



## One strawberry does not make a summer

# Strawberries – Ingredients in focus – Universal tool capillary electrophoresis

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The most delicious symbol of early summer invites us to enjoy and feast – the strawberry. The first plants of strawberries came to us from America in the beginning of the 18th century. Due to different breeds we now have many popular types like „Mieze Schindler“ or „Senga Sengana“ [1]. The generation of this variety aimed at an increase in harvest season as well as at the resistance against different diseases.

Directly from the field or as ingredients in all kinds of sweets or cakes strawberries also make a good addition in hearty meals [2]. In the meantime, they also offer healthy nutrients. So let's use the strawberry season to combine business with pleasure!

By comparison to other homegrown types of fruits, strawberries have fewer calories – 100 g contain only about 37 kcal (155 kJ). A high fibre content, minerals and vitamins contribute to the healthy image of strawberries [3]. Sugar, which is most important for the flavour, is a mixture of glucose and fructose. Sucrose content is either very low or completely absent. As the ingredients depend on the type as well as on the cultivation conditions and the degree of maturity, data from literature only represent a rough indication of that. Reason enough for us to thoroughly investigate different types of these tasty fruits.

The various properties of the strawberries like size, colour, and shape are shown in table 1 and figure 1 respectively. Most surprising are differences in weight, which are up to a factor of ten.

All fruits were harvested on the same day (mid-June) in the same field. The treatment was made immediately. Fortunately, some of the fruits could be saved for the chemical analysis after the sensory evaluation, although this was the hardest part. For the measurements, the fruits were weighed and mashed and stored in the freezer until examination.



### Spicy recipes:

Refinement of hearty meals with strawberries: what about an asparagus salad with strawberries or roast beef with spicy strawberry-chili-salsa? [2]

Prior to the analysis, the samples were diluted with pure water and centrifuged.

For the evaluation of the differences between the types of strawberries, capillary electrophoresis was the method of choice [4]. For the different analytes different methods were applied. The chosen electrolytes were tailor-made for the analytes and include different basic chemicals like phosphate for the determination of anions and carbohydrates or Aminopyridine for the analysis of cations. For detection direct and indirect UV detection was used.

First of all, cations were evaluated. Therefore, an electrolyte on the basis of Aminopyridine was used. The absorption of the electrolyte permits the sensitive measurement of the UV inactive cations with indirect detection.

Tab. 1: types of strawberries investigated

	Asia	Christine	Clery	Lambada	Mieze Schindler	Senga-Sengana	Vima Zanta	White Pineapple
<b>weight of fruit [g]</b> (mean value, n=5)	14	32	17	13	4	8	15	4



Fig. 1: types of strawberries investigated

Figure 2 shows the electropherograms for a standard solution of cations and as an example two types of strawberries. For comparison reasons an electropherogram of cations in banana is added.

Especially notable is the high amount of potassium for all types of strawberries. The recommended daily allowance (according to DGE [5]) is at least 4 g per day (see also info box). Additionally, the particularly low amount of sodium complies with the recommendation to reduce sodium in the daily intake. With the given method the analysis of ammonium is also possible. Surprisingly small amounts of ammonium were found in all types of strawberries. The presence of ammonium in the strawberries cannot be explained clearly. On the one hand it could be the result of fertilization but on the other hand it could also be of natural origin, which results from the degradation of amino acids or proteins. More meaningful could be the relation of the ions among each other, but no significant differences were found. An important realization for us was that strawberries show similarly high amounts of magnesium like bananas, which are very popular among athletes. Additionally, strawberries offer a high amount of calcium.

**recommended intake per day for adults [5]:**

Sodium: 1500 mg  
 Potassium: 4000 mg  
 Calcium: 1000 mg  
 Magnesium: 300 – 350 mg  
 Vitamin C: 95 – 110 mg

**maximum intake per day for adults [7]:**

Nitrate: approx. 200 – 300mg

For the analysis of carbohydrates a very alkaline phosphate electrolyte was used. The detection was made with indirect UV detection [6].

The analysis of carbohydrates shows different absolute amounts for the individual types but they all show a relation of about 1:1 regarding fructose and glucose. Sucrose was found on a very low level or not at all. The total amount of sugar in all types is found to be between 50 and 100 g per kg. The banana can be well distinguished from the strawberries because of its high

Tab. 2: amount of cations

	amount [mg/kg]								
	Asia	Christine	Clery	Lambada	Mieze Schindler	Senga-Sengana	Vima Zanta	White Pineapple	Banana
Ammonium	30	36	81	37	59	60	18	34	<1
Potassium	1632	1476	1442	1690	1660	1475	1297	1977	1638
Calcium	115	105	127	96	154	120	94	175	9
Sodium	6	5	7	3	7	3	<1	7	9
Magnesium	96	95	102	111	112	83	79	159	100

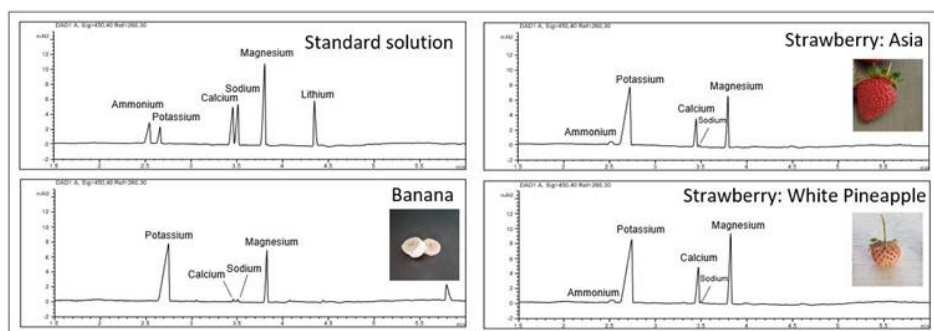


Fig. 2: determination of cations in strawberries (banana for comparison)

Tab. 3: amount of carbohydrates

	amount [g/kg]								
	Asia	Christine	Clery	Lambada	Mieze Schindler	Senga-Sengana	Vima Zanta	White Pineapple	Banana
Sucrose	0,8	4,2	0,5	0,8	<0,1	<0,1	<0,1	<0,1	99
Glucose	37	38	38	44	40	25	37	40	35
Fructose	39	39	41	48	45	29	41	42	35
<b>sum</b>	<b>77</b>	<b>81</b>	<b>80</b>	<b>93</b>	<b>85</b>	<b>54</b>	<b>78</b>	<b>81</b>	<b>169</b>

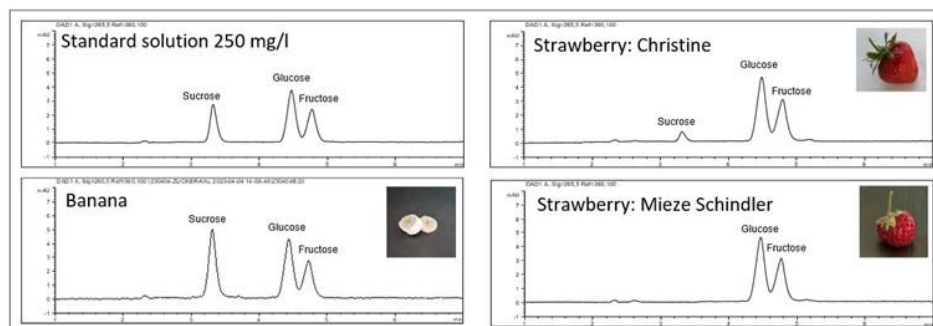


Fig. 3: determination of carbohydrates in strawberries (banana for comparison)

amount of sucrose (figure 3). The total sugar is higher as well (see table 3).

The aromatic flavour of the strawberries is influenced by the combination of sugars und fruit acids. Similar to wine

the relation of sugars and acids is important. The well-known fruit acids were determined as anions in the strawberries.

The variety of the acid profiles found in the analyses shows the different flavours of the strawberry types. The amounts found for nitrate may be attributed (like in case of ammonium) to fertilization of the plants. They are far below the critical amounts [7].

The multiple flavours of the strawberries cannot be derived from the results of the analytical determination. And the personal preferences in the evaluation of flavour cannot be attributed to the analytic. But the good news is: all types are from an analytical perspective equally healthy. Like the universal tool capillary electrophoresis strawberries also are universal food. Everybody can enjoy his or her own particular flavour.

### Reference

[1] *Bayerische Landesanstalt für Weinbau und Gartenbau (LWG)* Zugriff: 21.04.2023

[2] *Erdbeer-Rezepte: Einfach himmlisch!* Zugriff 28.04.2023

[3] *Erdbeeren.de* Zugriff: 21.04.2023

[4] *Theorie der Kapillarelektrophorese* Zugriff 28.04.2023

[5] *Deutsche Gesellschaft für Ernährung e. V.* Zugriff: 21.04.2023

[6] *Dem Zucker auf der Spur – Untersuchung von Kohlenhydraten mit der Kapillarelektrophorese; Analytik NEWS* 03/2015 Zugriff 28.04.2023

[7] *Evaluation of certain food additives; WHO Technical Report Series, 2002* Zugriff: 21.04.2023

[8] *Wikipedia Gartenerdbeere* Zugriff: 21.04.2023

[9] *Wikipedia Fragaria × vescana* Zugriff: 21.04.2023

Tab. 4: amount of acids in strawberries

	amount [mg/kg]							
	Asia	Christine	Clery	Lambada	Mieze Schindler	Senga-Sengana	Vima Zanta	White Pineapple
Nitrate	38	35	10	18	4	47	9	13
Citric acid	9046	5775	6331	9590	9426	6809	5755	12298
Malic acid	1222	1126	990	887	1940	1900	629	980
Ascorbic acid	<1	322	231	64	<1	<1	<1	182

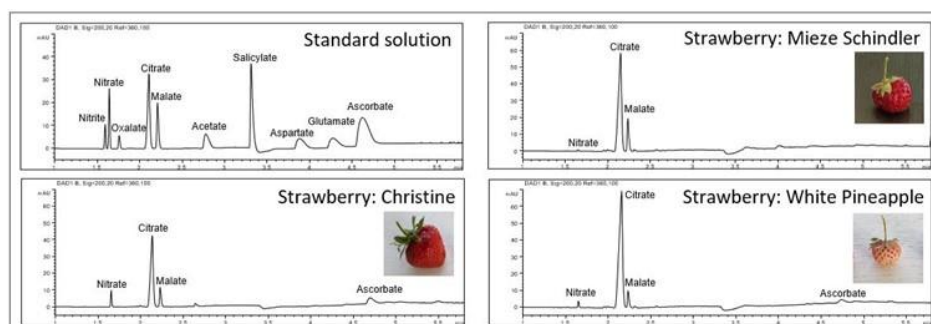


Fig. 4: determination of acids in strawberries

### By the way...

The analysed garden strawberry has historically and genetically nothing to do with the wild strawberry. The wild strawberry has already been used for nutrition for a long time. It has a diploid set of chromosomes. Yet the garden strawberry has an octoploid set of chromosomes [8] Though breeding there have been attempts to combine the flavour of the wild strawberry with the size of the fruit of the garden strawberry. The resulting type (*Fragaria × vescana*) has a dekaploid set of chromosomes and is commercially available for gardening [9].