product data of tomatoes

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PRODUCT
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OF
TOMATOES

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Preface

In South-America tomatoes have been used as food since approximately 500 years B.C. However, it was not until the beginning of the 20th century that the culture of tomatoes in The Netherlands commenced.
After 1950 it became a very important product and now, tomatoes are the largest horticultural export product in The Netherlands.
Partly due to the efforts of research institutes and stations, the Dutch growers have succeeded in greatly increasing the production and quality of tomatoes during the past years.
Preservation of the quality of horticultural produce whilst it is on route from producer to consumer is the main field of research of the Sprenger Institute. Therefore research on handling and marketing of tomatoes has been a central item in the institute's program for a long time. The results are primarily published in the "Produktgegevens Groente en Fruit". In this publication over 50 fruit and vegetables varieties are described. On the occasion of the golden jubilee of the Sprenger Institute (June 12, 1986) the edition on tomatoes is also issued in English. We hope that it will meet the many requests from abroad.

Drs. G.J.H. Rijkenbarg, director

1. BOTANICAL DATA

1.1 Nomenclature

The tomato belongs to the family of the Solanaceae (nightshade-family). Many species which belong to this family, as well as the tomato, produce edible fruit. Some species produce poisonous fruit as a result of the appearance of tamatine and solanine. The generic name Solanum (Solani (Lat.) means calm down. To this family belong a few other important cultivated plants, such as potatoes, eggplants, peppers and tobacco, as well as some officinal plants. The tomato belongs to the genus Lycopersicon (lycopersicum: lycos (Gr.) = wolf; persicos (Gr.) = peach), wolfspeach). To this genus belong two subgenus:
Eulycopersicon. Red fruited tomatoes.
The most important species belonging to this subgenus are:
- Lycopersicon lycopersicum (L.) Karst. ex Farw.. This species includes all large-fruited cultivars.
- Lycopersicon pimpinelli folium Mill., a species with very small fruit resembling red berries. They are called currant-tomato and are especially important for breeding in connection with certain Fusarium-disease resistances.

Eriopersicon Green (white) fruited tomatoes. A few species of this subgenus are also of importance for breeding purposes in relation to certain disease resistances. These species are:
- Lycopersicon hirsutum Humb. et Bonpl., the hairy tomato (hirsutus).
- Lycopersicon peruvianum Mill., the Peruvian tomato.

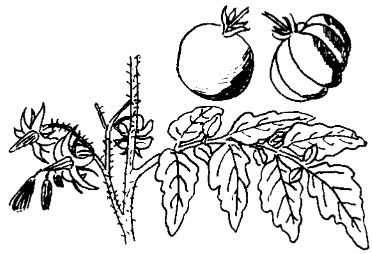
Tomato comes from the Mexican word "tomatl" derived from tomana = to swell. It was used for the fruit of other nightshades and especially for the genus Physalis e.g. Physalis ixocarpa, the tomatillo or jamberry. The small edible fruit, which looks like tomatoes, is hidden in the strongly enlarged calyx.
The tomato has 12 pairs of chromosomes 2 n = 24. (Currence, 1962, Dassler et al., 1969, Jenkins, 1948, Magoon, 1962 and Ooststroom & Reichgelt, 1966).

1.2 Plant assortment

The tomato is an annual cultivated plant, but botanically it is perennial. When the plant can survive frost, as in it's country of origin, it continues to grow and forms new flowers and fruit. It is a herbaceous crop with an erect, strongly branched, 40-100 cm (sometimes 150 cm) high stem.
When cultivated, the lateral branches are most often removed. The mainstem can become several meters long when grown in a greenhouse.
Stems and leaves are hirsute with long hairs and short glandular hairs. When broken, they spread the typically unpleasant tomato odor. At first, young plants develop a shoot-shaped main root. Many lateral roots are formed as the plant grows so that the growth of the main root is backward. In contrast to the main root, lateral roots at first grow horizontally, but later on slant downwards. When plants grow older roots can develop at the lower end of the stem. A close mesh-work of hair roots grows on the lateral roots. The root system develops quickly, and is already 20 cm two weeks after planting. After three weeks, a number reach a depth of 75 cm. They can reach 125-150 cm, depending on soil type and structure. Most roots (about 70%) however, are to be found in the upper part (20 cm) of the soil. About 20% reach a depth of 20 to 50 cm and only a small part grows deeper than 50 cm.
Tomato plants are fond of warmth and are reasonably resistent to drought. The

best growth occurs with sunny weather, with even temperatures between 20°C and 25°C. The quality of the fruit is strongly influenced by the temperature; the fruit does not increase in size at temperatures above 35°C.
Plants are usually frozen below 0°C.
High temperatures, together with a high relative humidity, promote diseases.
The tomato, which is not sensitive to day length, flowers and sets fruit at a daylight length varying from seven to nineteen hours. It may not set fruit at a day length of less than five hours or at full day length. (Magoon, 1969, Van der Meijs, 1977 and Ooststroom & Reichgelt, 1966)

1.3 Leaf



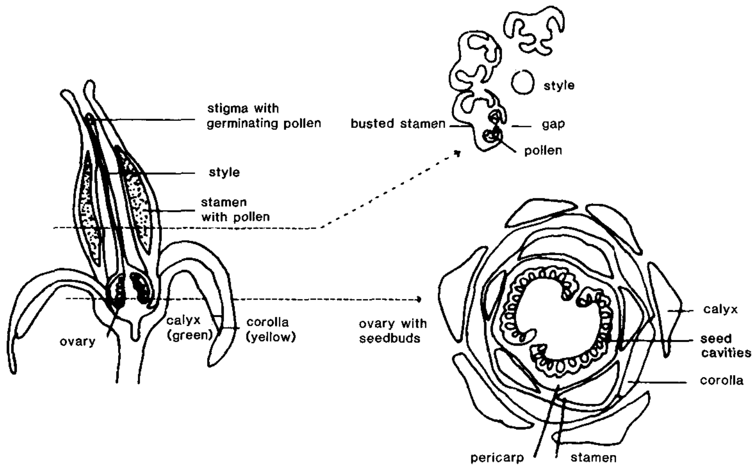
The tomato has large, 10 to 20 cm, sometimes up to 30 cm long, compound leaves with a strong, thick nerve. The leaf is often spoon-like, and may be folded and rolled up at the edges. The upper side is mostly dark green; the under side more blue green.
The leaves are alternate along the stem. Only close to the flowerstem do we often find two leaves at the same height, but not opposite each other. The leaf base is often oblique, while the stipules are wanting. The leaf is compound and oddly interupted pinnate, that is to say, each leaf is composed of a great amount of separate leaves on either side of the midrib, whereby greater and smaller leaves alternate, with a leaf seated on top of the nerve.
These oblong and ovate leaves are irregularly pinnately lobed to pinnatifid and are seated on small stems. The leafmargins are lightly dentated. In contrast to the normal leaves, the seed leaves are simple. They are very narrow, oblong, entire and hairy. Often they are somewhat violet coloured.
Tomatoes grown under glass on one stem are noteworthy for the appearance of shoots out of the adventitious buds on the leaves. Along the midrib little shoots are formed, while the ends of the peduncles grow on as leaf shoots. (Ooststroom & Reichgelt, 1966)

1.4 Flower

The tomato has 20 to 30 mm bright yellow flowers, born in clusters and located on the stem between the nodes.
The corolla is deeply five clefted, yellow with recurving and broadly lanceolate petals. The calyx possesses five long, lineair or lanceolate sepals, shorter than the petals at first, but increasing in size as the fruit matures. In contrast to some other Solanaceae, the calyx of the tomato hardly grows during the ripening of the fruit. It stays green and intact on the fruit. This shows the freshness of the fruit.
The fruit form is more or less to be seen at the flower form: round or oblong fruit is formed from totally symmetrical star-shaped flowers with five petals and five sepals; ribbed tomatoes are formed from oval flowers with more than five petals or sepals, bilaterally symmetrical on cross-section.
The inflorescence is a protracted cluster. Depending on the genus, simple, forked or compound clusters are distinguished. The amount of flowers per cluster varies, from four to numerous depending on the genus. Small fruited varieties bear large clusters with thirty to fifty flowers. The flower clusters are often located on the stem between the nodes opposite a leaf. The

first cluster is formed after the third to sixth leaf. As a result of an interruption in growth, abnormal flowers, called "barley flowers", may be formed instead of normal ones, from which only small tomatoes develop. (Currence, 1962, Magoon, 1969, Ooststroom & Reichgelt, 1966, Ravestijn, 1977a, Anonym, 1979/1980)

Cross section of the flower



1.5 Propagation organs

The tomato has bisexual flowers with five or more stamens and a pistil. The stamens are born in the throat of the corolla. On the underside, they are rather broad, but upwards they become more narrow and they end in a point.
The lowest, broadest part of the stamen is formed by a band of 1-2 mm long filament, on which a 7-8 mm long, narrow, dark yellow anther is placed. It ends in a narrow sterile point which is turned to the outside. Together the stamens form a cone around the pistil. The anthers contain innumerable pollen grain. The pollen leaves the anthers through long split shaped openings. These continue to the top of the stamens and end in a pore. The style of the pistil which is planted on the inferior ovary can vary in length. The best chance for fruit setting is when the style is shorter than the cone of stamens. On the upper side is a green bud-shaped stigma, that can be seen through the stamens. Just like the petals and the sepals, the form of the fruit can be seen by the shape of the style: round tomatoes have flowers with a thin, round style, oblong tomatoes have a broad style and ribbed ones have a style which is more or less flat and furrowed.
The flowers are protandric, that means the stamens are ripe before the stigma. When the anther ripens, it springs open lengthwise at the inner side of the cone. (Currence, 1962, Ooststroom & Reichgelt, 1966 and Ravestijn, 1977a)

1.6 Pollination

Tomato flowers are not often frequented by insects because of absence of nectar. To become fruit, the flowers have to be pollinated. Natural parthenocarpy hardly occurs. When circumstances for pollination and fertilization are unfavourable, artificial parthenocarpy is stimulated by spraying with growth hormones.
During normal conditions, self-pollination usually takes place. This happens

by movement. The stamens are mature before the stigma. The anthers spring open lengthwise on the inner side of the cone and the pollen drifts through the closed space formed by the stamens. For fresh firm plants, the surface of the stigma is sticky and the humidity is increased by the protruding hairs of the stamens. When viable pollen touches the stigma it germinates quickly. The best germination occurs at temperatures between 18^{o} and $21^{o}C$; at a high (above $38^{o}C$) as well as at a low (below $10^{o}C$) temperature, germination is poor.
Since a good quality two-celled tomato contains at least 70 seeds, just as much pollen grain must be germinated.
To be ensured of a good pollination, the flower forms a surplus of pollen on one side and on the other a great amount of seedbuds, varying from one hundred to two hundred. Outdoors, pollination takes place by air movement (wind).
Because of lack of air movement in greenhouses, mechanical devices are used to execute pollination.
Shaking the plant is simplest, whereby the strings of the tomato are beaten. This method is effective but depends on the climatic conditions. With overcast weather, the result is next to nothing, but with sunny weather reasonable pollination can be obtained. Another method, mechanical vibration against the flowercluster with e.g. the american tomato vibrator, has much more effect. Experiments with automatic vibrating systems are disappointing as far as fruit setting is concerned because it is not possible to vibrate against the flower cluster. Most difficulties with pollination occur with the earliest crop because of insufficient viability of the pollen.

The american tomato vibrator gives the best results

After pollination, the pollen grains grow through the germ tube to fertilize the seedbuds.
Optimal temperatures for fertilization are between $20^{o}C$ and $25^{o}C$. Low temperatures slow down the growth.
The fertilized seedbuds attract many assimilation products, necessary for the edification of the seed. Also, the fruitwall and fruitmucus are stimulated to grow. This stimulation results in more seeds, which give better growth and a well filled tomato. Uneven fertilization of the seedbuds will give an uneven

growth of fruitwall and fruitmucus. Because of this, oblique fruit is created which ripens unevenly. Oblique fruit can also be created by touching the flower with a vibrator. The form of the fruit and fruit quality depends on pollination and fertilization. (Currence, 1962, Magoon, 1969, Ravestijn, 1977a and Ravestijn, 1977b)

1.7 Fruit

The fruit is a berry with two to eighteen locules (chambers). Large fruited types have five to ten locules. A gelatinous substance completely surrounds the seeds and fills the seed cavity. Growth hormones are found in the substance which reduces the viability of the seeds. The skin of the fruit is a thin peel.

In the first, green stage of development, the fruit contains the poisonous alkaloïdes tomatine and solanine, which disappears when the fruit ripens. Colouring of the tomato is caused by the red pigment lycopeen. Sunlight is not essential as colouring continues in the dark. Temperature is important with colouring the best at 24°C; over 30°C the fruit stays bleachy. The exterior colour is the total of both skin and flesh colour. Red tomatoes are the most common, but there are also pink, yellow and white tomato varieties.

flesh colour	skin colour	exterior colour
red	yellow	red
red	white	pink
white	yellow	yellow
white	white	white

The shape of the fruit is diverse. One can see by the flower and propagation organs which fruit form can be expected: round, oblong or ribbed.

Ribbed tomatoes arise from a natural, hereditary fasciation (= bundled coalescence). Tomatoes have two or more cells. Two-celled fruit is basic, which is dominant over many-celled fruit. Two-celled tomatoes are formed from two carpels. Three-celled fruit is created by doubling one of the two carpels. Many-celled tomatoes are formed by the growing together of two- or three-celled part ovaries.

With strongly ribbed three- to nine-celled fasciated tomatoes, two or three carpels are formed instead of one, which grow together as one part ovary.

The amount of seeds per fruit increases according to the number of cells but with increasing fasciation they decrease quickly. Big, strongly ribbed tomatoes contain only a few seeds.

Fruit size and fruit weight vary strongly with different species, apart from growing circumstances. The berry-tomatoes weigh only 1 to 3 g, and the biggest ribbed ones weigh about 1000 g each. (Magoon, 1969 and Ooststroom & Reichgelt, 1966)

1.8 Propagation

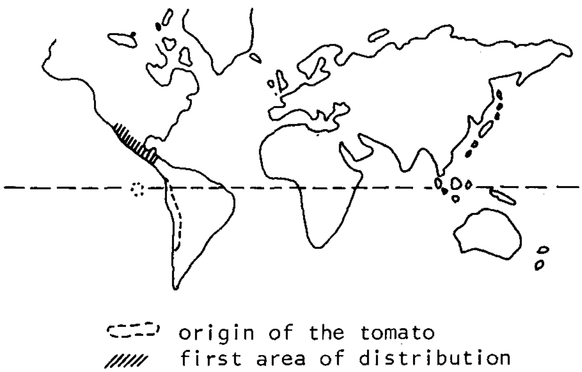
Tomatoes are only grown from seeds. With other Solanaceae, cutting and grafting is possible but this is never done in practice.

Seeds are rather small, about 3 to 4 mm diameter, and are kidney shaped, rounded and flattened. They are white-grey-yellow and have close white hairs. The

hairiness makes them seem winged and distinguishs them from similar seeds of other Solanaceae such as sweet pepper.
Tomato seed needs no light to germinate. Temperature is most important for germination. The optimum temperature for germination is about 25°C, while the minimum temperature is from 8 to 10°C. At temperatures between 20° and 30°C seeds germinate within fourteen days. Quickly germinated seeds often grow into extremely good plants. One thousand seeds vary in weight from 2.7 to 3.3 grams. Tomato seeds will remain viable for three to four years if stored at temperatures between 5° and 10°C with a relative humidity of 30-40%. (Magoon, 1969 and Van der Meijs, 1977)

2. HISTORY

Originally tomatoes came from South America (Peru and Chile). According to the Russian research worker Vavilov the original area is situated in a narrow coastal strip between the Andes Mountains and the Pacific Ocean.



To the north it stretches to Colombia and in the south to Lat. 30 S in Chile. A second and smaller area is found on the Galapagos Islands facing the coast of Ecuador.
All varieties which are found here have very small fruits like Lycopersicon lycopersicum and the L. pimpinellifolium (cherry tomato). The variety Ceraciforme, the cherry tomato, which is native in Peru and some remote areas, belongs to the L. lycopersicum. This variety is probably the direct ancestor of the cultivated tomato. The tomato was used as food in Peru as early as 500 years BC. Although no prehistorical remains or pictures have been found, it is certain that the tomato must have been cultivated in South America before 1500. Its culture spread via Central America to Mexico. In Mexico the fruit was named "tomatl" after the well known winter cherry Physalis, because of its similarity to this fruit.
For ages the tomato has been one of the most important ingredients of the daily menu in Mexico. In early days the Mexicans sowed tomatoes between corn.
After the discovery of the New World by Columbus the Spanish explorers brought the tomato seeds to Europe.

Europe The first man in Europe who mentioned the tomato was the Italian physician Mattioli (1554). It concerns a yellow tomato, named pomi d'oro (golden apple). In 1570 this name is also used in the German, Flemish, French and English language together with other names as pomme d'amour, pomum Indium and poma Peruviana. An English description dated 1578 mentions the culture of tomatoes in English herb gardens.
At first the tomato was cultivated in Europe as a peculiarity. The fruits were not eaten because people believed them to be poisonous.
Although an English description from 1596 says that tomatoes in other countries were cooked and eaten, it was not until the beginning of the 19th century that Europeans began to appreciate the tomato as food.
This development started in the countries around the Mediterranean. Italy is the first country to start growing tomatoes as a commercial crop. A description from 1812 tells of the cultivation of tomatoes in Sicily, and the shipping of the fruits to Naples and Rome. Later this commercial culture spread over Europe, first to Austria and Hungary and afterwards to France and England.
Most of the countries in Western and Northern Europe did not accept the tomato as an article of food until the end of the 19th century. In Germany and the

Scandinavian countries it took even longer (after World War I).
The United States The development in the United States was almost the same as in Europe. There too, the tomato was practically unknown as an article of food till the beginning of the 19th century. The first descriptions date from about 1835 but commercial culture started no sooner than 1885.
The Netherlands Tomatoes were already an important vegetable in England when at the beginning of 1900 the culture in The Netherlands started. The most important center is in Loosduinen and surroundings. Several growing systems are used, e.g. on a warm place outdoors in front of a wall or fence, and in hotbeds or greenhouses. English methods were applied in the greenhouse culture, whereby the small plants were cultivated in pots, crates, or in the soil. The last method was by far the best for the Dutch circumstances, because the market price for tomatoes in Holland was insufficient to make the roundabout way of culture in pots or crates payable.
English varieties were also used here. It was recommended to obtain the seed from Germany and not from England or Holland, because the German seed was better. Contrary to later methods of culture the plants are clipped after, or even before, the first cluster of flowers, which results in two or three stems: the side stems are always cut off after growing a flower cluster.
The culture of tomatoes in greenhouses has been increasing during the last century. Before World War II the culture of grapes was still important. After World War II the culture of tomatoes became more and more important.

Most of the tomatoes are cultivated on substrate

In a rather short time the grapes disappeared almost completely and the area with tomato greenhouses increased to almost 2600 ha in 1960. At that time almost 50% of the total surface was unheated. Heated greenhouses, however, became more and more in use. In 1964 gas was introduced (instead of oil) which resulted in a tremendous expansion of almost 500 ha in one year. This consisted completely of heated greenhouses. The total area extended to 3700 ha in 1970. Due to the energy crisis in 1973-'74, the heated area was reduced to a total area of 2500 ha in 1980 and 2000 ha in 1985. Apart from the cost of energy the increasing competition from the southern countries - mainly Spain -

contributed to the decrease in total surface. Even so, the total production is still increasing, mainly as the result of a new system of culture called "rockwool growing". This was introduced in the early nineteen eighties. With the new system, the production per square meter is much higher than with the traditional cultures. In fact, the average production of 12 kg per m in 1972 has risen to 36 kg per m in 1984 (Anonym, 1985, Claassen & Hazeloop, 1904, Currence, 1962, Magoon, 1969, Nelson et al., 1955 and Seelig, 1963).
The development of the production and the exports of Dutch tomatoes from 1950 till 1985 is shown in table 2.1 and table 2.2.

Table 2.1. Planted area and production figures

year	plant area in ha 1)			commercial production x 1 mln. kg
	hot glass	cold glass	total 2)	
1950	355	756	1,111	75.4
1955	713	1,108	1,821	125.0
1960	1,311	1,278	2,589	201.4
1965	2,254	1,210	3,464	312.4
1970	2,379	960	3,339	392.3
1975	2,061	355	2,416	345.5
1980	2,009	159	2,167	396.4
1985	1,947	92	2,039	524.7

1) "May-counting" CBS
2) excluding the autumn culture

Table 2.2. Exports of Dutch tomatoes to the main destinations

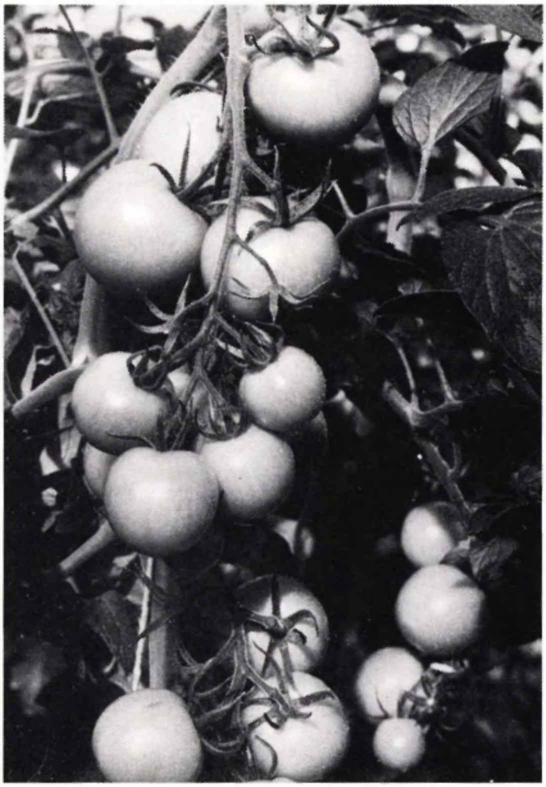
year	total x 1 million kg	in million kg sent to West Germany	United Kingdom	France	Sweden	Switser-land	Belgium/ Luxemb.
1950	41.2	21.3	15.2	-	0.7	0	0.7
1955	88.6	57.7	21.2	0.1	4.1	0.7	1.3
1960	163.9	113.8	34.6	0.3	8.2	1.4	3.4
1965	262.6	175.0	52.9	9.5	17.6	2.7	2.6
1970	309.3	217.8	51.7	12.4	19.9	3.9	2.3
1975	186.5	197.2	31.4	24.2	15.4	5.4	1.2
1980	337.8	217.8	58.5	25.5	19.4	5.4	1.2
1985	443.8	224.7	104.6	60.6	16.7	10.1	2.9

3. VARIETIES

3.1 Variety choice

The Dutch tomatoes are grown almost exclusively for the fresh market. Therefore, in this publication we will only discuss tomatoes for fresh consumption. There are different types of tomatoes. There is a distinction between fleshy and non-fleshy types. One can also distinguish the varieties by number of compartments in the fruit, for which the following classification is used:

- 2 or 3 compartments: round type
- 3 to 5 compartments: middle type
- more than 5 compartments: beef tomato



The growers can make a choice from many varieties

The cultivation of the beef tomato has increased during the last few years to 350 to 400 ha, which is about 17% of the total area in use for tomato cultivation.

On the basis of the colour of the immature fruit, varieties can be classified into three colour groups: green, semi-green and pale. A disadvantage of the green varieties is the problem of green shoulders and discolouration, which mostly occurs in the late culture. Sometimes irregular fruit setting occurs.

The pale varieties are preferred at this moment. Green and semi green varieties are still in use only for beef tomatoes.

The following factors play an important role in variety choice:
- the growing medium
- the way of growing
- the growing pattern (short or long culture, intercropping, trellising
- the growing potential and crop type, in relation to the points, mentioned above.

3.2 Desired properties
Important properties are:
- high productivity
- early for the winter culture, late for the autumn culture
- as many resistances as possible to diseases
- sufficient numbers of big fruits, especially for the late cultures
- round shape and smooth orange - red color of the mature fruit. Beef tomatoes don't have to be of round shape but they should be regularly shaped and fleshy
- fresh sour taste
- good internal and external firmness
- good keepability.

3.3 Growing periods
Tomato culture can be divided into:
- hothouse growing
- growing in glasshouse with a hot air heater
- growing in a cold glasshouse
- autumn culture.

All these cultures take place in glasshouses. Tomato growing in the open air is not practiced commercially in the Netherlands.
Hothouse culture can cover a long period by using intercropping and continued growing on trellises or strings.
In this way it is possible to harvest up to the middle of November. An overall picture is given for the growing periods of tomatoes in table 3.1.

Table 3.1. Growing periods of tomatoes

growing method	sowing date	planting date	harvest date
very early hothouse	Oct. 25	Dec. 15	March 10
early hothouse	Nov. 10	Jan. 1	April 1
late hothouse	Dec. 5	Febr. 1	May 1
hot air heater	Jan. 15	March 1	May 25
cold glasshouse	Febr. 20	April 1	June 15
late cold glasshouse	April 20	June 1	August 10
autumn culture	June 1	July 5	Sept. 15

3.4 Variety classification
The following data are borrowed from the 34th Dutch list of varieties for vegetables 1985, glasshouse crops.

Table 3.2. Survey of the commercial tomato varieties, grouped under different headings

variety	headings 1)					fruit type		
	hot-house	hot air	inter-crop-ping	cold	autumn	fruit colour 2)	number of cells 3)	fruit shape 4)
Abunda	B	A	A	A	B	b	2/3	r
Angela	-	-	0	B	0	b	2/3	r
Bellina	-	-	-	-	0	b	2/3	r
Buffalo	N	-	B	-	B	b	> 5	r-lg
Calypso	N	N	N	N	-	b	2/3	r
Concreto	B	B	B	-	-	b	> 5	lg-g
Dombito	A	A	B	-	-	g	> 5	lg-g
Dombo	0	0	-	-	-	g	> 5	lg-g
Estafette	-	-	A	N	A	b	2/3	r
Euroset	N	N	N	N	-	b	2/3	r
Everset	-	-	-	-	N	b	> 5	lg-g
Goldstar	0	0	-	0	0	b	2/3	r
Marathon	A	-	B	-	-	b	2/3	r
Novita	0	-	-	-	0	b	2/3	r
Perfecto	...	...	B	-	B	b	> 5	r-lg
Piranto	-	0	-	0	-	b	2/3	r
Portanto	-	0	0	0	0	hg	> 5	lg
Pierator	0	-	-	-	-	b	2/3	r
Rainbow	N	-	-	-	-	hg	> 5	lg
Rianto	B	0	B	0	0	b	2/3	r-lg
Rovato	-	0	-	0	0	b	2/3	r
Sonatine	0	A	0	A	-	b	2/3	r
Turbo	A	B	A	A	B	b	2/3	r
Vision	N	N	B	B	B	b	> 5	lg
Wilset	0	-	-	-	-	b	2/3	r
B81.810 5)						b	2/3	r
E 12457 5)						b	> 5	lg-g
660 5)						b	2/3	r

1) A = most important variety, B = limited recommended variety, 0 = variety of little importance, N = new variety, - = not recommended for this growing method, ... = still in study
2) b = pale, hg = semi-green, g = green
3) 2/3 = 2 or 3 celled fruits, > = 5 or many celled fruits, > 5 = more than 5 compartments
4) r = round shape, lg = lightly rubbed fruits, g = ribbed fruits
5) variety is still being tested.

The following table gives a survey of the resistances of the different varieties for certain diseases. The following abrieviations are used:

TMV = tomato mosaic virus

C = mildew or leaf mould. The figure gives the number of strains, to which the variety is resistant, for instance C3 means that the variety is resistant to the strains, 1, 2 and 3.

V = Verticillium wilt

F = Fusarium wilt; the figure shows the number of strains

W = Root knot nematode

P = corky root

Wi = white heads

Table 3.3. Resistance of varieties to different diseases

variety	resistant to						
Abunda	TMV	C5	V	F2			
Angela	TMV	C3		F2			
Bellina	TMV	C5		F2			Wi
Buffalo	TMV	C5	V	F2			
Calypso	TMV	C5	V	F2			Wi
Concreto	TMV	C5		F2			
Dombito	TMV	C2		F2			
Dombo		C2	V	F2			
Estafette	TMV	C5	V	F2	N		
Euroset	TMV	C5			N		Wi
Everset	TMV		V	F2	N		
Goldstar	TMV	C5	V	F2			Wi
Marathon	TMV	C5	V	F2			Wi
Novita	TMV	C5		F2	N		
Perfecto	TMV	C5		F2			
Piranto	TMV	C5		F2		P	
Portanto	TMV	C5		F2	N		
Purator	TMV	C5	V	F2			Wi
Rainbow	TMV	C5		F2			
Rianto	TMV	C5		F2			
Rovato	TMV	C5		F2			Wi
Sonatine	TMV	C5		F2			
Turbo	TMV	C5	V	F2			Wi
Vision	TMV	C5	V	F2			
Wilset	TMV	C5		F2			
B 81.810	TMV	C5	V	F2	N		Wi
E 12457	TMV	C5	V	F2			
660	TMV	C5	V	F2			Wi

4. DISEASES AND DEFICIENCIES

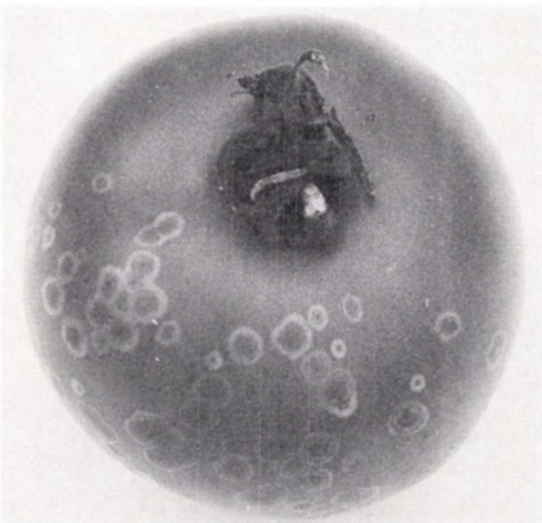
In this section, only those diseases are included which show symptoms on the harvested product.

4.1 Animal parasites

Aphids (plant lice) Macrosiphum euphorbiae Thos. and Myzus persicae Schulz. These red and green lice cause the leaves in the top to curl up and sometimes cause the fruits of the lowest raceme to be lumpy.
Tomato moth Diataraxia oleracea L. is an olive coloured, black speckled caterpillar with a light stripe on each side. These caterpillars bore holes in the leaves as well as into the fruits.
Red spider mite Tetranychus urticae Koch. These small, spidery creatures cause gold-coloured spots on ripe fruit.
Glasshouse White-fly Trialeurodes vaporariorum Westw. These white flying insects can cause honey-dew, on which black mould can develop.

4.2 Bacteria and mould

Grey mould Botrytis cinerea Pers. ex. Nocca & Balb. This mould infects the fruits around the pedicel. Often the attack begins via the calyx, and a grey-brown, rotten, soft lesion with a lot of fluffy mould develops around the pedicel. After a while a large number of spores are formed which give the whole a greyish appearance. The fruits often fall off from the plant.
Another indication of an initial infection by Grey mould is the appearance of small light-coloured rings with a darker spot in the center. These little circles are found at random in the fruit wall. They are often called "Botrytis-spots" or "ghost spots".



Initial infection by Grey mould

Cancer (Stem-rot) Didymella lycopersici Kleb. (stat. con. Phoma lycopersici Cooke). This mould causes dark brown greasy spots on the fruits of outdoor tomatoes. Later, small black-brown dots arise on the infected lesions. These are the fruiting bodies of the mould from which the spores later appear. The infected spot is usually surrounded by a light-brown watery zone. The contamination penetrates deeply into the tomato.

Bacterial Blight

- Dry fruit rot, Phytophthora infestans (Mont.) de Bary f. sp. infestans. This fungus causes dark brown, lumpy, dry patches on the surface of the fruit and a brown dry rot inside. Fruits of all sizes and all the racemes may be affected simultaneously.
- Wet fruit rot, Phytophthora nicotianae B. de Haan var. nicotianae. This mould cause dark grey-green, very soft lesions on the fruits. Sometimes brown, irregular, concentric rings occur on the fruit. The infection only occurs on fruits of the first and sometimes the second raceme, that is on the lowest-hanging fruits. Generally the fruits fall off from the plant. The infected pedicels are completely or partly brown both inside and out.

4.3 Virus diseases

Aucuba mosaic Tomato mosaic virus causes tomatoes to colour irregularly.

Mixed Streak disease. This is a complex of tomato mosaic virus + potato virus-x. If the plant has not died completely, large grey, brown, slightly sunken lesions occur on attached fruits.

Tomato streak disease Tomato virus mosaic causes brown spots and mosaic-characteristics to appear on the fruits.

4.4 Deficiency diseases

Calcium deficiency The primary symptoms of this deficiency are sharp edged, flat, brown or grey, slightly sunken lesions at the end of the fruit. In time, these lesions will rot, which is why this phenomenon is often called Blossom end rot.

Magnesium deficiency causes fruits at the end of the raceme to be quite green, whereas the rest ripen normally.

Manganese deficiency results in only the first fruits of a cluster developing a red colour.

Blossom end rot see calcium deficiency.

4.5 Physiological storage diseases

Low temperature injury If the fruits are exposed to too low temperatures (below 13^{o}C) for too long, soft and/or glassy patches appear on the fruits. Another type of low temperature injury is the occurrence of small sunken yellow coloured lesions. These symptoms appear if the temperature is between 8-10^{o}C for three or more days. Tomatoes affected with chilling injury will generally fail to ripen properly (Schouten, 1977b and Schouten & Stork, 1977).

4.6 Other diseases and deficiencies

Fruit splitting There are three types of splitting:

- Russeting. Russeting develops about three weeks before harvest. A changeable climate (during spring) will stimulate this. It decreases as temperature and radiation are higher. Russeting is one of the most important factors affecting the keeping qualities of tomatoes. The quantity of rot during storage will increase, as there are more cracks in the fruits.
- Radial splits starting at the stem and probably arising from a strong interaction between water uptake and evaporation.
- Concentric splits or cracks, almost always on the shoulders and around the

stem in the fruits, caused by strong sunlight on the fruits.

Water core During summermonths, with very high temperatures, glasshouse tomatoes can be waxy and soft. The keeping quality is highly shortened.

Greenback The fruit has a hard green colour around the stem. On ripening this part turns yellow.

Irregular colouration of the fruits Irregular colouration of tomatoes may have different causes and symptoms:

- Brown discolouration of the vascular bundles (blotchy ripening) may result from strong fluctuations in temperature and air humidity.
- Discoloured, less sharply defined spots resulting from inadequate colouration of the fruit. It occurs through irregular water uptake and a low nutrient level.

Blotchy ripening See irregular colouration of the fruits.

Sun scorch On ripe fruits, sunken brown spots appear around the fruit stem, especially fruits with a green back. Outdoor tomatoes show damage symptoms because the fruits are exposed to greater sunlight. On the side of the fruit a light-coloured dead tissue arises which is slightly sunken and shrivels somewhat on ripening of the fruit.

5. COMPOSITION AND ENERGY VALUE

General evaluation of the nutritive value
In comparison with the other vegetables the tomato is a moderate source of minerals and vitamins, as shown in the tables 5.1 and 5.2.

Table 5.1. The relative worth-factor (RW) for the evaluation of the vitamin and mineral content of the fresh tomato in % in relation to the "averaged vegetable"[1]) with order[2]), derived from Van der Meer (1979)

	on the basis of the contents			
	per quantity of weight		per quantity of energy	
	%	order	%	order
RW vitamins and minerals	61	35	72	28
RW vitamins	65	31	80	25
RW minerals	47	43	51	27

1) "averaged vegetable" = the average of the 47 vegetables from the Dutch Food composition table (Voorlichtingsbureau voor de Voeding, 1983)
2) place of the tomato in the series, arranged in order of diminishing values of the various RW's, for the 47 vegetables (47 = last place)

Table 5.2. The quotients of the contents of constituents in the tomato in relation to those of the "averaged vegetable", the weight-factors of the minerals and the vitamins in the RW(V+M) and the percentage that 100 grams of fresh tomato contributes to the daily allowance (norm) at 12552 kJ = 3000 kcal

constituents		weight-factor in the RW(V+M)	contribution of 100 g to the norm in %	quotients of the contents per quantity of weight	quotients of the contents per quantity of energy
protein		irrelevant	1.5	1/2	5/8
potassium	(K)	0.50	12 [1])	5/6	9/10
calcium	(Ca)	0.33	1	1/6	1/5
iron	(Fe)	0.50	2	1/7	1/6
thiamine	(vit. B_1)	0.75	4	4/5	1/1
β-carotene	(provit. A)	1.00	27	4/5	6/7
pyridoxine	(vit. B_6)	0.75	5	7/10	7/8
niacin	(vit. PP)	irrelevant	4	5/8	3/4
ascorbic acid	(vit. C)	1.00	30	2/5	1/2
riboflavine	(vit. B_2)	0.50	1	2/9	1/4

1) the daily allowance is not known; American recommendations indicate 2500 mg

Arranged in order of the RW(V+M) the tomato ranks 35th in the series of the 47 vegetables of the Dutch Food compopsition table (Voorlichtingsbureau voor de Voeding, 1983) but it is necessary to remark that tomatoes are consumed especially in fresh state, so that there are no cooking losses.

Table 5.3. Constituents and energy value of the fresh tomato in units per 100 g edible part, derived from Souci et al. (1981) and from Voorlichtingsbureau voor de Voeding (1983)

constituents		German Food composition table		Dutch table
		av.	range	av.
main constituents				
water		94.2 g	93.4-95.2 g	94 g
protein		0.9 g	0.7-1.0 g	1 g
fat		0.2 g	0.2-0.3 g	0.2 g [1)]
carbohydrates		3.3 g	1.9-4.0 g	3 g
crude fibre		0.7 g	0.6-0.8 g	0.5 g
minerals (ash content)		0.6 g	0.6-0.7 g	.
minerals incl. trace elements				
sodium	(Na)	6 mg	3-10 mg	10 mg
potassium	(K)	210 mg	260-315 mg	300 mg
magnesium	(Mg)	20 mg	.	.
calcium	(Ca)	14 mg	10-21 mg	10 mg
manganese	(Mn)	140 µg	.	.
iron	(Fe)	0.5 mg	0.4-0.6 mg	0.2 mg
cobalt	(Co)	9 µg	.	.
copper	(Cu)	90 µg	.	.
zinc	(Zn)	240 µg	.	.
nickel	(Ni)	23 µg	3-60 µg	.
chromium	(Cr)	5 µg	2-7 µg	.
phosphorus	(P)	26 mg	17-29 mg	20 mg
fluoride	(F)	24 µg	.	.
chloride	(Cl)	60 mg	24-70 mg	.
iodide	(J)	2 µg	.	.
boron	(B)	115 µg	30-210 µg	.
selenium	(Se)	.	0.5-10 µg	.

Table 5.3 continued

constituents		German Food composition table av.	German Food composition table range	Dutch table av.
vitamins				
β-carotene	(provit. A)	820 µg	150–2300 µg	650 µg
α-tocopherol	(vit. E)	490 µg	.	.
naphtochinone deriv.	(vit. K)	630 µg	400–800 µg	.
thiamine	(vit. B_1)	57 µg	20–80 µg	50 µg
riboflavine	(vit. B_2)	35 µg	20–50 µg	20 µg
niacin	(vit. PP)	530 µg	300–850 µg	500 µg[1])
pantothenic acid	(vit. B_5)	310 µg	280–340 µg	.
pyridoxine	(vit. B_6)	100 µg	70–150 µg	80 µg
folic acid	(vit. B_c)	39 µg	.	.
biotin	(vit. H)	4 µg	.	.
ascorbic acid	(vit. C)	24 mg	20–29 mg	15 mg
amino acids				
alanine		51 mg	.	.
arginine		28 mg	23–32 mg	.
aspartic acid		108 mg	.	.
cystine		0 mg	.	.
glutamic acid		145 mg	.	.
glycine		41 mg	.	.
hystidine		14 mg	10–18 mg	.
isoleucine		28 mg	.	.
leucine		39 mg	.	.
lysine		40 mg	23–47 mg	.
methionine		6 mg	2–9 mg	.
phenylalanine		27 mg	23–31 mg	.
proline		44 mg	.	.
serine		51 mg	.	.
threonine		31 mg	28–35 mg	.
tryptophan		8 mg	4–13 mg	.
tyrosine		14 mg	12–16 mg	.
valine		26 mg	21–32 mg	.
γ-aminobutyric acid		9 mg	.	.
organic acids				
malic acid		37 mg	20–70 mg	.
citric acid		440 mg	260–610 mg	.
total oxalic acid		0 mg	.	.
chlorogenic acid		10 mg	.	.
quinic acid		8 mg	.	.
ferulic acid		.	1–2 mg	.
α-ketoglutaric acid		.	1–8 mg	.

Table 5.3 continued

constituents	German Food composition table av.	German Food composition table range	Dutch table av.
various constitutents			
glucose	0.9 mg	.	
fructose	1.4 mg	.	3 g 1)
sucrose	7 mg	.	
starch	90 mg	.	
pentosan	130 mg	.	0 g 1)
hexosan	220 mg	.	
cellulose	700 mg	.	.
myoinositol	11 mg	.	.
serotonine	1.2 mg	.	.
tyramine	400 µg	.	.
tryptamine	400 µg	.	.
total dietary fibre	1.8 g	.	1.4 g 1)
dietary fibre, water soluble	0.1 mg	.	.
total sterol	7 mg	.	.
campesterol	1 mg	.	.
β-sitosterol	3 mg	.	.
stigmasterol	3 mg	.	.
energy value	19 kcal	.	18 kcal
	80 kJ	.	76 kJ
edible part	96%	86-100%	95%

1) comprehensive table (Commission U.C.V. , 1984)

For all of the constituents, the contents in the Dutch table, see table 5.3, are within the range of the contents in the German table (Souci et al., 1981), with the exceptions of vitamin C and iron. The value of 25 mg vitamin C per 100 g, mentioned in the Dutch table of 1973, does agree with the German value. The English table (Paul & Southgate, 1978) and the American table (Watt & Merrill, 1963) mention values of, respectively, 20 and 23 mg/100 g, which agree with the value in the German table. The same is true for iron: the value in the Dutch table of 1973 (0.4 mg/100 g) concurs with the value (0.5 mg) in the German table, together with the English and American values (both 0.5 mg). The proteins furnish 22% of the energy value, in contrast to 32% for the average vegetable. The protein of the tomato has a very moderate biological value: the contents of the amino acids methionine, tyrosine and tryptophan account for respectively 27, 51 and 58% of the contents of these acids in a protein with ideal composition of the amino acids. Further, valine with 63%, isoleucine with 68% and leucine with 84% are the amino acids, which limit the quality of the protein.
The review of Herrmann (1979) reveals particulars about the very small fraction of fat in the tomato.
According to the comprehensive Dutch Food composition table (Commissie U.C.V., 1984) the carbohydrates consist totally of mono- and disaccharides, whereas

the German table mentions a fraction of about 1/6 for polysaccharides. The English table notes only traces of starch. According to the German table fructose has the highest content, followed by glucose, and sucrose (nearly negligible). However, Hobson & Davies (1971) mention about equal contents of glucose and fructose. According to these authors the contents of sucrose and starch rarely exceed 0.1 and 0.05 g/100 g respectively, see further Davies & Hobson (1981).
Corré & Breimer (1979) classify the tomato in the group of vegetables with the lowest contents of nitrate, i.e. with contents mostly below 20 mg NO_3 per 100 g. The weighed average of 101 values, found by 13 non-Dutch authors, was 4 mg NO_3 per 100 g, with a range from 0 to 17 mg. The Food Inspection Department at Haarlem (North-Holland) analysed six samples of tomatoes cultivated in alternative agriculture and found an average of 7 mg/100 g (range 6-9 mg).
The English table mentions the content of sulphur in the tomato at 11 mg S per 100 g.
Herrmann (1979) gives a detailed review, with many references, of the organic acids, phenolic acids and other phenolic constituents, occurring in the tomato.

Specific constituents

The bitter toxic alkaloid-glycosides tomatine and solanine (well known from the potato) occur in practically all parts of the tomato plant. These compounds have a complex structure (steroid skeleton).
Jadhav et al. (1981/'82) in their review of toxic alkaloids in foods mention that the tomato only contains α-tomatine and β_1-tomatine (α-tomatine minus D-xylose) of the variously occurring tomatines. Davies & Hobson (1981) in their detailed review (537 references) of the constituents in the tomato mention the following contents of tomatine: 0.9-2.2% in the dry matter of the totally opened flowers, 0.9-1.9% in the dry matter of the leaves, and 90 mg per 100 g fresh weight of green mature tomatoes. In young green tomatoes, as small as a cherry, contents of 100-200 mg/100 g have been found (Herrmann, 1979). In ripening tomatoes the tomatine is decomposed by the enzyme tomatinase, that is effective to tomatine very specifically. Tomatine has also been found in red tomatoes, but there is no agreement in the literature as to whether full ripe tomatoes are free from tomatine or whether they contain small amounts of the alkaloid. Artificially ripened tomatoes were found to contain more tomatine than tomatoes ripened on the plant. Red, ripe tomatoes lost nearly all their tomatine when the fruits remained on the plant for another 2-3 days. Red tomatoes proved to be able to decompose injected tomatine within a few days, whereas deep green tomatoes could not. The above mentioned results are referred to by Jadhav et al. (1981/'82).
Also the solanine occurs mainly in the green fruit (Herrmann, 1979). Spiesz (1981) found 9-32 mg solanine per 100 g in six samples of deep green tomatoes, 7-13 mg in five samples of mature green tomatoes and 0.1-1.8 mg in two samples of orange ones. Simekovā & Horcin (1980) analysed seven varieties at six stages of ripeness proceeding from green to red. They found 3-14 mg/100 g solanine in the green tomatoes and 0-0.7 mg/100 g in the red ones. These authors processed the tomatoes at the yellow-green stage (0.7-5.6 mg solanine per 100 g) to pickles in a sweet acid solution. After three months storage they found only 0.1-1.7 mg per 100 g. This decline is much more pronounced than can be expected on the basis of the dilution by the covering liquid, since solanine and tomatine are described as stable substances. Kibler et al. (1985) accor-

dingly found a small loss of solanine (about 10%) during the processing of sweet-acid pickles, provided that it was corrected for the dilution by the covering liquid. These authors discourage the swallowing of this food. An equal loss occurred during the processing of jam (a decline of 35% by the dilution resulting from additional contents in the recipe). Swallowing 30 grams of jam per capita per day is acceptable from the point of view of health.
For the growing-hormones occurring in the tomato, is referred to the review of Herrmann (1979).

Characteristic aroma volatiles

More than 200 volatiles can be found in fresh and processed tomatoes. Johnson et al. (1971) and Herrmann (1979) provide partly comparable lists. Johnson et al. (1971) stated that cis-3-hexene-1-ol probably is an important aroma component, and that Ψ-ionone, i.e. 2,6-dimethylundeca-2,6,8-triene-10-one, causes a hay-like smell in some tomatoes. The concentration of many volatiles changes during ripening. The decrease in the content of amino acids is associated with the formation of volatiles. Herrmann (1979) states, on the basis of literature review that in addition to cis-3-hexene-1-ol, other important aroma components of fresh tomatoes include: n-hexanal, trans-2-hexenal, 2-isobutylthiazole, and another four volatiles, especially cis-3-hexenal. The presence of methionine is important in the production of the most important hormone, ethylene.
The aroma of tomato-juice and tomato-purée becomes more intense and "fresher" through the application of 25-50 ppb 2-isobutylthiazole (Furia & Bellanca, 1975). During processing the volatiles decrease in concentration. After processing, furfural, linalylacetate and 6-methyl-5-heptene-2-one among others, are considered of importance (Herrmann, 1979). Dimethylsulfide occurs mostly in the head space of cans and jars of processed tomatoes (Johnson et al., 1971). Herrmann (1979) mentions that the quality of tomato-juice decreases in direct proportion to the increasing content of dimethylsulfide.
The aroma of the tomato is approximated by a mixture of cis-3-hexenal, 2-methyl-heptene-2-6-one, eugenol, and β-ionone in the ratio 20:1:7:1 (Hanson, 1975). This mixture ameliorates the aroma of tomato-juice, made from tomato-powder (foam-drying), see Herrmann (1979).

Distribution of the constituents

The distribution of amino acids between pericarp tissue, skin and seeds is reviewed by Herrmann (1979).
From an average of seven varieties the pericarp tissue contained 36% more glucose than the locular tissue (jelly with seeds), whereas no significant differences were found for fructose. However, the content of titratable acidity and the content of citric acid (determined separately) was higher in the locular tissue, respectively 48% and 57% (Stevens et al., 1977), see also Herrmann (1979).
Higher contents of β-carotene were found in the locular tissue. This was also valid for vitamin C in fruits grown in the shade. However, tomatoes grown exposed to the sun had more vitamin C in the pericarp tissue. The concentration decreased inversely proportional to the depth of the tissue from the skin (McCollum, 1956 and Hobson & Davies, 1971). As a rule, the skin of the tomato is richer than the pericarp tissue in vitamin C. Doesburg (1947) also found this result. This author studied the constituents according to the tissue from which they were derived: the skin (epidermis + hypodermis), outer exocarp,

inner exocarp, septa, placentae and seeds with surrounding gelatinous material. For five of the six tested varieties he found that the skin ranked first for ascorbic acid content; the placentae ranked first for one variety, second for four varieties and third for one variety. The septa and the seeds mostly ranked in fifth and sixth places. For some other results in this field, see the review by Van der Meer (1984).

Berkholst (1967 and 1968) found for two varieties (fruits in the orange-stage) the highest cellulase-activity was in the pericarp and the lowest activity was in the skin. For one variety the differences were rather small.

For the distribution of tomatine between the various parts of the plants, refer to the sub-chapter on specific constituents.

Cutting-firmness

For domestic consumption of fresh tomatoes a good cutting-firmness of the fruit is important. Berkholst (1968 and 1972) developed a method to measure this cutting-firmness. A tomato slice of about 6 mm in thickness, held between two gauze frames, is rotated at 900 rpm for 2 minutes, followed by determination of the loss in weight of the tomato slice. Berkholst noted that these "fling-out" values increased relatively faster during the post harvest ripening than during ripening on the plant. Tomatoes with high "fling-out" values proved to be more susceptible to disintegration of the interior when dropped.

Influence of the varieties

Herrmann (1979), in his review, mentions a study with 55 varieties and hybrids, in which no marked variation was found in the content of fructose (average 1.9 g/100 g, range 1.2-2.4 g) and of glucose (average 1.4 g/100 g, range 0.8-1.9 g). Variations proved to be larger in citric acid (average 3.3 g, range 1.9-4.7 g) and in malic acid (average 0.9 g, range 0.6-2.1 g).

The content of β-carotene is highly dependent on the variety. There is a cultivar with a content of 4.7 mg/100 g, about eight times the average of the Dutch tomato (Tigchelaar & Tomes, 1974). Herrmann (1979) reveals that the variation is caused more by the distribution of these carotenoids between β-carotene and lycopene than by the total content of carotenoids. In a normal variety, such as "Summer Sunrise", β-carotene accounts for 7% and lycopene for 74% of the total carotenoids. However, in a high-beta variety β-carotene accounts for 88% and lycopene for 0.1%. See also the review by Davies & Hobson (1981).

The content of vitamin C is also highly dependent on the variety. There are cultivars with contents up to 76 mg/100 g, about five times the average of the Dutch tomato (Unterholzner, 1973), see also Herrmann (1979). Wieringa (1939) found in 19 varieties an average of 19 mg ascorbic acid per 100 g with a range of 14-26 mg. Mathot (1945) found a range of 13-53 mg per 100 g for tomatoes from seven varieties and 50 hybrids grown outdoors on three plots. The percentage of dehydroascorbic acid in the content of vitamin C of some varieties, is covered in a review by Davies & Hobson (1981).

Influence of conditions during growth

Toul et al. (1970) studied the effect of a greenhouse culture on gravel (without soil) and the effect of growing on soil with reference to the content of dry matter, total sugars, β-carotene and ascorbic acid.

Zuber et al. (1971) compared the lead content of tomato plants grown along a motor highway with that of plants grown in an area without traffic. They

found, in the first case, in addition to a much higher lead content a larger difference between leaf and stalk or fruit, and a stronger effect of the washing of the fruits.
Herrmann (1979) in his review mentions that outdoor grown tomatoes have more aroma, somewhat higher content of β-carotene and a distinctly higher content of vitamin C (as a result of the difference in received sunlight) than greenhouse tomatoes, see also Hobson & Davies (1971) and Magoon (1969). For a special variety Lefebvre & Leclerc (1973) found that outdoor grown tomatoes had about 50% more β-carotene and vitamin C, whereas the contents of nitrogen, magnesium, phosphorus and vitamin B_2 were about the same. Greenhouse tomatoes, however, had more potassium and about 50% more vitamin B_1.
Doesburg found a tendency to higher contents of ascorbic acid of the tomatoes higher on the plants in respect of a lower position of the fruits.
Jen (1974) observed that the illumination of tomatoes with blue, red, green and white light and no illumination in this sequence gave diminishing contents of carotenoids.
Stenvers and Stork (1976a) found no reliable differences in softness and content of vitamin C when the ratio fruit/leaf was altered. A ratio fruit/leaf of 6:3 proved to be the most favourable ratio for a normal ripening (Stenvers, 1977c).

Influence of the manuring

Adams et al. (1973) observed that the content of titratable acidity increased with increasing N-manuring of tomato plants; however the content was not influenced by manuring with potassium. The potassium content of the tomatoes increased with both larger potassium- and larger nitrogen doses.
In their book dealing with nitrate in vegetables, Corré & Breimer (1979) mention various factors influencing the content of nitrate, such as the level and sort of the nitrogen source, point of time of manuring, other (non-N) fertilizers and the season. Luh et al. (1973) ascertained that N-manuring increased the content of amino-, ammonium- and nitrate-nitrogen of tomatoes. The highest contents of nitrate occurred at the lowest day temperatures tested (20^{o} to 35^{o}C), and remained below 10 mg /100 g. For additional information refer to the sub-chapter General evaluation of the nutritive value.

Influence of the ripeness and the size

About 80% of the colour of the ripe tomato comes from the carotenoid lycopene, which has no vitamin A activity. The remainder of about 20% consists of carotenes, such as β-carotene and some xanthophylls. During ripening of the tomato from green to red, chlorophyll is decomposed and lucopene and carotene are synthesized (Hobson & Davies, 1971). Berkholst (1966) in her review, goes further into the merits of the factors which condition the colour development. In his dissertation, Stenvers (1976) uses colour development as an indicator for the ripening of the tomato (Stenvers & Stork, 1976b). Heidema et al. (1979) stated that the selection of tomatoes (for the benefit of a homogeneous sample), based on the colour, needs to be amplified with a second selection based on production of ethylene.
Berkholst (1965) reviewed endogenous and exogenous factors, that affect fruit firmness. Softening of tomatoes during ripening was measured by Stenvers et al. (1973) by means of a non-destructive portable firmness meter.
Stenvers and Stork (1977b) stated that the exact picking time needs to be ascertained by yield and keeping quality. The physiological and anatomical as-

pects of the picking time were elaborated further by Stenvers & Staden (1976). No difference in post harvest quality was observed between tomatoes picked early in the morning and those picked in the afternoon.
During ripening the content of sugars (especially fructose) increases and the acid content decreases (Hobson & Davies, 1971). The ratio malic acid/citric acid appeared to shift from 0.46 in green tomatoes to 0.13 in ripe ones (Unterholzner, 1973). During a period of two months the amounts of potassium and total N distinctly decreased, whereas the contents of magnesium and phosphorus remained constant. During this period the tomatoes proved to contain more vitamin C and vitamin B_2, whereas the content of vitamin B_1 even doubled (Lefebvre & Leclerc, 1973). Stenvers & Staden (1976) found a slight increase in ascorbic acid during the ripening. Fruits abnormally ripened as a result of a ratio fruit/ leaf of 1:3, had a green locular tissue and revealed distinctly higher contents of ascorbic acid, see table 5.4.

Table 5.4. Contents of ascorbic acid in mg/100 g fresh weight of "Moneymaker" tomatoes with green and red locular tissue at different stages of ripeness, derived from Stenvers & Staden (1976)

ripeness or colour stage	experiment 1 locular tissue		experiment 2 locular tissue		experiment 3 locular tissue	
	red	green	red	green	red	green
4/4 green	.	.	.	.	17.0	24.2
3/4 green 1/4 orange	17.0	25.8	12.2	22.4	15.4	22.5
1/2 green 1/2 orange	22.0	24.2	14.6	24.3	18.1	20.3
1/4 green 3/4 orange	18.7	20.9	13.8	19.3	18.7	22.3
4/4 orange	.	.	15.7	19.6	19.2	22.5
4/4 bright red	.	.	16.0	25.4	.	.
average	19.2	23.6	14.5	22.2	15.7	22.4

The distribution of ascorbic acid between three parts of the tomato during ripening was also studied by Stenvers & Stork (1976b). Mathot (1945) found that during ripening the maximum ascorbic acid content occurred during maximum sunlight.
Gorin & Heidema (1981) stated that the total peroxidase activity in the non-climacteric RIN tomato mutant, picked green, was similar to that when picked yellow; whereas in the classical variety Moneymaker, this activity decreased during the ripening.
Twomey & Ridge (1970) observed that the averaged vitamin C content of early English tomatoes ripened in May amounted to 12 mg/100 g as compared to 22 mg/100 g in tomatoes ripened in July. The previously mentioned effect of sunlight was probably important in this. Doesburg (1947) found a slight increase in ascorbic acid content during the period from the end of August to the end of October.
In tomatoes of seven varieties, completely ripened on the plant, the contents of monosaccharides and ascorbic acid were respectively 7 to 41% and 10 to 39% (one variety was even 132%) higher than those in tomatoes picked green and then ripened at 20 °C (Betancourt et al., 1977), see also Van der Meer (1983a).

The contents of titratable acidity and of β-carotene were about the same for these two lots of tomatoes (Betancourt et al., 1977, and Matthews et al., 1974).
Van der Meer (1983b) reviewed the effect of picking time on the content of AIS (Alcohol Insoluble Solids).
Tigchelaar & Tomes (1974) observed in general that small tomatoes have higher contents of vitamin C and of dry matter than large fruits. Unterholzner (1973) also mentions this.

Influence of storage

In the last paper of his dissertation, a collection of five papers, Stenvers (1976) stated that tomatoes picked green are more susceptible to damage at high humidity and low temperature than the red coloured ones. Under the experimental conditions, Controlled Atmosphere (CA)-storage provided no improvement over the standard storage at 12.5-13°C in air. Hypobaric (reduced atmospheric pressure) storage is more promising (Stenvers & Stork, 1977a), (see the end of this section).
During storage tomatoes picked in the afternoon showed no differences in the progress of ripening, the rate of ripening, the occurrence of rot and the development of softness, as compared to tomatoes picked early in the morning (Stenvers, 1977c). Stenvers et al. (1978) could not demonstrate a visible relationship between the external quality at the moment of harvest and the keeping quality. Stenvers (1977a) reviewed the research done at the Sprenger Institute from 1965 till 1977, on ripening, on the influence of storage-temperature and relative humidity, and on CA-storage.
Ottoson & Wiberg (1977) observed during storage a more pronounced decrease of the sugar content of completely red coloured tomatoes than of tomatoes with starting redness. In this study with four varieties, combined with a storage of 3 weeks, the decrease of the sugar content was smaller in the varieties Sonato and Stella than in the varieties Growers Pride and Reverdan. The last variety revealed a small loss of acid content as compared to the other three varieties, see also Davies & Hobson (1981). For all four varieties Ottoson & Wiberg (1977) found a decrease of the ratio of malic acid/citric acid during storage. Meyer (1967) determined the contents of dry matter, sugars, titratable acidity, potassium, ash and fiber in tomatoes picked at four points of time. The determinations were made at 3 day intervals during ripening (after harvest) at 19°C for 21 days. Meyer (1967) found only a slight decrease of the sugar content; the acid content did decrease distinctly, but the contents of the other determined constituents practically remained constant. These constituents have also been studied in comparatively fast growing vs. slowly growing tomatoes.
Wieringa (1939) found 22 mg ascorbic acid per 100 g fresh weight in tomatoes picked yellow, before post harvest ripening. After ripening during 13 days at 30°C this author found 31 mg/100 g, and 27 mg at 25°C, 31 mg at 20°C,, 29 mg at 15°C, 24 mg at 10°C, and 25 mg at 5°C; after 20 days at 30°C to 5°C 26 mg to 24 mg of ascorbic acid per 100 g were analysed. No demonstrable loss of vitamin C was observed in ripe tomatoes during 18 days in the refrigerator or at room temperature. The same was true for slices of tomatoes stored for 5 hours in the refrigerator (Magoon, 1969). Salminen et al. (1970) kept green tomatoes of the variety Immuna for 56 days at 10°C and they kept harvest-ripe tomatoes of the same variety for 42 days at 10°C and 20°C. The authors determined the contents of dry matter, reducing sugars, starch, pectin, β-carotene,

lycopene and ascorbic acid. Salminen et al. (1970) observed in green tomatoes after 42 days of storage at 10°C ascorbic acid and β-carotene values of, respectively, 125% and 390% of their values before storage. In harvest-ripe tomatoes stored 42 days at 10°C they observed values of, respectively, 135% and 110%, and in those stored at 20°C values of, respectively, 145% and 90%, compared with before storage levels.

Stenvers (1977a) stated that hypobaric storage could extend the period of storage. Pure oxygen instead of normal air proved to be no improvement. Not only the ripening after harvest was retarded, but also the initiation of the climacteric was delayed. The action of the hypobaric storage is attributed by Stenvers & Bruinsma (1975) mainly to the reduced partial pressure of oxygen, because nitrogen + very little oxygen at 1 atmosphere (pO_2 = 0.04 and which is identical to the pO_2 in hypobaric air storage at 0.2 atmosphere) produces even a somewhat larger extension of the period of storage than the hypobaric storage.

Bangerth (1974) kept tomatoes for 8 weeks at 10-12°C in hypobaric storage as well as in normal air storage (with ventilation). He observed considerable difference in the degradation rate of chlorophyll, fast (hypob.) and slow (normal air) respectively, in the formation of lycopene and water soluble pectin (slight and sharp respectively) and in the decrease of firmness (regular and very pronounced in the first two weeks respectively), see also the review by Davies & Hobson (1981).

Influence of the domestic cooking

The Dutch Food composition table (Voorlichtingsbureau voor de Voeding, 1983) mentions for cooked tomatoes a vitamin B_6 content of 60 µg/100 g and a vitamin C content of 12 mg/100 g, corresponding with a cooking loss of 25% for vitamin B_6 (Keller et al., 1968) and a cooking loss of 52% for vitamin C (Weits & Lassche, 1965). This percentage loss of vitamin C is based on the previously used value of 25 mg/100 g in fresh tomatoes. For additional information on this subject refer to the sub-chapter General evaluation of the nutritive value. The American table (Watt & Merrill, 1963), corrected for a weight loss of 25% by cooking (Weits & Lassche, 1965), notes cooking loss of about 25% for vitamin C and losses of only 10% or less for the other constituents. There is not much literature about the cooking of tomatoes. Evidently this is due to the tomato being mostly consumed in fresh state.

Table 5.5. Constituents and energy value of canned tomatoes in units per 100 g edible part, derived from Souci et al. (1981)

constituents		German Food composition table av.	range
main constituents			
water		93.9 g	93.6-94.2 g
protein		1.15 g	1.0-1.3 g
fat		0.2 g	.
carbohydrates		3.6 g	3.5-3.7 g
crude fibre		0.46 g	0.40-0.52 g
minerals (ash content)		0.68 g	0.66-0.70 g
minerals, incl. trace elements			
sodium	(Na)	9 mg	1-22 mg
potassium	(K)	230 mg	195-270 mg
calcium	(Ca)	25 mg	6-47 mg
iron	(Fe)	0.2 mg	.
phosphorus	(P)	12 mg	.
selenium	(Se)	.	0.9-1.0 µg
vitamins			
β-carotene	(provit. A)	610 µg	.
thiamine	(vit. B_1)	60 µg	.
riboflavine	(vit. B_2)	29 µg	27-30 µg
niacin	(vit. PP)	700 µg	690-7000 µg
ascorbic acid	(vit. C)	16.5 mg	16-17 mg
amino acids			
arginine		34 mg	28-39 mg
histidine		17 mg	12-22 mg
isoleucine		34 mg	.
leucine		47 mg	.
lysine		48 mg	28-57 mg
methionine		7 mg	2-11 mg
phenylalanine		33 mg	28-38 mg
threonine		38 mg	34-42 mg
tryptophan		10 mg	5-16 mg
tyrosine		17 mg	15-19 mg
valine		31 mg	25-39 mg
energy value		21 kcal	.
		88 kJ	.
edible part		100%	.

Table 5.6. Constituents and energy value of concentrated[1]) tomato purée in units per 100 g edible part, derived from Souci et al. (1981) and from Voorlichtingsbureau voor de Voeding (1983)

constituents		German Food composition table		Dutch table
		av.	range	av.
main constituents				
water		86.0 g	.	77 g
protein		2.3 g	.	3 g
fat		0.5 g	.	0.1 g[2])
carbohydrates		9.0 g	.	14 g
crude fibre		0.5 g	.	.
dietary fibre		.	.	2.8 g[2])
minerals (ash content)		1.7 g	.	.
minerals, incl. trace elements				
sodium	(Na)	590 mg	360-820 mg	450 mg
potassium	(K)	1160 mg	670-1440 mg	1000 mg
calcium	(Ca)	60 mg	41-80 mg	35 mg
iron	(Fe)	1.0 mg	0.8-1.1 mg	5 mg
phosphorus	(P)	34 mg	30-37 mg	70 mg
vitamins				
β-carotene	(provit. A)	1.2 mg	0.7-4.5 mg	2.0 mg
thiamine	(vit. B_1)	93 µg	88-110 µg	120 µg
riboflavine	(vit. B_2)	58 µg	40-70 µg	120 µg
niacin	(vit. PP)	1.5 mg	0.9-2.1 mg	2.6 mg[2])
pyridoxine	(vit. B_6)	180 µg	180-190 µg	250 µg
ascorbic acid	(vit. C)	9 mg	0-16 mg	30 mg
energy value		50 kcal	.	69 kcal
		211 kJ	.	293 kJ
edible part		100%	.	100%

1) the degree of concentrating is not mentioned in either table
2) comprehensive table (Commission U.C.V., 1984)

Table 5.7. Constituents and energy value of tomato juice in units per 100 g edible part, derived from Souci et al. (1981)

constituents		German Food composition table av.	German Food composition table range	Dutch table av.
main constituents				
water		94.1 g	93.5-95 g	94 g
protein		0.75 g	0.5-0.8 g	1 g
fat		46 mg	40-50 mg	0.2 g[1])
carbohydrates		4.3 g	3.5-6.2 g	4 g
crude fibre		0.19 g	0.18-0.20 g	0 g
dietary fibre		.	.	1.0 g[1])
minerals (ash content)		0.6 g	0.4-0.9 g	.
minerals, incl. trace elements				
sodium	(Na)	5 mg	4-7 mg	300 mg
potassium	(K)	240 mg	180-330 mg	300 mg
magnesium	(Mg)	10 mg	7-11 mg	.
calcium	(Ca)	15 mg	9-19 mg	7 mg
manganese	(Mn)	8 µg	2-13 µg	.
iron	(Fe)	0.6 mg	0.4-0.9 mg	0.4 mg
copper	(Cu)	120 µg	50-200 µg	.
zinc	(Zn)	85 µg	60-130 µg	.
nickel	(Ni)	5 µg	.	.
molybdenum	(Mo)	.	0-4 µg	.
phosphorus	(P)	16 mg	12-20 mg	15 mg
boron	(B)	.	20-140 µg	.
vitamins				
β-carotene	(provit. A)	540 µg	410-630 µg	600 µg
α-tocopherol	(vit. E)	700 µg	.	.
thiamine	(vit. B_1)	56 µg	50-80 µg	50 µg
riboflavine	(vit. B_2)	26 µg	20-30 µg	20 µg
niacin	(vit. PP)	720 µg	500-800 µg	500 µg[1])
pantothenic acid	(vit. B_5)	200 µg	.	.
pyridoxine	(vit. B_6)	110 µg	.	80 µg
biotin	(vit. H)	.	1-4 µg	.
ascorbic acid	(vit. C)	15 mg	12-18 mg	15 mg
organic acids				
malic acid		41 mg	40-50 mg	.
citric acid		440 mg	370-510 mg	.
various constituents				
glucose		1.4 g	.	.
fructose		1.2 g	.	.
sucrose		0 g	.	.

Table 5.7 continued

constituents	German Food composition table		Dutch table
	av.	range	av.
energy value	21 kcal	.	22 kcal
	86 kJ	.	93 kJ
edible part	100%		100%

1) comprehensive table (Commission U.C.V., 1984)

Influence of preserving method and of storage of the preserved product

Comparing the contents noted for fresh tomatoes in table 5.3 with those for canned tomatoes in table 5.5, it is obvious that the differences are small. Only the contents of potassium, phosphorus, β-carotene and vitamin C are somewhat lower in the canned product. This agrees with the literature as reviewed by Hoogzand (1958) and by Van der Meer (1982), about losses occurring during sterilizing of tomatoes: a loss of 20% for β-carotene, 14% for vitamin C, 4 to 19% for vitamin B_1, and 0% for vitamin B_2. After storing canned tomatoes for one year at 17-35°C the amounts of vitamin B_2 and PP were unchanged, the amounts of vitamin B_1 and C were somewhat lower, and the iron content somewhat higher (Saldana et al. 1979).
The tin content of canned tomatoes and that of tomato purée varied considerably: respectively 13(8-19) mg and 11(2-21) mg per 100 g (Eyrich, 1972). De Groot (1976) studied the toxicity of tin, using rats fed with tomato purée from lacquered or unlacquered cans.
Comparing the contents for fresh tomatoes in table 5.3 with those for tomato juice in table 5.7, it is evident that the amounts of the constituents are about the same. However, the amounts of β-carotene and vitamin C are lower in the juice. Hoogzand (1958) and Van der Meer (1982) reported, from literature accounts, the following losses during the processing of tomatoes to tomato juice: 35 to 50% for vitamin C, 35% for β-carotene, 3 to 11% for vitamin B_1, and 3% for vitamin B_2. Compared to other juices, tomato juice has a high potassium content, but the beneficial effect of this is reduced by the ample addition of salt during processing. In unlacquered cans a distinct detinning occurs, broadly proportional to the nitrate content; in lacquered cans a brown discolouration of the juice occurs more rapidly. The ascorbic acid content decreased linearly with the storage time and logarithmically with the storage temperature and with the level of addition of ascorbic acid (Herrmann, 1968 and Pope & Gould, 1973).
Lempka & Promiński (1967) studied the losses of ascorbic acid, occurring during the freeze-drying of whole fresh tomatoes and of tomato purée.

Particulars

The seeds, remaining as waste product after the processing of tomato juice, are richer in protein and fat than the whole tomato itself. The biological value of the protein proved to be much better than that of the whole tomato: cystine and methionine, which account for 62% and 68% respectively of the amounts of these amino acids in a protein with ideal composition, were the quality limiting amino acids (Lech et al., 1969).

6. PHYSICAL AND PHYSIOLOGICAL PROPERTIES

6.1 Water content

The water content of fresh tomatoes is about 95%.

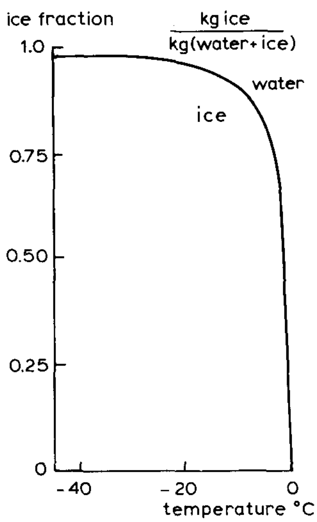
6.2 Density $\rho_{product}$ = about 1005 kg/m^3,
porosity - $\varepsilon_{product}$ = about 0,011 m^3 air/m^3 total.

6.3 Bulk density

ρ_{bulk} = about 560 kg/m^3,
porosity - ε_{bulk} = about 0,44 m^3 air/m^3 total.

6.4 Freezing point

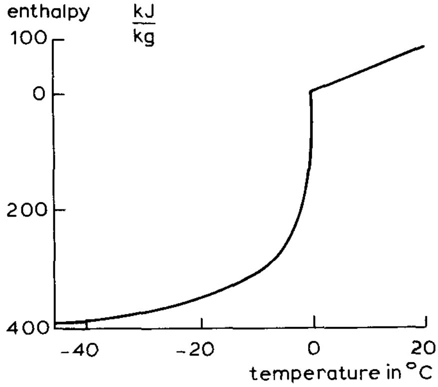
The highest freezing point is about -1,0^{o}C. At this temperature the first ice crystals are formed.



Ice fraction of the tomato as function of temperature

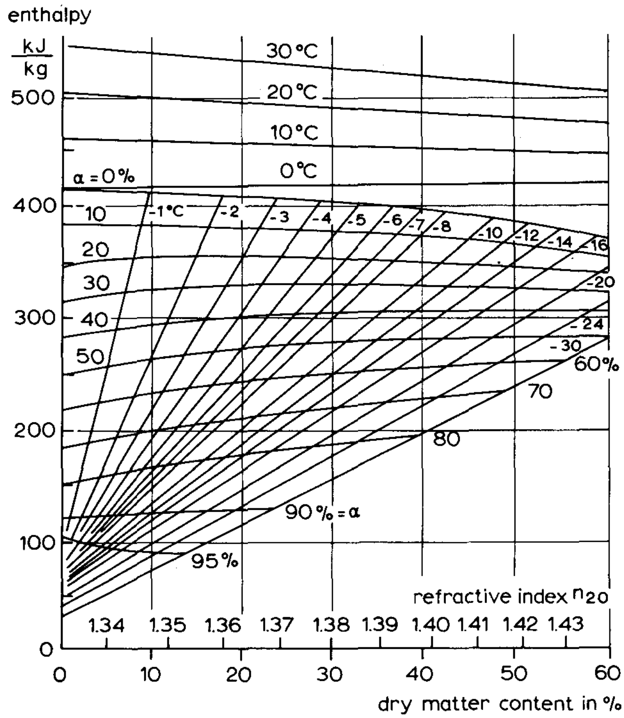
6.5 Enthalpy

The enthalpy of the tomato at freezing and defrosting is given in the corresponding figure.



Enthalpy of the tomato as function of temperature

The enthalpy of tomato juice, tomato purêe and tomato pulp as a function of the dry matter content at freezing and defreezing is shown in the next figure.

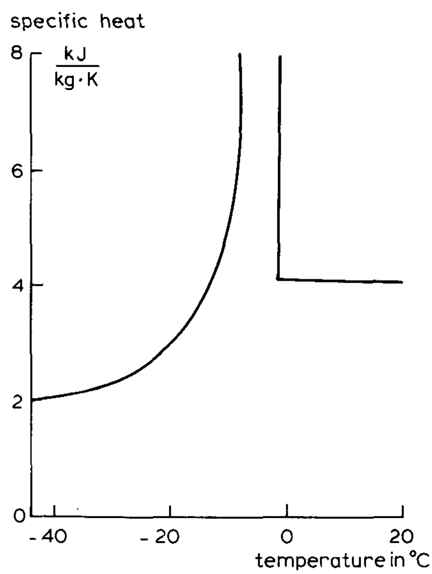


Enthalpy diagram of vegetables and fruit juice (Riedel, 1950)

ice fraction (α) = $\dfrac{\textit{mass ice}}{\textit{mass (water + ice)}}$

6.6 Specific heat

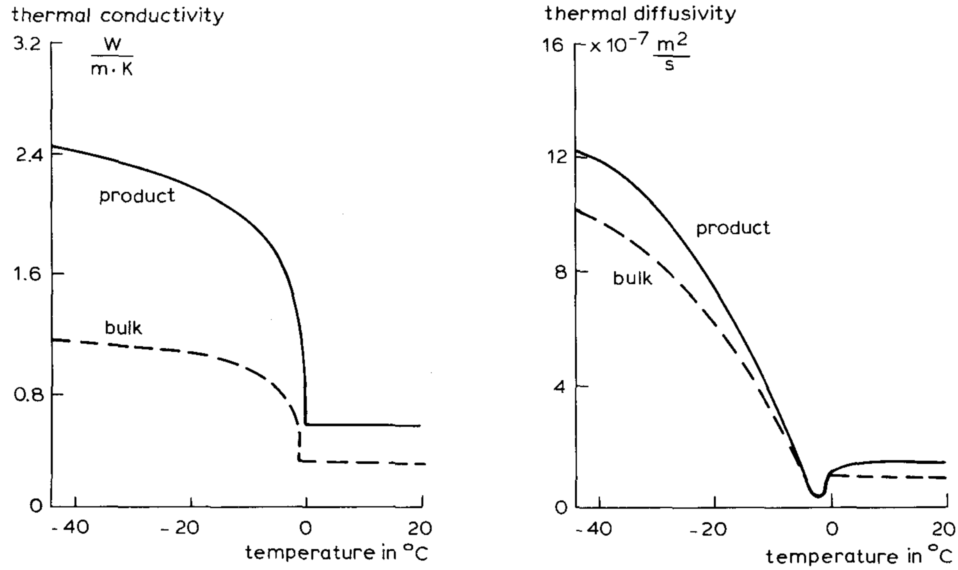
The specific heat of fresh tomatoes is shown in the corresponding figure. Because the amount of the air between fresh tomatoes is negligible the specific heat of product in bulk is equal to the specific heat of the individual product.



Specific heat of the tomato as function of temperature

6.7 Thermal conductivity

The thermal conductivity and the thermal diffusivity are shown in the following figures. Table 6.1 gives a survey of the thermal fysical properties.



Thermal conductivity and thermal diffusivity of the tomato as function of temperature

Table 6.1. Thermo-physical properties of tomatoes

temp. in °C	product				bulk	
	h kg/kg	c kJ/kg.K	λ W/m.K	a m /s	λ W/m.K	a m /s
20	81	4	0.59	$1.44.10^{-7}$	0.28	$1.25.10^{-7}$
0	0	4.04	0.56	$1.36.10^{-7}$	0.27	$1.19.10^{-7}$
-2	-166	82.6	1.27	$1.52.10^{-8}$	0.59	$1.28.10^{-8}$
-5	-269	15.2	1.80	$1.17.10^{-7}$	0.84	$9.83.10^{-8}$
-10	-311	5.39	2.04	$3.75.10^{-7}$	0.94	$3.12.10^{-7}$
-20	-348	2.83	2.23	$7.84.10^{-7}$	1.03	$6.51.10^{-7}$
-30	-374	2.28	2.37	$1.03\text{-}10^{-6}$	1.09	$8.55.10^{-7}$
-40	-397	2.04	2.49	$1.21.10^{-6}$	1.15	$1.00.10^{-6}$

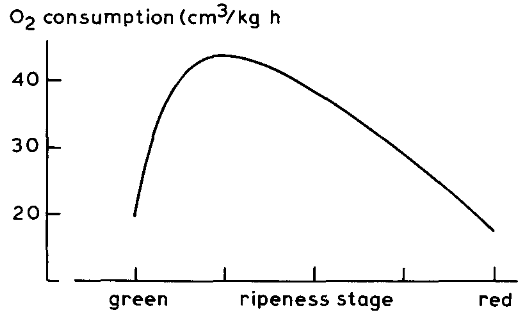
h = enthalpy; c = specific heat; λ = thermal conductivity; a = thermal diffusivity

6.8 Heat production, oxygen consumption and carbon dioxide production

The tomato, like many fruits, also has a climacteric, i.e. a clear change after harvest in the development of the fruit from unripe to ripe. During this ripening many of processes take place, after which the fruit is edible. Some developments during the climacteric of the tomato are a change of colour from green to orange and red, softening and an increase of respiration activity.

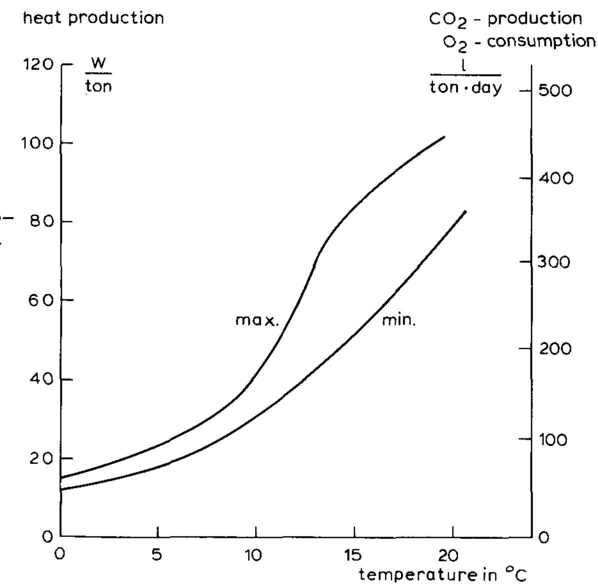
The next figure shows the oxygen consumption during the climacterium change.

O_2-consumption of the tomato as function of colour stage at a constant temperature (25^oC)



In the following figure the upper values are shown for tomatoes directly after harvest. The lower values are for product in a ripe stage.

Heat production, oxygen consumption and carbon dioxide production of the tomato as function of temperature



If the heat production, bulk density and the thermal conductivity are known, the so-called safe diameter can be calculated for a stack of products (form-factor = 2). The safe diameter is the smallest dimension of a stack of non-packed tomatoes in which the temperature rise in the center, due to the heat production, does not exceed 1^oC.
If one of the sides of such a stack is smaller than the safe diameter, the temperature rise in the center will be less than 1^oC.
In table 6.2 the safe diameter is given for a stack of non-packed tomatoes as a function of the temperature, without accounting for the effect of any moisture loss.

Table 6.2. Safe diameter of a stack of non-packed tomatoes as a function of temperature 1)

temperature °C	safe diameter in m
0	0.46
5	0.42
10	0.33
15	0.24
20	0.21

1) without accounting for the effect of any moisture loss

6.9 Ethylene production

The ethylene production depends upon the stage of ripeness of the tomatoes and fluctuates between about 3 and 12 μl/kg.h at 20°C.

6.10 Moisture loss

The specific moisture loss of the tomato is at normal air cooling (air velocity between the product 0 m/s) $0.3.10^{-10}$ kg water/kg product.Pa.s.

7. CONSUMPTION

7.1 Part of the plant for consumption

The fruit is the eatable part of the tomato plant. Fruits can be divided into three groups: 2-3 celled fruits, lightly ribbed, 3-5 celled fruits and many-celled, lightly to heavily ribbed fruits, the so-called beef tomatoes.

7.2 Methods of consumption

Tomatoes can be prepared in different ways, for instance:

1. Raw
   - in slices
   - in slices in combination with cucumber slices and/or lettuce
   - as hollowed fruits, filled with cheese, meat, fish, egg, shrimps or with a salad of other products.

2. Cooked
   - fried slices
   - as a vegetable (stewed)
   - as a hot course with the cold lunch, sometimes in combination with other vegetables, for example with sweet peppers and onions.
   - as hollowed fruits, filled for example with minced meat or ragout.

3. Prepared products
   - as soup
   - as sauce
   - as juice
   - as puree
   - as jam
   - as ketchup.

7.3 Per capita consumption

Tomatoes are available during the whole year. During winter tomatoes are mainly imported and the supply increases yearly. The per capita consumption was 5.7 kg in 1984, an increase of about 1 kg per capita since 1980.
Most of the total consumed quantity of tomatoes is round tomatoes. The demand for beef tomatoes is still small, even in the summer months, when plenty of this product is available.
As a result of a poll the Commodity-Board for Fruit and Vegetables calculated that during the winter of 1983/'84 almost 25% of the families bought round tomatoes. In springtime the percentage was growing, about 54% of the families bought round tomatoes in June and July. For beef tomatoes this percentage was about 2 percent in the winter months and not quite 5 percent in the summer months.

Table 7.1. Consumption of fresh tomatoes (round and beef)

	1950	1960	1970	1975	1980	1982	1983	1984	1985
kg per capita	1.9	2.7	3.4	4.2	4.7	5.0	5.4	5.7	5.5

8. ECONOMIC DATA

8.1 Area and producing areas

According to the the test "horticultural growths under glas", carried out by the Central Bureau of Statistics, the total area of tomatoes has decreased yearly to 2260 ha in 1984.
This decrease includes all cultures, with the exception of the very early horticulture. After 1981 the area of this culture increased to approx. 70 per cent to approx. 800 ha. About 6 per cent of the total area is for culture in cold glasshouses.
The growing of beef tomatoes increased slowly to about 200 ha. The growing on rockwool has increased substantially, especially in 1984. Until February of this year 51 per cent of the round tomatoes and about 80 per cent of the beef tomatoes were grown on rockwool.
About 75 per cent of the total tomato production area is in the province of Zuid-Holland. Here, the Westland, Delft- and Schieland and the Zuidhollandse reclaimed marshlands are the most important producing areas. Considerable production also occurs in the Voornse Duinstreek, Rijnland, the Hoeksche Waard and IJsselmonde. In Noord-Brabant, producing areas are found principally in the westerly and the easterly Langstraat and in the north/west part. In Limburg Province tomato growing is concentrated in the northern Maasvallei and in the west of Noord-Limburg.
Table 8.1 presents data from the "May-counting" of the Central Bureau of Statistics (CBS). Data for autumn production is not included. The second table presents data on the total planted area.

Table 8.1. Planted area 1)

year	hot glass in ha	cold glass in ha	total area in ha	of which in per cents		
				Zuid-Holland	Noord Brabant	Limburg
1979	2052	187	2239	78	11	5
1980	2009	159	2167	77	11	6
1981	2022	143	2165	76	12	7
1982	2099	149	2249	75	11	8
1983	2003	123	2126	76	11	8
1984	1959	117	2076	74	11	9
1985	1947	92	2039	74	11	9

1) excluding the autumn culture

Table 8.2. Total planted area in ha 1)

1970	1975	1980	1981	1982	1983	1984	1985
3764	3018	2521	2466	2641	2541	2260	2117

1) CBS-test of horticulture growths under glas

8.2 Commercial production and distribution

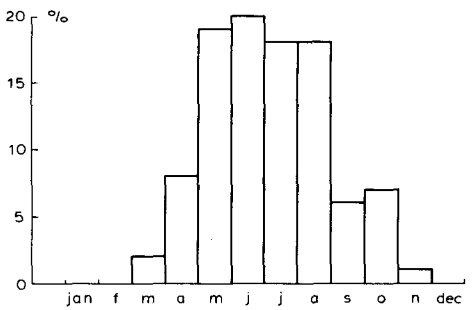
Table 8.3. Commercial production and distribution of tomatoes x 1000 kg

year	commercial production 1)	im-ports	comm. prod. + imports	ex-ports	indus-try	not-sold	fresh consump-tion
1950	75,437	13	75,450	41,281	9,010	6,135	19,024
1955	125,024	803	125,837	89,022	6,691	5,104	25,010
1960	201,362	897	202,259	162,509	3,284	5,060	31,406
1965	312,410	2,437	314,847	262,041	3,895	9,861	39,050
1970	392,254	7,797	400,051	312,339	3,753	40,130	43,829
1975	345,539	26,049	371,588	303,304	561	9,798	57,925
1980	396,433	34,217	430,650	357,451	85	6,578	66,536
1981	408,633	45,258	453,891	373,934	24	9,580	70,353
1982	473,113	56,571	529,684	424,775	52	32,867	71,990
1983	474,970	59,414	534,384	434,374	51	22,500	77,459
1984	488,339	69,811	558,150	461,082	47	15,581	81,440
1985	524,737	74,998	599,735	504,002	.	16,638	79,000

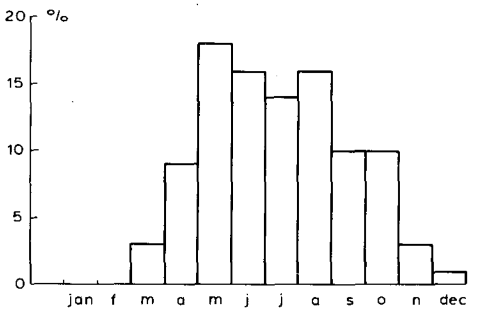
1) grown for the trade, excluding tomatoes grown in private gardens

8.3 Production

In spite of a decrease in production area, the commercial production of tomatoes increases yearly. Changes in growing, such as the use of new varieties and the change over to rockwool growing have provided a considerable increase in yield per m^2. After 1980 the total commercial production increased more than 90 million kg to 488 million kg in 1984. About 90 per cent was sold by the auctions with a value of more than 890 million guilders in 1984. Beef tomatoes increased from 7 per cent of the total auction supply in 1980 to 15 per cent in 1984. Ninety-four per cent of the total supply of round tomatoes which are sold by the auctions, were classified as class 1. This percentage of beef tomatoes is about 97 per cent.



Monthly auction supply of round tomatoes (average 1983-1985)



Monthly auction supply of beef tomatoes (average 1983-1985)

Table 8.4. Commercial production and auction-supply of tomatoes

year	commercial production x 1 million kg	auction-supply x 1 million guilders	auction-supply x 1 million kg	per cent of total by production season: January/ June	June/ August	August/ October	October/ January
average 1975/'79	372.4	487.9	358.4	.	.	.	.
1980	396.4	675.0	381.2	25	39	25	11
1981	408.6	722.8	392.9	28	38	25	9
1982	473.1	678.8	454.9	30	38	25	7
1983	475.0	809.9	456.7	28	38	25	9
1984	488.3	890.2	469.6	28	36	28	8
1985	524.7	870.4	504.6	28	36	27	9

8.4 Auctions
The following table shows the percentages of the total auction-supply of round and beef tomatoes together for the various principal auctions.

Table 8.5. Principal auctions of tomatoes 1)

place	name of the auction	per cent of total 2)
Poeldijk	Coöp. Tuinbouwveiling "Westland-Noord" W.A.	27
De Lier	Coöp. Tuinbouwveiling "Delft-Westerlee" W.A.	18
Bleiswijk	Coöp. Groenten- en Fruitveiling "De Kring" B.A.	17
's-Gravenzande	Coöp. Tuinbouwveiling "Westland-Zuid" W.A.	12
Grubbenvorst	Coöp. Venlose Veilingvereniging B.A.	6
Breda	Coöp. Tuinbouwveiling RBT B.A.	5

1) auctions with an arrival of more than 25 million kg (average 1983/1985)
2) in per cent of the total auction-arrival in the period of 1983 up to and including 1985

The principal auctions for beef tomatoes are: Bleiswijk (22 per cent), Poeldijk (20 per cent), Grubbenvorst (10 per cent), De Lier (8 per cent), Venlo (6 per cent), Breda (6 per cent) and Gouda (5 per cent). These are percentages of the total auction-arrivals of beef tomatoes.

8.5 Imports
The total imports of fresh tomatoes, including re-export has increased from 34.2 million kg in 1980 to 69.8 million kg in 1984. The import season runs from the end of October to June, with 40 to 50 per cent of the imports coming in February and March. Of the total imports 13 to 29 per cent remains in Holland. This means that from 1980 through 1984 8 to 15.6 million kg of imported tomatoes were sold yearly in the home market.

Imports from the Canary Islands dropped from 88 per cent in 1980 to 79 per cent of the total imports in 1984, but the quantity of tomatoes increased from 34.2 million kg to 69.8 million kg in this period.
Imports from Spain are increasing with 10 million kg being imported in 1984.

Table 8.6. Imports of fresh tomatoes

	total imports 1)		per cent of total imports from		
years	x 1 million guilders	x 1 million kg	Canary Islands	Spain	United Kingdom
average 1975/'79	48.7	28.6	88	2	1
1980	74.9	34.2	88	6	2
1981	91.9	45.3	85	8	2
1982	86.4	56.6	84	11	3
1983	99.1	59.4	83	9	3
1984	109.3	69.8	79	14	3
1985	122.7	75.0	78	15	3

1) including re-exports

The import of tomato puree fluctuate between 20 and 25 million kg. Greece and Italy are the most important suppliers with 9 to 12 million kg and more than 8 million kg respectively. Hungary, Portugal and Spain are also suppliers of tomato-purée. Imports of canned peeled tomatoes range from 5 to 8 million kg with about 80 per cent coming from Italy. In 1983 and 1984 1.7 and 1.1 million kg was imported from Spain. The tomato-puree and the peeled tomatoes are intended for the processing industry, for re-export and for home-consumption.
After 1980, imports of tomato-juice decreased to 2.5 to 3.5 million kg from 1982 through 1984. This decrease resulted primarily from reduced imports from Italy, previously our most important supplier. Since 1981 Belgium has been the primary supplier of tomato-juice, with West Germany being the second most important supplier in 1984.

Table 8.7. Imports of tomato-juice

	total imports 1)		per cent of total imports from				
years	x 1 million guilders	x 1 million kg	Greece	Italy	Hungary	Portugal	Spain
1981	34.3	19.1	30	35	8	9	3
1982	44.5	23.4	41	35	8	6	2
1983	53.6	25.4	46	35	7	4	2
1984	53.4	22.2	40	37	6	4	4
1985	63.8	26.9	35	38	4	12	4

1) including re-exports

Table 8.8. Imports of canned peeled tomatoes

	total imports 1)		per cent of total imports from	
years	x 1 million guilders	x 1 million kg	Italy	Spain
1981	6.0	6.3	80	7
1982	5.6	5.5	82	8
1983	7.4	6.0	61	28
1984	10.9	7.7	78	15
1985	11.0	9.2	83	10

1) including re-exports

Table 8.9. Imports of tomato-juice

	total imports 1)		per cent of total imports from		
years	x 1 million guilders	x 1 million kg	Belgium	West Germany	Italy
1981	6.5	6.9	57	8	35
1982	2.8	3.0	47	17	36
1983	3.3	3.5	41	27	31
1984	2.2	2.5	48	40	11
1985	2.5	2.6	51	40	8

1) including re-exports

8.6 Exports

Of the total quantity of fresh tomatoes - including both commercial production and imports - 80 to 83 per cent is exported.

From 1982 through 1984 239 to 250 million kg annually were exported to West Germany, our major customer.

The per cent of the total exports decreased gradually but the quantity increased almost yearly. The United Kingdom is the second most important country for our exports, with 78, 89 and 93 million kg exported to that country during 1982 through 1984 respectively. France ranked third with exports of 51, 55 and 65 million kg during those years. Exports to Sweden decreased gradually to 19, 16 and 15 million kg yearly respectively, while exports to Switzerland increased from 9 million kg in 1982 to 12 million kg in 1984.

Of the total quantity of exported fresh tomatoes 11 to 12 per cent is re-exported from the countries to which they were originally exported from Holland. West Germany was the principal re-exporting country.

The export period runs from April until November, with almost 75 per cent passing the frontier between May and September, and 43 per cent of the total exports of tomatoes occurring during May and June.

Of the tomatoes produced in The Netherlands, 75 to 81 per cent are exported. The proportional division into sizes has changed lately. Exports of smaller tomatoes has decreased. Compared with 1980, the 40-47 mm size has decreased from 11 per cent to 5 per cent, and the 47-57 mm size from 61 per cent to 58 per cent. Exports of larger sizes of tomatoes increased as follows: size 57-67 mm from 21 to 25 per cent, size 67-82 mm from 4 to 8 per cent and size 82-102 mm from 2 to 4 per cent.

Table 8.10. Total exports of fresh tomatoes

	total exports[1)]		per cent of total export to				
years	x 1 million guilders	x 1 million kg	West Germany	United Kingdom	France	Sweden	Switzerland
average 1975/'79	580.1	263.6	69	11	9	5	2
1980	782.6	357.5	64	18	8	5	1
1981	869.5	373.9	59	20	11	5	1
1982	925.6	424.8	58	18	12	4	2
1983	994.3	434.4	55	21	13	4	2
1984	1085.3	461.1	54	20	14	3	3
1985	1122.8	504.0	52	21	14	3	2

1) including re-exports

Exports of preserved tomatoes consisted principally of re-exports. Tomato-purée and peeled tomatoes were the most important products. From 1982 through 1984 1.8, 1.1 and 1.8 million kg respectively of tomato-purée were exported, with a value of 3.1, 2.2 and 3.2 million guilders respectively.
Exports of peeled tomatoes fluctuated between 0.2 and 2 million kg with a value of 0.9-3.5 million guilders.
Exports of tomato-juice increased from 0.5 million kg in 1982 to 0.9 million kg in 1984, with a fluctuation in value of between 0.8 and 1.2 million guilders.

8.7 Processing
In The Netherlands the industrial processing of tomatoes is very small with production during 1982 through 1984 being about 50 tons annually.

8.8 Competition
West Germany is the most important export market for fresh tomatoes produced in Holland. The Netherlands account for about 60 per cent of the total amount of tomatoes imported into West Germany. Dutch tomatoes are sold in the West German market principally during March through November.
The following tables give a survey of the competing countries.

Table 8.11. Imports of tomatoes into West Germany

year	total x 1 million kg	per cent of total from various supplier countries: Nether-lands	Spain	Canary Islands	Bel-gium	Maroc-co	Ruma-nia	Italy
average 1975/'79	454.7	62	7	7	5	8	4	3
1980	359.9	60	11	7	6	8	3	3
1981	350.5	57	15	8	5	7	2	3
1982	357.4	62	14	7	6	5	2	1
1983	360.0	58	15	9	6	4	3	2
1984	374.8	59	15	8	6	4	3	2
1985	379.0	59	14	10	7	4	3	2

Table 8.12. Imports of tomatoes into West Germany per month in per cents of the total imports 1)

	March	April	May	June	July	Au-gust	Septem-ber	Octo-ber	Novem-ber
Nether-lands	17	69	86	82	76	82	84	40	9
Canary Islands	50	13	2	-	-	-	-	-	4
Spain	12	4	-	1	-	-	1	43	71
Marocco	18	9	4	-	-	-	-	-	4
Israel	2	-	-	1	-	-	-	-	-
Belgium	-	2	4	7	9	10	11	7	4
Rumania	-	-	1	3	5	2	1	7	7
Albania	-	1	2	3	2	-	-	-	-
Bulgaria	-	-	1	2	2	-	-	-	-
Italy	1	1	-	1	5	4	1	1	-
France	-	-	-	1	1	1	1	1	-

1) averages of 1982, 1983 and 1984

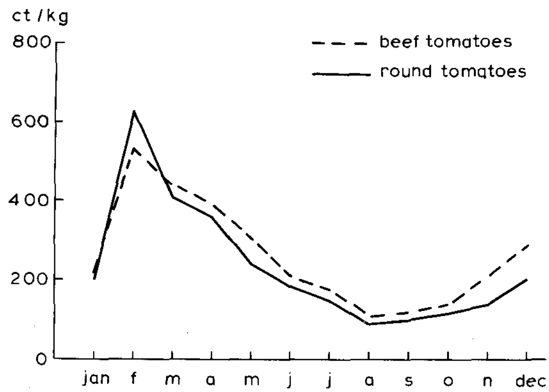
Tomatoes from Spain, the Canary Islands and Marocco are imported into West Germany mostly during the winter.
The United Kingdom is the second consuming market for the Dutch tomatoes and received 74, 87 and 91 million kg respectively in 1982, 1983 and 1984. Dutch tomatoes are exported to the British market principally during April until October. In the United Kingdom Dutch tomatoes must compete with domestically produced tomatoes and those imported from the Channel Islands, the Canary Islands and Spain.
In France, Dutch tomatoes are imported from April until September/October. Belgium is our major competitor, followed by Marocco, Spain and Italy.
On the Dutch market, competition is met especially from the Canary Islands from the beginning of the tomato season until May and at the end of the season.

8.9 Prices

Table 8.13. Average grower prices of tomatoes in cents per kg

	1980	1981	1982	1983	1984	1985
total	177	184	149	177	190	172
round tomatoes	188	177	172	173	185	169
beef tomatoes	206	213	190	208	217	190

Average grower prices of tomatoes (average 1983-1985)



9. HARVEST

9.1 Harvest method

Tomatoes are harvested by hand. The little crown (sepals) stays mostly on the fruit.
Tomatoes are picked into 20 kg plastic boxes. The boxes are placed on a low four-wheeled cart. The picker takes the cart, carrying two boxes stocked one on top of the other with him into the greenhouse. The picker fills the upper box and then places the empty lower box on top of the filled box for filling.
Special picking carts are used in greenhouses where the heating system is also used as a transport rail. Another system is the so-called "onderloswagen", a cart constructed with a movable bottom. This system is used in combination with a water flume system to transport the fruit from the greenhouse to the packing station. Very few growers use a belt along the main path. In another system, picking baskets or picking buckets are used in combination with a layercart. The cart, which can hold 300-600 kg, goes along the main path in the greenhouse and transports the tomatoes to the packing station.

Water flume system for internal transport

Rough handling damages tomatoes and shortens their "lifespan". Therefore, various picking and transport systems have been developed to prevent bruising. Mechanical bruising caused by excessive falling during picking and sorting causes soft and/or glassy spots to occur. Ripe fruits are more sensitive than less mature fruits. Fruits harvested during early spring and late autumn seem to be more sensitive to developing soft spots than fruit harvested in the summertime.
To protect the tomatoes as much as possible, handling is reduced to a minimum by growers who pack their fruit directly after sorting.
The tomatoes are floated in flowing water in the flume to the sorting machine. This method prevents the particularly hard stems of the fruit from damaging other tomatoes and also avoids bruising. Adding some salt (KNO_3) to the water helps the fruit to float and prevents fruit splitting from water uptake. The

concentration of the salt solution should be maintained at a 5-10 EC (electrical conductivity). Adding 1.35 kg KNO_3 per m^3 water enlarges the EC with 1. The fruit should not stay in the water longer than two hours, to avoid loss of quality.

9.2 Harvest time and harvest period

The optimal moment of harvesting is when the fruit is about 10-70% orange-coloured. Fruits that are fully red have a short life.

Tomatoes harvested immaturely (hard green) will never ripen satisfactorily and will not have maximum keeping qualities.

Green harvested tomatoes will produce a lower total output.

Sometimes growers will harvest their tomatoes in a too immature stage to meet the demands of the customers who want light-coloured tomatoes.

Tomatoes are harvested 2 to 4 times each week.

The harvest period generally begins in early March and lasts till the end of November.

9.3 Output

The output depends on the growing method.

Table 9.1. Harvest periods and output per growing method

growing method	start of harvest	end of harvest	output in kg/m^2
very early heating	mid March	late June	16 1)
early heating	early April	late July	20 1)
late heating	early May	late August	20
heated air	late May	mid September	20
cold	mid June	late September	15
late cold	early August	late October	13
autumn	mid September	mid November	10

1) at continued culture till mid October 30-35 kg/m^2

10. PACKAGING AND TRANSPORT

10.1 Package

Tomatoes of quality Class Extra and Class I with a diameter smaller than 67 mm must be supplied to the auction in a non-returnable package. The material and the dimensions of this package, the wooden tomato tray, are accurately described in the "Quality and Grading Directions" of the Commodity Board for Fruit and Vegetables. The tray must be provided with a corrugated interior liner and contains 6 kg of tomatoes. Exported tomatoes must be packed in trays with a film sheet or carton cover on top.
Mostly the trays are covered by the exporters with a film sheet printed with the name of the export company. The sheets are fixed to the tray with staples.

Beef tomatoes in export trays

Tomatoes of quality Class Extra and Class I with a diameter larger than 67 mm must be packed in a non-returnable package with larger bottom dimensions than the export tray used for smaller size tomatoes. The fruits must be packed in one layer and the tomatoes are separated from each other by a protective material (paper honeycomb).
Beef tomatoes are also packed in this way. The single layer tray also contains 6 kg of tomatoes and is not covered with a film sheet.
Tomatoes with some defects and lesser quality are supplied in small plastic trays, so-called small pool packages. These returnable trays also contain 6 kg of tomatoes.
In 1986 a new, non-returnable package for the larger gradings with a diameter between 67 and 102 mm (BB and BBB) will be introduced. This package has a larger bottom size of 59 x 39 cm, and contains 7 kg tomatoes. It has been developed for beef tomatoes in particular. The largest grading, with a diameter of 102 mm and up (BBBB), will continue to be packed in the present one layer tray, but with a net product content of 7 kg, instead of 6 kg. After this change over 7 kg tomatoes will be packed in one-layer trays and 6 kg in multi-layer standard trays.

Since 1977 research has been conducted to replace the wooden tomato tray with a fibreboard box (carton) having the same dimensions. Although the use of cartons could lead to cost savings, because of lower purchase and storage (smaller in plane) costs, their introduction has not occurred. The main reasons for continued use of the wooden tray are its greater amount of ventilation and better adaptability to precooling prior to shipment. Also people in the trade appreciate the better presentation of tomatoes in trays. (Verbeek & Bons, 1980 and Verbeek & Bons, 1981) Master cartons are used in which small consumer packs (shells or nets) are packed. The wooden standard tray is also used to pack tomatoes in net packs of 500 grams. These trays are not covered with a film sheet.

Table 10.1. Dimensions and contents of packages for tomatoes

type of package 1)	exterior dimensions in cm 2)			exterior volume in dm^3	weight in kg 2)		number of packages per layer on pallet	
	l	b	h		nett	gross	80x120 cm	100x120 cm
non-returnable								
1. wooden tray	39.5	29.5	14.0	16.9	6	6.7	8	10
2. one layer tray small	49.5	39.5	9.5	18.6	6	7	4	6
3. one layer tray small	49.5	39.5	9.5	18.6	7	8	4	6
4. one layer tray large	59	39	9.5	21.9	7	8.3	4	5
5. carton box	39	29	3	14.7	6	6.7	8	10
6. carton box for retail packaging	59	39	20	46	10	11.5	4	5
returnable								
7. small pool tray	39.6	29.5	15.5	18.1	6	6.8	8	10

1) see text for explanation of the one layer tray with 6 or 7 kg
2) packages 1-4 include the height of corner posts.

10.2 Packing directions

- The contents of each package must be uniform and contain only tomatoes of the same origin, variety, quality and type. The degree of maturity and colour of the tomatoes must be uniform for quality Classes Extra and I.
  The length of oblong tomatoes must be fairly uniform.
- The package must protect the tomatoes well.
- Paper and other packing materials used inside the package must be new, not detrimental to the product and not be harmful for human consumption.
  Any ink or gum used must not be poisonous. The packages may not contain any odd substances. No stamps or stickers may be put on the tomatoes themselves.
- It is allowed to the retailer to present tomatoes unpacked.

Particular directions for tomatoes of Dutch origin:

- Tomatoes of Class Extra and I must be packed, either in small consumer units with a weight of maximum 1 kg or in clean, sound unused new packages with a net content of 6 kg.
  In 1985 an exception was made "Vrijstellingsbesluit 1985/3" in which is stated that tomatoes with a maximum diameter equal 67 mm and up may also be packed in packages with a net content of 7 kg instead of 6 kg. Probably this resolution will be prolonged or adjusted elsewise for the coming years.
- Except for small consumer units, open packages must have a film sheet or cover on top. Tomatoes with a maximum diameter of 67 mm and up are excluded from this rule.
- Except during the retail stage small consumer units are handled in returnable auction pool packages.
- Packages manufactured wholly or partly from wood and used for maximum diameter tomatoes of Class Extra or I and with a net content of 6 kg, must be new and must meet a number of requirements with respect to dimensions and construction (see Quality Directions of Vegetables and Fruit by the Commodity Board for Fruit and Vegetables).
- Tomatoes with a maximum diameter of 67 mm and up in the quality Class Extra and Class I must be packed in a single layer and the fruits must be separated by means of protective material.
- During the retail stage the prescribed cover or sheet on top of the tray may be removed and the contents of the unit may be less than prescribed due to gradual sales.

10.3 Marking directions

The following items must be printed clearly and non-removably on the outside of each package

- Name and address or code of the packer and/or sender.
- The indication of the type of tomatoes in case closed packing is used.
- For ribbed tomatoes of Dutch origin the indication of the type is obliged in open and closed packages.
- Cherry tomatoes if the package contains the greenhouse product of quality Class III within the grading 20-25 mm.
- Oblong tomatoes if the package contains oblong tomatoes of quality Class III within the grading 20-30 mm.
- The name of production area or country, region or place.
- Quality class.
- The grading by indication of the grading limits in mm when the tomatoes are graded for diameter.
- The indication "not graded" in case the tomatoes are not graded for diameter.
- The net weight or the number in case of tomatoes of Dutch origin.

10.4 Handling

The production of tomatoes is so large that all handling occurs with palletised units. The supply at the auctions as well as storage, loading, unloading and transportation to the various destination markets all happens on pallets. All tomatoes in non-returnable trays (quality Extra and I) are stacked on non-returnable pallets at growers' packing houses.
The exporter generally must restack the packages of tomatoes one more time on another pallet to be able to fix the film sheets on top, or to use another

pallet size (80 x 120 cm).
Palletized units normally contain 100 trays of 6 kg (10 layers of 10 packages each) or 102 one-layer trays (17 layers of 6 trays per layer) on a pallet. The exporter may stack more layers on the pallet. A net or a stretch film is wrapped around the pallet for stability. This is necessary for support during transport because the trays cannot be stacked in an interlocking pattern.

Table 10.2. Specific masses of tomatoes in types of packages used in Holland

type of package	number of units per m^3		specific masses in kg/m^3			
			in package		in package on pallet	
	stacked on loose	pallet 1)	net	gros 2)	net	gros 3)
non-returnable						
1. wooden tray	59.2	53.0(53.0)	355	396	317(317)	365(365)
2. one layer tray small	53.8	40.4(48.5)	323	377	242(291)	281(335)
3. one layer tray small	53.8	40.4(48.5)	377	431	283(339)	334(398)
4. one layer tray large	45.7	40.4(40.4)	320	366	283(283)	334(334)
5. carton box	60	59.2(59.2)	408	456	355(355)	405(405)
6. carton box for retail packing	21.7	19.2(19.2)	217	250	192(192)	232(232)
returnable						
7. small pool tray	55.4	49.4(49.4)	332	376	296(296)	347(347)

1) pallet 80x120 cm; ( ) = pallet 100x120 cm a loading height of the pallet is supported between 1.8-2 m
2) weight of packing included
3) weight of packing and pallet included (20 kg for pallet 80x120 cm and 25 kg for pallet 100x120 cm

10.5 Transportation

During transportation of tomatoes to destination markets, various product temperatures may be used, depending upon the length of the transit period and whether the fruits are destined for fresh consumption or for processing.

transport time	tomatoes for fresh consumption	tomatoes for processing*
shorter than 1 day	5-18°C	1- 5°C
1-3 days	8-15°C	1-10°C
longer than 3 days	12-14°C	1-10°C

* not longer than 3 days at 1°C, thereupon processing is necessary

Tomatoes are sensitive to low temperature injury during prolonged storage at temperatures below about 13°C. The injury effects increase with storage, including transit time and with decreases in temperatures below 13°C. The product is reasonably well protected against desiccation by the skin, so that a relative humidity of 80% is considered to be optimal.
Tomatoes produce ethylene (see 06.09) and fruit that is harvested with some pink, red, or orange colour is not sensitive to this gas.

10.6 Precooling
Tomatoes should be cooled to the desired transport temperature as soon as possible after harvest, and always before transportation. Precooling can be most effectively done by forced-air flow in a cold store with a suction tunnel or pressure wall (pressure cooling or flow through cooling).

Precooling of tomatoes by means of a pressure wall

Pallet loads of boxes with sufficient openings, as well as pallet loads of packed standard wooden trays can be effectively cooled in 1 to 3 hours at air velocities of about 5 to 6 m/s. The shortest cool-down times are achieved by forced-air cooling by maintaining the air temperature a few degrees e.g. 6 K below the desired product temperature.
The application of pallet covers at least doubles the required cooling time even with 8% ventilation openings at every layer. (Verbeek & Bons, 1980)
Another application of air cooling of tomatoes is the cooling of separate trays with tomatoes in a cooling tunnel. In cooling tunnels the measured half cooling times of packaged tomatoes are 23 minutes for a layer of 10 cm of tomatoes and 38 minutes for a layer of 17 cm with air velocities of 5 m/s. (Boer, 1977)
Cooling with cold water (hydro cooling) is also possible. The half cooling time amounts to about 10 minutes in cold water. The cooling in cold water has been tried in combination with a grading system. Water cooling systems are not used in practice, because of complications like damage to the products with long retention times and water pollution. (Boer, 1977)
Vacuum cooling is not suitable for tomatoes.

11. STORAGE

11.1 Quality deterioration

Quality deterioration may be caused by water loss, loss of firmness, soft spots and colour deviations.
Rot is mainly caused by botrytis mould (see 04.02). Weightloss is mainly due to the evaporation of water from the fruit, which causes fruit to become soft. Fruits begin to soften at a weight loss of about 4%, which is mainly loss of moisture. (Van Beek, 1975) This can be reduced by handling and storing tomatoes at a high relative humidity (about 75-80%). In a dry atmosphere this can be achieved through adequate packaging (see 13.03).
Loss of firmness will occur as fruit ripens. Wholesalers, retailers and consumers demand a firm, not overripe tomato. Ripening rate increases at high temperatures above ca. 20°C. The occurrence of soft fruits is not always due to excessive ripening. Special growing conditions can limit fruit firmness, which is already visible at harvest. The fruits are often hollow. Glassy spots may occur on the surface of the fruits. Fruit softening can also result from storing tomatoes at undesirably low temperatures. In general, tomato keepability is limited at low temperatures below about 13°C. During the winter tomatoes may be exposed to a too low outside temperature on their way through the trade channels.
The occurrence of small deep-lying dimples in the skin of the fruit, which will yellow, is symptomatic of a form of low temperature bruising. (Schouten, 1977b, Schouten & Stork, 1977)
Too low temperatures during storage will cause a deterioration of taste. (Damen, 1986)

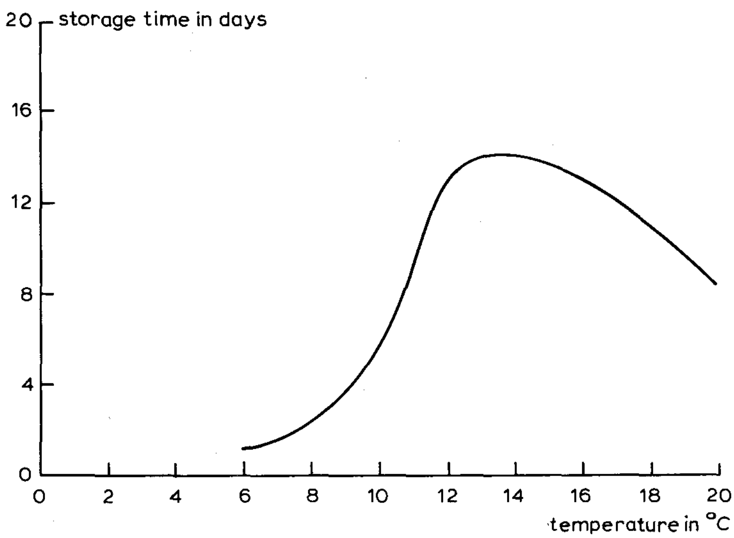
11.2 Storage method

Tomatoes are normally stored under moderate temperatures. The need for refrigeration depends upon the time of supply and on weather conditions.
Because tomatoes are very sensitive to low temperatures, during part of the year (pre- end after-season) they may need some heating or protection by extra packaging to prevent chilling.
Tomatoes have a limited storage life, which may be increased by proper use of precooling and storage at optimum temperatures. Growers, auctions and wholesalers have improved their handling of tomatoes. Most tomatoes are pre-cooled and in the near future handling at optimum temperatures will be maintained during the whole distribution period. This is necessary to meet the export demand.
CA-storage is not commercially used. Research results have been mainly negative. (Damen, 1980 and Damen & De Punder, 1982)

11.3 Storage conditions and storage time

Tomatoes are stored best at a temperature of 13°C and at a relative humidity of 75-80%. Under these conditions tomatoes will keep for about 14 days.
Immature green, and green/orange coloured tomatoes will never ripen satisfactorily when stored below 13°C. After some days of storage at 5°C or lower, chilling injury and decay will occur (see 04.06).
In comparison with most other fruit and vegetables the relative humidity must be lower to avoid mould and rot.
Low temperatures, for instance 8° to 10°C are sometimes used during weekend

storage to prevent excessive ripening. This is done to meet the market demand for light coloured tomatoes. Temperatures below 13°C delay ripening but do not lengthen the lifetime (time between harvest and consumption).
An objection to low-temperature storage during the weekend is the risk of condensation.
Ripe tomatoes for processing may be stored for some days at 1°C. This will avoid mould and rot; however, processing is necessary directly after cooling.
The figure shows the storage time of orange/red tomatoes (for fresh consumption) at different temperatures.



Influence of the temperature on the storage time of tomatoes

11.4 Mixed storage
Because tomatoes require moderate temperatures and a special relative humidity, mixed storage with other produce is difficult and should be avoided. Tomatoes give off ethylene gas (see 06.09), which causes other types of vegetable to decay or to ripen more quickly. For example the ethylene will cause cucumbers to yellow.

12. QUALITY AND SORTING

Quality and grading requirements are standardized for the EC. For packaging and indication predictions see 10.02 and 10.03.

12.1 Quality sorting and requirements

Quality sorting is still done visually and by hand. Misshaped and defective tomatoes are picked out and are given a lower classification. Depending on the type, quality sorting is done before or after sorting for size.
Colour sorting is an important aspect of the quality sorting and it is currently done mostly electronically. The fruits are divided into three classifications: light (green), normal (semi-green) and red (orange/red). Colour sorting is almost always done before size grading. Also see 12.03. For tomatoes the following quality requirements are in effect:

Minimum demands

Tomatoes must be
- intact
- free from diseases but can have the allowable defects
- clean, especially almost free of visible pollution
- externally fresh
- free of excess external moisture
- free of abnormal colour and undesirable taste.

In addition the quality, especially the degree of maturity and firmness must be such that the fruit can withstand normal transportation and handling, so that it meets the demands of the final destination.

Classification

Tomatoes are grouped in four classes, namely Class Extra, I, II and III.
1. Class Extra. The tomatoes of this class have to be qualitively supreme. They must have firm fruit flesh and show all the characteristics of the variety. Green shoulders are not allowed. Except for small external deviations which influence neither the quality nor the general appearance or presentation of the product, the fruits must be free of all defects.
2. Class I. Tomatoes in this group must be qualitively good. They must have firm fruit flesh and show all the characteristics of the variety. Cracks, whether or not healed, and visible green shoulders are not allowed. If the general appearance, quality and keepability or the fruit presentation is not influenced in a negative way, the following defects are allowed:
   - slight variation in shape and maturity
   - slight variation in colour
   - slight injury of the skin
   - very slight bruises.

   Ribbed tomatoes may also show:
   - healed up cracks with a maximum length of 1 cm
   - slight malformations
   - slight forming of a blossom scar without corkgrowth
   - corky navel shaped flower scar with a surface of less than 1 cm^2
   - very narrow oblong flower scar (like a suture), which has to be shorter than 2/3 of the diameter of the fruit.
3. Class II. Tomatoes in this class meet the minimum demands but fail to meet the demands of a higher class. The fruits must be qualitatively reasonable and rather firm. Cracks which are not healed are not allowed.

If they meet their specific properties on quality and presentation, the following defects are allowed:
- deviations in shape, development and presentation
- injuries of the skin or bruises provided that the fruit has not been seriously damaged
- healed cracks must be no longer than 3 cm in length.

Ribbed tomatoes may also show:
- malformations which are bigger than those in Class I
- forming of a blossom scar depression
- corky navel shaped flower scar with a surface of less than 2 cm^2
- very narrow oval flower scar (like suture).

4. Class III. In this class tomatoes are grouped which meet the minimum demands but which cannot be grouped in a higher class. The fruits must meet the demands for class II, except that healed up cracks of more than 3 cm are allowed.

Tolerations in quality

In every package, some fruits are allowed which do not meet the qualifications of the class in which they are grouped.

Maximum allowances are described as follows:
- Class Extra, 5% of the number of fruits or weight may meet the qualifications of Class I including the tolerations for that class.
- Class I. 10% of the number or weight may meet the qualifications of Class II, including the tolerations of that class.
- Class II. 10% of the number or weight, provided that these fruits are suitable for consumption.
- Class III. 15% of the number or weight, provided that these fruits are suitable for consumption.

12.2 Size or weight grading and requirements

Tomatoes are graded into different groups depending on the maximum diameter of the largest cross section. This diameter may not be smaller than:

	Class	
	Extra, I and II	III
round and ribbed outdoor tomatoes	35 mm	35 mm
round and ribbed glasstomatoes	35 mm	20 mm
long shaped tomatoes	30 mm	20 mm

Tomatoes of the classes Extra and I must be graded taking into account the following limits:

30- 35 mm only for long shaped tomatoes
35- 40 mm
40- 47 mm
47- 57 mm
57- 67 mm
67- 82 mm
82-102 mm
102 mm and more.

The minimum diameter for ribbed tomatoes of the classes Extra and I is 57 mm.

Tolerations in size

- Class Extra, I and II. 10% of the number or weight, if these fruits meet the limits of the next grading, with the remark that no fruits are allowed if their diameter is less than:
  - 33 mm for round and ribbed tomatoes
  - 28 mm for long shaped tomatoes.
- Class III. 10% of the number of weight, with no further size limitations.

The following names or codes are used for Dutch tomatoes which are classified in class Extra and I.

< 35 mm "kriel"	57- 67 mm B
35-40 mm CC	67- 82 mm BB
40-47 mm C	82-102 mm BBB
47-57 mm A	102 mm and more BBBB

12.3 Grading machinery

In Holland, tomatoes are mainly sorted by the grower. Central sorting is not practised any more. Sorting mostly takes place immediately after harvesting. Until a few years ago tomatoes were mainly sorted by hand for colour and quality. Only size grading was mechanised.

Colour sorting was very labour intensive. Prior to 1970 studies were conducted at the Sprenger Instituut on electronic colour sorting of tomatoes. (Rudolphij & Veltman, 1970) On the basis of these studies some manufacturers developed prototypes of colour sorting machines. Since 1976 colour sorting machines have been widely used.

Presently tomatoes are electronically colour sorted, mechanically sized but visually and manually graded for quality. Nowadays a complete tomato sorting installation consists of a colour sorting unit and a mechanical sizer. It is not absolutely necessary that the two machines are from the same manufacturer, but servicing and maintenance generally are easier and less expensive when they are supplied by the same company.

After sorting for colour and size the trays are being filled up till the correct weight

<u>Quality sorting</u> is generally done by hand immediately after size sorting, and is done on the tables or conveyor belts of the sizer. Ribbed tomatoes, > 67 mm, are also sorted by hand, at the same moment as the size grading.
<u>Colour sorting</u> is done by an optical scanning colour detection installation that analyses the fruits individually and sends the data to an electronic memory which feeds the information to the transport system for separation of fruit into colour classes. Tomatoes are sorted into three classes: pale (green), normal (semi-green) and red (orange/red). All colour sorting machines presently used work on the same principle. A sorting system consists of three parts:

- A mechanical part, which consists of a transport and a throw-out system. This transports the fruits to the colour sorting unit and transports the colour analysed tomatoes to the proper exit and then to the size sorting machine.
- An optical part which consists of a colour analysing system. This uses a measuring head with photocells and a source of light. The light is focused on to the tomato. The light reflected from the fruit is divided into a red and a green part. the red/green relationship of the reflected light is then automatically analysed. Originally growers' machines have only one measuring head. This has the disadvantage that irregularly coloured tomatoes or tomatoes lying in the wrong position (for instance the corolla just in front of the lens) can be analysed in a wrong way.
  Since 1984 machines with more than one measuring head are in use, which abolishes this disadvantage.
- An electronic part which consists of a sending unit that strengthens the measuring signal, decides on the basis of the measuring signal in which class the measured fruit belongs, and a memory that stores information on the basis of the measuring signal in which class the measured fruit belongs, and a memory that stores information on the measured fruit and directs it to the right exit, steers the throw-out mechanism and feeds the three above mentioned parts.
  The capacity of automatic colour sorting machines varies between 1500 and 3000 kg per hour, depending on the type.

<u>Size sorting</u>
In larger installations two or three size sorting units are coupled with the colour sorting machine. This means that all three colour classes are sorted for size at the same time. Every unit can sort into four sizes. Round shaped tomatoes are classified into sizes A, B, C and CC. Ribbed tomatoes are classified into the larger B and BB sizes. The very large fruit is sorted by hand and sized into BBB-size because of damage risks. After sorting there is a total of 12 classes, which differ in size and colour. The size sorters can be divided into three types on the basis of the working principle.

- Enlarging diaphragms. This system is practised on AWETA-machines. Size sorting takes place on a transport band with enlarging round gaps (diaphragms). The enlarging can be attained continuously or stepwise. The speed of the transport band can be adjusted continuously. As opposed to the other systems, the fruits do not move while being measured. The maximum capacity of this machine is 1500 kg/hour. Balances are placed at the end of the machine.
- Rotating conical disc. This principal is used in the GREEFA and BRITOS sizes. The machine leads the fruits, continuously turning, along a stepwise broadening cleft. If the rotation of the turning speed, height of the conus

and adjusted diameters are correct, the fruits are sorted on their maximum diameter. The sorting is accurate and the maximum capacity is 1500 kg/hour. In modern installations three size-sorting machines are combined with one colour sorting machine. After automatic sizing of the largest size fruit balances can be placed.

Weight sorting

The manufacturers of tomato sorting machines (e.g. OWETA and GREEFA) also make weight sizers. These 4 to 6 channel machines have cups on which the fruits are individually transported and weighed. It is possible to combine weight and colour sorting into one machine. In that case the results of weight measuring and colour measuring are combined and transmitted to one of the twelve machine exits. The capacity of this machine is about 1000 kg/hour per channel.
There are three weighing systems: one weighing point under each cup, three weighing points under each cup and one weighing point with free-balancing cup. The last two mentioned systems were developed to improve the weighing of irregularly and long-shaped fruits.
Previously used size sorting machines worked according to the maximum diameter of the fruits. These machines are no longer used. Other sorting machines work according to the widening band principle. Few, if any, of these are still in use.
To prevent injury caused by dirt on contact surface, the machines should be regularly cleaned, preferably every week.

12.4 Cleaning

Due to growing methods (in Holland all tomatoes are grown in glasshouses) pollution of the fruits almost never occurs. Therefore, it is not necessary to clean the fruits. The water gutter in the glasshouse is meant for transportation, and not for cleaning (see 09.01).

13. PREPACKAGING

Only glasshouse grown tomatoes of the standards Extra and Class I are being considered for prepackaging. Until the end of 1977 these were mainly the more red grades. Research by the Sprenger Institute in 1977 and 1978 showed the harmful influence of prepackaging in nets with the help of the automatic clippers of that time. Since 1978, at the request of the Dutch Quality Control Bureau, only the less vulnerable greener tomatoes are being used for prepackaging. (Schouten & Stork, 1977 and Schouten & Stork, 1979)

13.1 Quantity

Prepacked tomatoes, according to the "Hoeveelheids Aanduidingen Besluit" (Warenwet) (Quantity Indication Resolution) dated 23 December 1982, must be labeled with the correct weight. Whereas this legislation is valid for the whole Common Market, prepacked tomatoes for export as well as for home market are usually packed by weight.
The net weight is mentioned on the package. In nets the produce is almost exclusively packed in units of 500 grammes, and only occasionally in units of 1000 g. On trays as well as in blisters this is the same, whereas in the beginning of the season packages of 250 g occur.
The amount of tomatoes depends on the size. For prepackaging usually the A-grade is used, incidentally the B- or C-grade. All sizes above 67 mm are beef tomatoes.

Table 13.1. Amount of tomatoes per kg at different sizes

grade	diameter in mm	number per kg
BBBB	102 and larger	2 - 3
BBB	82 - 102	3 - 5
BB	67 - 82	5 - 8
B	57 - 67	8 - 10
A	47 - 57	14 - 16
C	40 - 47	23 - 25

Cardboard boxes of different sizes are used as transport packaging for tomatoes packed on trays and in blisters. Often, a special box sized 59x39x20 cm is used. In these boxes 20 to 21 trays (= 10 kg of A-sized tomatoes or 11 kg of B-sized tomatoes) can be packed when the trays are placed on their sides. When the trays are placed flat in two layers, 12 trays (= 6 kg tomatoes) can be put in one box. The normal non-returnable 6 kg tomato box is used as transport packing for net packed tomatoes. In each box are packed 12 nets of 500 g = 6 kg tomatoes. No cover is used over the boxes when the produce is packed in nets. (Anonym, 1983 and De Maaker & Greidanus, 1985)

13.2 Preparing

Not applicable.

13.3 Packaging

Until now tomatoes are exclusively prepacked after auction. Supply of prepacked tomatoes at auctions, such as e.g. chicory, sprouting-broccoli and mushrooms does not occur. Prepacking takes place at wholesalers, exporters or at contract-packers. From the total supply at auctions about 15% is being prepacked. In Holland according to a NIAM-panel investigation (1984 and 1985) 14.5% of the normal tomatoes and 13.5% of the beef tomatoes are sold prepacked (NIAM, 1985). An investigation among consumers of the Dutch Central Bureau of Auctions, that took place in 1982 in Western-Germany, showed that at that time 32% of the tomatoes were sold in retail packs; 13% was packed in nets, 9% on foodtainers wrapped with PVC (polyvinylchloride) stretch-film and 6% in bags. This picture has hardly changed since the previous investigation in 1979. (Anonym, 1979 and Geeson et al., 1981)

Besides the above mentioned prepackagings, tomatoes are also packed in several other ways, such as on trays of polystyrene foam and of vacuum formed PVC as well as in cardboard boxes and in blisters. Attached is a review of the different kinds of prepackaging.

Nets The material is almost exclusively red polyethylene. The nets are closed on both sides with a metal clip. It is the cheapest packing, but the nets give the least protection. This is specifically demonstrated during display in the shops.

Nets are cheap but they do not give much protection

Trays Trays of paperpulp are mostly used, polystyrene foam trays are much less applied. As a result of differences in manufacturing processes the side walls of pulp trays can be higher than of the foam trays. The higher the side walls the better the protection for the tomatoes. The height of the pulp trays varies from 1 to 2 inches. These trays also have a certain moisture absorbing quality, which the polystyrene foam trays do not have. The trays can have a flat bottom or a bottom which has been raised in the middle. This has the advantage that the fruit lies fixed without being pressed together. According to the recommendations of the "Food Standard", trays with a purple colour are mainly used. (Anonym, 1982) The trays are wrapped with PVC stretch-film, (14-

17 μ). After to the above mentioned trays, trays of vacuum formed clear PVC are more and more being used. Around these trays a wide closed polypropylene film is fixed, which has some (8-10) perforations of about 5 mm O. An advantage of this packaging is the good visibility of the produce from all sides. This packaging is specially used for the British market.

Boxes The material is often cardboard consisting of three layers. To obtain enough firmness, the middle layer can be of corrugated cardboard. The side-walls are 6 cm high and are glued together, the bottom is often flat, however there is one type of cardboard box with a raised bottom in the middle. (Anonym, 1977)

Just like the trays, the boxes are mostly purple, and are wrapped with PVC stretch-film (14-17 μ).

Blisters This is a packaging of transparant PVC, polypropylene or ABS (acryl-nitril butadiene styreen), which fits completely around the produce and is semi-riged. For tomatoes the blisters are made of two trays which are hinged together. The fruit is put into one, the other one is the lid. Mostly the fruit lies in two rows next to each other. Depending on the type, the tomatoes lie in two slots together or separately in premoulded cups. Blisters are closed by staples, joints or by a button.

Bags The material used is usually polypropylene- or polyethylene-film. The bags are provided with perforations. To prevent rot, the bags are sometimes heavily perforated. Packaging studies at the Sprenger Institute showed that weight losses of tomatoes in nets are about twice as high as those packed on trays with stretch-film. In a comparative investigation the weight losses in nets amounted to upwards of 5%, in open cardboard boxes, 4.5% and on pulp trays wrapped with PVC stretch-film 2 to 2.5%. (Anonym, 1971)

From an investigation in Britain it became clear that with PVC or other semi-permeable films of 15-25 μ completely wrapped unperforated consumer packs, after a storage of 3 to 4 days at 10°C, a modified atmosphere is created which exists of 3-6% CO_2 and 3-6% O_2. This extends the shelf life by one to two weeks. The flavour,scent and consistency of the MA-packed tomatoes was the same or better than that of the control, which were packed in normal air packages. However, there was more rot in the closed packages. (Geeson et al., 1981)

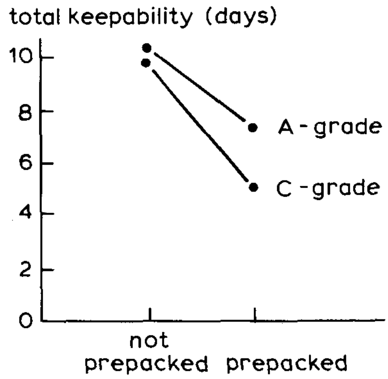
With all these forms of prepackaging, mechanisation is much advanced. Small amounts of trays and boxes are still wrapped by hand with the help of a hand-wrapper and sealed. When packing automatically, only the filling of trays and boxes is done by hand. The trays are placed one by one on the belt by an automatic dispenser. After filling, a piece of film is wrapped around the trays at the wrapping-station and with the use of a hot plate. The wrapped trays are transported on a conveyer-belt in which a weighing- and price-labeling can be placed.

Blisters are still being filled by hand and closed by staples, but this can also be done automatically. In Norway a machine was developed with which blisters with press-button closing are automatically placed on the belt and after being filled by hand are folded and closed mechanically. For boxes for either four or eight tomatoes the same machine can be used. For sealed blisters, packing can be fully mechanized.

For packing in nets the tomatoes are transported over a belt from a store-box into a weighing-machine. There, a pre-determined amount of tomatoes go into the net-tube. The nets are closed on both sides with a metal clip. The clipper closes simultaneously the upper side of the filled net and the bottom of the

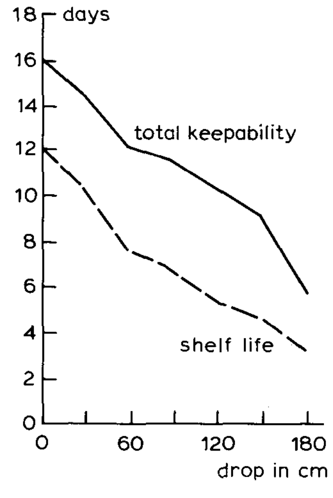
next one. After that the net is cut through between both clips.
Until about 1975, packing in nets was mainly done by handworked apparatus. Between 1975 and 1980 there was a strong development in the mechanizing of the net-packaging, whereby the fully automatical net-packaging machines took the place of the handworked apparatus.
For net-packed tomatoes, quality losses appear which are caused to a large extent by this new way of packing. The distance which the tomatoes, after being weighed, must travel to the net tube, before falling into the net is much longer with these fully automatical machines than with the handworked apparatus. A fall of 150 cm under a gradient of 45° or more frequently occurs with these machines against a maximum of 50 cm with the hand apparatus. This means not only a much larger fall but also a higher speed, through which the tomatoes hit each other. Research at the Sprenger Institute made clear that there is a connection between the length of the fall when packing in nets and the shelf life of the tomatoes. This affected the total holding period as well as the shelf life. This amounted to a shortening of the shelf life from 30 to 60% with regard to fruit that did not fall. This is shown in following figure.

Shortening of the keepability of tomatoes as a result of falling when packed into nets



On the whole the keepability of the C-grade tomatoes was worse than that of the A-grades as the next figure shows.

Influence of packing in nets with an automatic clipper, working under a gradient of 45° C, on the shelflife of tomatoes of the A- and C-grades



Partly as a consequence of the negative research result - confirmed by, among others, the Dutch Quality Control Bureau, the first fully automated, horizontally working net packing machines were put on the market in 1980. These were designed specifically for the packaging of vulnerable products, especially tomatoes. The great difference between these and the previously described machines is the slight difference in level between the weighing unit and the netclipper because of the horizontally placed net tube. In this net tube, a transport belt is placed. Instead of falling through the tube the tomatoes are now transported horizontally via the belt. Results of the investigations confirm the suggestion that this method is an improvement on the old type of net-packing machine.
Also with other types of packing, on trays or in boxes, produce is being transported in a horizontal direction, so that the tomatoes do not fall.
(Anonym, 1977, Goedendorp, 1979, Schouten & Damen, 1979, Schouten & Stork, 1979, and Stork at al, 1980)

14. PROCESSING

14.1 Processed product

In the Netherlands tomatoes are grown in glasshouses; the dry mattercontent is low, the colour light red and the price high. These conditions make processing of tomatoes uninteresting. Instead large quantities of tomato paste and powder are imported mainly from South European countries. The usual concentrations of paste used contain about 28 to 30 percent solids. The powder contains about 96% solids. The paste is used in making different sauces. Tomato ketchup is the most important product.

Tomato paste is also used in processing white beans in tomato sauce. Further, tomato juice is made of a mix of paste, water, salt and some flavourings. Wholesale packagings (10 lbs and approx. 4.5 kg) are repackaged into smaller consumer sized cans and are brought onto the market under a personal brand name.

The powder is a necessary component of dry soups.

In the South European countries small size unripe green tomatoes are sometimes processed into pickles. Green tomatoes contain a very small amount of the poisons tomatine and solanine. Health authorities warn consumers about these poisons. More of this subject is given in chapter 5.

14.2 Food standards

The regulations for tomato products in the Netherlands are settled in the regulation of the Commodity Board for Fruit and Vegetables 1982 "Tomato juice and some allied products".

The different types of tomato products and the regulation for juice, paste, powder, diet products and sauces are described.

Tomato juice is the liquid product from crushed tomatoes. It must have a specific gravity of the NaCl free product of at least 1.018 (4.7^{o}Brix). The maximum level for NaCl is 1.5%.

Tomato paste is the pulped fruit. The indication "concentrated" means that the product is twice concentrated. Higher concentrations are described with three times higher or more. The dry matter content must be at least 12% with a maximum of 96.

After dilution with a corresponding quantity of water, the specific gravity must be at least 1.018. Maximum 1.5% NaCl may be added (1.5% of the diluted product).

Tomato powder must have a dry matter content of at least 96%.

Tomato nectar is a mixture of at least 50 per cent by weight of tomato juice with water and sugars.

In an appendix of the Regulation the labelling, ingredients, keeping qualities etc. are given. In other appendices processing regulations are given for tomato juice, purée, powder and nectar.

The Codex Alimentarius Commission has recommended international standards for tomato juice preserved exclusively by physical means under CAC/RS49-1971 and international standards for processed tomato concentrates under CAC/RS57-1972 FAO (1972) and FAO (1974).

These standards can be obtained from the FAO, Rome: Director, Publications Division, Food and Agriculture Organization of the United Nations, Via delle Ferme di Caracalla, 01100 Rome, Italy.

In the U.S. Food, Drug and Cosmetic Act the product definition of tomato juice is the unconcentrated liquid obtained from sound, mature red tomatoes, blanched or not, and pressed. Such liquid is strained or otherwise processed to exclude skins, seeds, and other coarse or hard substances from the finished product. The product is preserved by physical means. The diluted product (containing approximately 8% natural tomato soluble solids) should not contain mould filaments in a quantity indicative of unsuitable raw materials or unsanitary processing lines. A guide for determining compliance with these requirements would be a mould count, as determined by the Haward Method, not in excess of 50% positive fields, based on the diluted products (containing approximately 8% natural tomato suluble solids). (Goose & Binsted, 1973, Gould, 1983, Horwitz, 1960, Kramer & Twigg, 1970, Troy, 1952 and Vas, 1958)

14.3 Flow sheet processing

Tomato juice

- Washing.
- Sorting.
- Crushing.
- Rapid heating of the pulp for 2 à 3 minutes at 85°C to prevent pectine degradation by enzymes. The temperature of 85°C has to be reached within 10 seconds after crushing. Alternative is heating the whole tomatoes for 2 to 3 minutes in 95°C water before crushing.
- Into separators containing fine screens (0.8 mm holes) and then into a refiner with screens having even smaller holes (0.6 mm). After this, the pulp passes through a Super Refiner containing screens with even smaller holes (only 0.4 mm).
- Salt added, 0.5 to 0.8%.
- De-aeration of the juice by vacuum treatment.
- Treatment by high pressure homogenises at 200 to 250 bar.
- Sterilising with plate or tube heat exchanger for approximately 40 seconds at 122°C, or for 20 seconds at 124°C (to prevent flat sour). Cooling to 91 to 93°C.
- Filling into bottles or cans. The empty bottles and cans are normally sterilized in jets or boiling water.
- Pasteurisation of packed cans for 3 minutes (on the head) at 100°C and bottles for 6 to 10 minutes in a channel.
- Cooling.

(Bodenstab, 1977, Fonseca & Luh, 1977, Goose & Binsted, 1973, Gould, 1983 and Kardos, 1975)

14.4 Processing period

During the whole year the import product is reprocessed. Small quantities of Dutch tomatoes are incidentally processed during the summertime.

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