin (Hp) is a protein present in blood plasma that binds with haemoglobin and prevents the latter's oxidative reactions. Vitamin C and hemopexin do the same. The

This explains the variable effectiveness of anti-scurvy treatment campaigns in the 19th century.

Asian populations are the most vulnerable to scurvy. They developed anti-scurvy diets based on sprouted grains, which were highly effective at sea. However, scurvy seems to have wreaked havoc on armies on land in China, Japan and Korea. The populations least susceptible to scurvy are the Amerindians of Latin America, the Rapa Nui of Easter Island, the inhabitants of Papua New Guinea and the Inuit of Hudson Bay in Northern Canada. The latter live scurvy-free on a meat diet low in vitamin C [Delanghes, Langlois & al. 2011, 343 and Fig. 1].

After the British Navy gave up using malt decoction in favour of concentrated lemon juice at the end of the 18th century, Cook's recipe was no longer used, either by the British Navy or by other navies around the world, except very occasionally as a substitute antiscorbutic.

Nowadays, only sailors in non-stop single-handed competitions experience sailing conditions similar to those experienced by the discoverers of the 15th, 16th and 17th centuries. They take on board carefully balanced food rations enriched with synthetic vitamins. There's no need to stock up on malt to sustain their long, sporting crossings.

8. Conclusions

Malt and beer are at the heart of this history of antiscorbutic recipes. The practical success of the malt infusion tested by MacBride and Cook in 1774 and the paradoxical failure of its adoption by European navies illustrate the complex roles played by beer and brewing technologies in modern societies. Many obstacles prevented the widespread use of malt infusion as a preventive and curative remedy for scurvy. Each of these obstacles relates more or less directly to the three facets of beer: its socio-technical dimension, its socio-political dimension and its socio-psychotropic dimension.

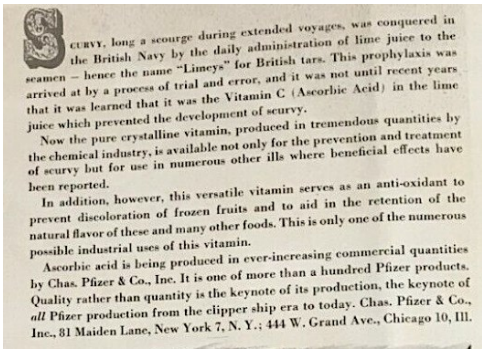
On the technical and scientific (socio-technical) front, research into scurvy has progressed with knowledge of the biological processes at work in the germination and fermentation of grains, the technological fundamentals of brewing. To understand the medical effect of sprouted grains on scurvy sufferers, it was necessary to understand the biological mechanisms of germination and the underlying biochemical processes: the production of enzymes to saccharify the starch, and the production of an antioxidant such as vitamin C. Enzymes were discovered in 1896 by Eduard Buchner in Munich. His experiments were successful

---

haptoglobin protects like vitamin C when the latter is lacking. The generation of haptoglobin in the human body is controlled by the 2 alleles (Hp1 and Hp2) of a gene on chromosome 18. In the world population, the 3 combinations of these 2 alleles are distributed as follows: Hp1-Hp1 (15%), Hp2-Hp2 (35%) and Hp1-Hp2 (50%). Antioxidant capacity is highest for the haptoglobin variant generated by the Hp1 allele, and lowest for Hp2. Hence, the Hp1-Hp1 populations are the most resistant to vitamin C deficiency, while the Hp2-Hp2 populations are the most exposed to the risks of scurvy. The genetic combination Hp1-Hp2, most prevalent among European populations, correlates with a moderate biological resistance to scurvy (Delanghes, Langlois & al. 2011).

thanks to a strain of brewer's yeast known as "bottom-fermenting" and his use of diatoms to crush the yeast. Buchner demonstrated that even crushed 'dead' yeast could trigger an alcoholic fermentation [Beer-Studies]. The "vitalist" principle is definitively removed from the field of science. Biochemistry is born. Plant germination and fermentations are now studied as purely (bio)chemical phenomena.

The discovery of vitamins comes later. It depends on research into nutrition, that of the poor and that of the rich, and remains linked to the eating habits of the various countries of the world [Gratzer 2006, 100-117]. Beriberi rather than scurvy provides the experimental ground for demonstrating the role of vitamins. The first was chemically isolated by the Polish scientist Kazimierz Funk, the vitamin B3[40]. Scientific research into vitamins once again crosses paths with the world of brewing when sprouted seeds prove to be good antiscorbutics during the 1914-18 war (**7.1**). Physicians understand that germination is the biological process that provides essential nutrients, micronutrients that are not yet called vitamins. Not only malt but all sprouted vegetable seeds contain these precious nutrients. The therapeutic link between malt-beer and scurvy then extends to all sprouted plants. The fields of experimentation spread to every scientific community on the planet, and expand beyond the case of scurvy alone.


SCURVY, long a scourge during extended voyages, was conquered in the British Navy by the daily administration of lime juice to the seamen – hence the name "Limeys" for British tars. This prophylaxis was arrived at by a process of trial and error, and it was not until recent years that it was learned that it was the Vitamin C (Ascorbic Acid) in the lime juice which prevented the development of scurvy.

Now the pure crystalline vitamin, produced in tremendous quantities by the chemical industry, is available not only for the prevention and treatment of scurvy but for use in numerous other ills where beneficial effects have been reported.

In addition, however, this versatile vitamin serves as an anti-oxidant to prevent discoloration of frozen fruits and to aid in the retention of the natural flavor of these and many other foods. This is only one of the numerous possible industrial uses of this vitamin.

Ascorbic acid is being produced in ever-increasing commercial quantities by Chas. Pfizer & Co., Inc. It is one of more than a hundred Pfizer products. Quality rather than quantity is the keynote of its production, the keynote of *all* Pfizer production from the clipper ship era to today. Chas. Pfizer & Co., Inc., 81 Maiden Lane, New York 7, N. Y.; 444 W. Grand Ave., Chicago 10, Ill.

Fig. 28: vitamin C and its trade by Pfizer, mid-20th century

On the socio-political front, the brewers play a decisive economic and political role, as they are contractual suppliers to the English Admiralty. This contractual system also exists in Holland, France, Sweden, etc. These brewers could have supplied fresh, unroasted malt to the naval authorities, no doubt to the detriment of supplying beer barrels[41]. But these barrels of beer are part of a socio-political grid that is not easily disrupted on board ship and at ports of call: the best beers go to the officers, small beer to the sailors. Sailors take on board beer and rum or gin, while officers take on board premium beer (porter, India pale ale, etc.), cooked wines and quality spirits. On the ships, social barriers are reasserted in the smallest details of life on board. Barrels of beer of different qualities are the embodiment of an omnipresent social ladder. On the other hand, using the same malt and the same malt infusion for the entire crew, sailors and officers alike, partially abolished this social ladder. Officers in the navy and merchant navy had no doubts about the effectiveness of malt infusion against scurvy. They consumed it. They questioned the infusion, which was distributed to the entire crew, because this medical potion was not

[40] In 1881, the Baltic-Russian physician Nikolaï Lunin concluded that "a natural food such as milk must therefore contain besides these known principal ingredients small quantities of unknown substances essential to life" (quoted by Frederick Hopkins Nobel Lecture in December 1929).

[41] Cook's 2nd and 3rd voyages, and other explorations, have shown that supplies of well-dried malt can be kept on board for a long time.

distinctive. It did not reaffirm the on-board discipline based on the strict (and often fierce) segregation between those in command and those who obeyed. The history of mutinies shows that this segregation was precarious.

On the mentalities front, beer retained its aura amongst sailors in 18th and 19th centuries, not for its anti-scorbutic qualities, which had more or less disappeared (**4.6**), but for its alcoholic content, just like the wine supplied to Spanish and Portuguese sailors (**3.4**), and more generally all the distilled spirits - rum, gin, brandies - that hydrated the daily lives of sailors and officers at the time. So it was the alcohol in beer that promoted it among sailors and officers amid the dangers of the high seas, rather than its nutritional qualities and possible anti-scorbutic properties. Unfermented malt infusion didn't bring any intoxication!

The islands and lands bordering the Caribbean Sea are visited by European sailors and freebooters in the 17th and 18th centuries. When their beer reserves are exhausted, they learn to brew the beers of the native Amerindians with manioc or sweet potatoes, with varying amounts of cane sugar or local fruit [Beer-Studies]. They know how to do without cereals and malt. Their stubborn search for alcohol is cited. These native beers were also effective antiscorbutic drinks during fruitless winters[42]. The cooked roots of cassava and sweet potatoes are saccharified by insalivation or with amylolytic ferments. These indigenous Caribbean beers have a nutritional value equivalent to the South African *kaffir beer* described by the military doctor Hamilton in 1918 (**7.2**). Since then, international teams of nutritionists have analysed most of the world's traditional beers and shown that their vitamin content is high enough to prevent the main nutritional deficiencies [Beer-Studies].

9. Bibliography

Anon. 1918, *Beer, Germinated Beans and Scurvy*, The Lancet 192, pp. 822-823. sciencedirect.com.gate3.inist.fr/science/article/pii/S0140673601045081

Anon. 1960, *Historical notes*, In: Acta Scandinavia Medica 167 Issue S357, pp. 9-24. onlinelibrary.wiley.com/doi/10.1111/joim.1960.167.issue-S357/issuetoc

APPERT Nicolas 1810, *L'art de conserver, pendant plusieurs années, toutes les substances animales et végétales*. gallica.bnf.fr/ark:/12148/bpt6k202755q

BATTESTI Michèle 2021, *Le blocus maritime de 1815 à la Première Guerre mondiale, théorie et pratique*, Les Cahiers Sirice 2021/1 (N° 26), pp 33-45. www.cairn.info/revue--2021-1-page-33.htm

BEAGLEHOLE JC 1955, ed. *The voyage of the Endeavour 1768-1771*. Cambridge University Press.

BERGER Christian (2021), *Beer for collective work among the Xhosa of South Africa*. beer-studies.com/en/explorer?geo=86&chrono=495&theme=227

[42] Vitamin C: 20mg/100g of cassava (same for potato), 3 mg/100g of sweet potato.

BLANE Gilbert 1795, *Observations on the Diseases of Seamen*. London. archive.org/details/observationsondi1789blan

CARPENTER Kenneth J. 1986, *The history of scurvy and vitamin C*. Cambridge University Press. books.google.com/books?id=kx5JHTuDE84C

CARRÉ Adrien 1997, *Les mystères du scorbut marin à la lueur de la biologie moderne*, in *L'homme, la santé & la mer*, Paris, Honoré Champion, 377-395.

CARTIER Jacques, *Bref récit et succincte narration de la navigation faite en 1535 et 1536 par le capitaine Jacques Cartier aux îles de Canada, Hochelaga, Saguenay et autres*, éd. 1863. gallica.bnf.fr/ark:/12148/bpt6k1096855?rk=64378;0

CHICK Harriette, HUME Margaret, SKELTON Ruth 1918, *The Relative Content Of Antiscorbutic Principle In Limes And Lemons Juice in the Prevention of Scurvy*, *A. Experimental Inquiry*. The Lancet Volume 192, Issue 4970, pp. 735-737. sciencedirect.com/science/article/abs/pii/S0140673600590266

COOK Gordon C. 2004, *Scurvy in the British Mercantile Marine in the 19th century, and the contribution of the Seamen's Hospital Society*. Postgraduate Medical Journal 80, 224-229. www.ncbi.nlm.nih.gov/pmc/articles/PMC1742980/

COOK James 1777, *A voyage toward the South Pole and round the world*. London, 2 vols. Vol. I books.google.fr/books?id=KfoG1Fy5UHEC&printsec=frontcover& Vol. II books.google.fr/books?id=78xeAAAAcAAJ&printsec=frontcover&

DAVIES C. S. 1963, *Les rations alimentaires de l'armée et de la marine anglaise au XVIe siècle*. In: Annales. Économies, Sociétés, Civilisations. 18e année, N. 1, 1963, pp. 139-141. persee.fr/web/revues/home/prescript/article/ahess_0395...

DELANGHES, LANGLOIS & al. 2011, *Vitamin C deficiency: more than just a nutritional disorder*, Genes Nutr 6:341–346. doi.org/10.1007/s12263-011-0237-7

DODOENS R. 1578, *A niewe herball or historie of plantes …* translated by Henry Lyte, London.

FAUVELLE-AYMAR F., HIRSCH B. 2003, *Voyage aux frontières du monde Topologie, narration et jeux de miroir dans la Rihla de Ibn Battûta*. Afrique & histoire, 1, 75-122. www.cairn.info/revue-afrique-et-histoire-2003-1-page-75.htm

FÜRST Valentin 1912, *Weitere Beiträge zur Ätiologie des experimentellen Skorbuts des Meerschweinchens*, Zeitschrift für Hygiene LXXII, pp. 121-54.

GRATZER Walter 2006, *Terrors of the table. The curious history of nutrition*, Oxford, Oxford University Press.

Earl J. HAMILTON 1929, *Source Wages and Subsistence on Spanish Treasure Ships, 1503-1660.* In: Journal of Political Economy, Vol. 37, No. 4, 1929), pp. 430-450. jstor.org/stable/1820856

HAMILTON W. Dyke 1918, *Report on an outbreak of scurvy in the South African Native Labour Corps*, The Lancet 192, Number 4964, pp. 513-515. thelancet.com/journals/lancet/issue/vol192no4964/PIIS0140-6736(00)X3475-7

HARDEN A., ZILVA S. 1918, *A note on the susceptibility of the Anti-scorbutic Principle to Alkalinity*. The Lancet 192, p. 320. sciencedirect.com.gate3.inist.fr/science/article/pii/S0140673601028021

HENDERSON SMITH Alice 1918 a, *The Relative Content Of Antiscorbutic Principle In Limes And Lemons Juice in the Prevention of Scurvy*, *B. Historical Inquiry*. The Lancet Volume 192, Issue 4970, pp. 737-738. sciencedirect.com/science/article/abs/pii/S0140673600590266

HENDERSON SMITH Alice 1918 b, *BEER and SCURVY. Some notes from history*, Lancet Volume 192, Issue 4972, pp. 813-815. sciencedirect.com/science/article/abs/pii/S0140673601045020

HUGHES R. Elwyn (1990), *The Rise And Fall Of The "Antiscorbutics": Some Notes On The Traditional Cures For "Land Scurvy"*, Medical History, 1990, 34: 52-64. cambridge.org/core/journals/medical-history/volume/E8239B2…

HUGHES R. Elwyn (2000), article *Scurvy* in *The Cambridge World History of Food*, vol. 1, K.F. Kiple (dir.). archive.org/details/cambridgeworldhi0001unse

JOINVILLE Jean de 1309, *Histoire de Saint Louis suivie du Credo et de la lettre à Louis X* ... gallica.bnf.fr/ark:/12148/bpt6k2003200/f149.item

KEEVIL J. J. 1957, *Medicine and the Navy 1200-1900*. Edinburgh & London, 2 vols. onlinelibrary.wiley.com.gate3.inist.fr/doi/10.1111/j.0954-6820.1960.tb08334.

La PEROUSE 1797, *Voyage de La Pérouse autour du monde*. T. 1, gallica.bnf.fr/ark:/12148/bpt6k1098831

LIND James, M.D. 1757, *A TREATISE on the SCURVY IN THREE PARTS. Containing An Inquiry into the Nature, Causes, and Cure, of that Disease. Together with a Critical and Chronological View of what has been published on the Subject*. The Second Edition corrected, with Additions and Improvements, London 1757. archive.org/details/treatiseonscurvy00lind. Third Edition books.google.fr/books

MacBRIDE *David 1764*, *An historical account of a NEW METHOD of treating the SCURVY at SEA* containing TEN CASES. Which shew that this destructive Disease, may be easily and effectually cured, without the Aid of fresh Vegetable Diet. archive.org/details/2702111R.nlm.nih.gov/page/n221/mode/2up

MacBRIDE *David 1767*, *An historical account of a NEW METHOD of treating the SCURVY at SEA* containing TEN CASES. Which shew that this destructive Disease, may be easily and effectually cured, without the Aid of fresh Vegetable Diet. archive.org/details/b30787956/page/2/mode/2up

MacBRIDE David 1764, *On the scurvy, with a proposal for trying new methods to prevent or cure the same at sea.* London. (3rd edition in 1772) collections.nlm.nih.gov/catalog/nlm:nlmuid-2702111R-bk

MAGELLAN, *Le Voyage de Magellan (1519-1522). La relation d'Antonio Pigafetta et autres témoignages*. Edition de Xavier de Castro, Chandeigne 2007.

MA HUAN 1433, *Ying-Yai Sheng-Lan*. Trad. 1970, J. V. G. Mills, *The overall survey of the ocean shores*. Hakluyt Society.

MARTIN 1604, *Description du premier voyage faict aux Indes Orientales par les François en l'an 1603... par François Martin, de Vitré*. gallica.bnf.fr/ark:/12148/btv1b86196970/f146.item.zoom

MASSON Philippe 1985, *Expansion maritime et santé*, in *Histoire des Médecins et Pharmaciens de Marine et des Colonies*, P. Pluchon (dir.), Toulouse.

MATHIAS P. 1959, *The brewing industry in England 1700-1830*. Cambridge University Press. archive.org/details/brewingindustryi0000math

MEHLE Nicholas 2021, *The India Pale Ale: A Tool of British Colonial Expansion*. undergradjournal.history.ucsb.edu/spring-2021/mehle/

MONNIER Raymonde 1989, *Un bourgeois sans-culotte, le général Santerre suivi de l'Art du brasseur*, Paris, Publications de la Sorbonne, coll. « Histoire moderne » (nº 23).

MOURT 1865, Mourt's relation or journal of the plantation at Plymouth by Bradford William & Winslow Edward, Dexter Henry Martyn (ed.), Boston 1865. archive.org/details/mourtsrelationo00dextgoog/page/n2/mode/2up

OLIVER Martha H. 1973, *Germinated seeds as antiscorbutics. Western use of an ancient Chinese botanical medicine*. Economic Botany 27(2), 204-209. jstor.org/stable/4253413

POISSONNIER-DESPERRIERES Antoine 1767, *Traité sur les maladies des gens de mer*. gallica.bnf.fr/ark:/12148/bpt6k6254868n

POISSONNIER-DESPERRIERES Antoine 1780, *Traité des fièvres de l'isle de St-Domingue, avec un Mémoire sur les avantages qu'il y auroit à changer la nourriture des gens de mer*, gallica.bnf.fr/ark:/12148/bpt6k64889496

PRYOR Alan 2009, *'Indian Pale Ale: an Icon of Empire'*, Commodities of Empire Working Paper No.13, University of Essex. commoditiesofempire.blogs.sas.ac.uk/files/2016/03/WP13.pdf

QUINLAN Michael 2013, *Precarious and hazardous work: the health and safety of merchant seamen 1815–1935*, Social History, 38:3, 281-307. researchgate.net/publication/263080832

RIAUD Xavier - *L'empire, les grandes expéditions maritimes, le scorbut et les dents*. www.napoleonicsociety.com/french/riaudscorbut.html

RODDIS Louis H. (1951), *James Lind founder of nautical medicine*, archive.org/details/jameslindfounder0000loui

SMITH A. H. 1918, *Beer and scurvy, some notes from history*. The Lancet 192, pp. 813-815.sciencedirect.com.gate3.inist.fr/science/article/pii/S0140673601045020

SOLAR Peter, HENS Luc (2013), *The speed of East India Company ships.* International Conference of the International Trade and Finance Association, Montréal, 29--31 May 2013. jstor.org/stable/24806671

SPOONER Franck 1932, *Régimes alimentaires d'autrefois. Deux nouveaux cas espagnols.* In: Annales E.S.C. 17ème/1 1962, pp. 93-94. persee.fr/web/revues/home/prescript/article/ahess_0395-2649_1962_num_17…

STUBBS Brett J. 2003, *Captain Cook's beer: the antiscorbutic use of malt and beer in late 18th century sea voyages*, Asia Pacific Journal of Clinical Nutrition, vol. 12, nº 2, pp. 129-137. www.apjcn.org/APJCN.aspx?id=20032

TESSIER Abbé 1785, *Projet d'Expériences à faire pour préserver de corruption l'eau qu'on embarque*, dans Voyage de La Pérouse autour du monde, Tome 1, pp. 197-204. gallica.bnf.fr/ark:/12148/bpt6k1098831

TORCK Mathieu 2005, *Maritime Travel and the Question of Provisions and Scurvy in a Chinese Context*. East Asian Science, Technology, and Medicine 23, Brill, 54-78. brill.com/view/journals/east/23/1/article-p54_5.xml

TORCK Mathieu 2009, *Avoiding the Dire Straits: An Inquiry Into Food Provisions and Scurvy in the Maritime and Military History of China and wider East Asia*. East Asian Economic and Sociocultural Studies: East Asian Maritime History; 5. Harrassowitz Verlag.

TRÖHLER U. 2005, *Lind and scurvy: 1747 to 1795*, J. R. Soc. Med. 98(11) 519–522. www.ncbi.nlm.nih.gov/pmc/articles/PMC1276007/

TROTTER Thomas 1786, *Observations on the scurvy: with a review of the theories lately advanced on that disease; and the opinions of Dr Milman refuted from practice*. Edinburgh. archive.org/details/b21522819

TROTTER Thomas 1797, *Medicina nautica: an essay on the diseases of seamen comprehending the history of health in his majesty's fleet, under the command of Richard Earl Howe, Admiral*. London.

de VEER Gerrit 1609, *A True Description of Three Voyages by the North-east Towards Cathay and China Undertaken by the Dutch in the Years 1594, 1595 and 1596*, Published at Amsterdam in the Year 1598, and in 1609 translated into English by William Phillip. Hakluyt Society 1853. archive.org/details/threevoyagesofwi00veerrich

WILTSHIRE H. W. 1918, *A note on the value of germinated beans in the treatment of scurvy, and some points of prophylaxis*. The Lancet 192, 811-813. sciencedirect.com.gate3.inist.fr/science/article/pii/S0140673601045019 ou www.jameslindlibrary.org/wp-data/uploads/2014/07/Wiltshire_HW_1918.pdf