A consideration on the difference of the nourishments in the tomato juices

by

Masana Yokoya, Nobuaki Hattori＊

市販トマトジュースの成分の違いに関する考察

横家将納・服部宣明＊

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1．Introduction

In recent years, various kinds of tomato juices are sold on the open market in Japan. Some tomato juices are produced in major companies, while others are produced by individual farmers. Moreover, some tomato juices are imported from foreign countries and others are produced as local specialties for boosting the economy of rural villages. Thus, there are various backgrounds in production of tomato juices, and there may be big difference in their nourishing qualities.

From the viewpoint of the consumer, it is important to check these nourishing qualities for securing nutritional health. Similarly, from the viewpoint of the producer, it is good to clear the content of nutrients for promoting a brand of their products. Therefore, in this study, we collected various kinds of tomato juices from all over Japan, and measured nourishing properties of these tomato juices. Moreover, we tried to consider the causes that influence the content of nutrients, and tried to explain the difference in geographical environment or postplanting environment of production districts, and the difference of processing techniques of producers.

＊環境学園専門学校
Professional training College of Ecology, Amagasaki, Hyogo, 660-0083 Japan

2．Materials and Methods

2・1　Samples

We collected 14 various kinds of tomato juices, which were produced in Hokkaido, Gifu, Nagano, Tokushima, and foreign countries as samples (Fig. 1). These tomato juices were sold in can or carton package, and conservable in room temperature. Table 1 shows the summary of production districts and processing methods of tomato juices.

2・2　Analyses of Nourishments

Simple analyses were performed to determine nutrients in tomato juices. Sugar content was measured as an index of carbohydrates, and total nitrogen was measured as an index of proteins. Also, iron content was measured as an index of minerals, and vitamin C content was measured as a representation of vitamins. Each was measured by the following way.

(1)Sugar content

Sugar content was measured by a Brix refract meter (Tenkou REF113).

(2)Total nitrogen (T-N)

Total nitrogen was measured by UV Spectrophotometric Analysis in JIS (Japanese Industrial Standard) K0102 45.2 [1].

(3)Iron content

Iron content was measured by Spectrophotometric Analysis in JIS K0102 57.1 [1].

(4)Vitamin C content

Vitamin C content was measured by an indophenol titration method [2].

These analyses were repeated at least three times, and performed timely so that samples did not degrade.

2・3　Cluster Analysis

Cluster analysis was performed using results of the analyzed nutrients in order to make comparisons of these tomato juices objectively. Normalized data (results of analysis of nourishing properties, consisted of 4 parameters and 14 cases) was used for analysis. Cluster analysis ware preformed using statistical software “R” on Ward’s algorithm with Euclidean distance [3].

Fig. 1　Parts of samples, which were collected for this study.

Table 1.　The summary of production districts and processing method of tomato juices.

Sample	Production District	Variety of Tomato	Processing Method
①	Iwamizawa Hokkaido	Eating tomato	Straight
②	Kamo Gifu	Eating tomato(Momotaro)	Straight
③	Asahikawa Hokkaido	Eating tomato(Momotaro)	Straight
④	Yame Fukuoka	Eating tomato(Momotaro)	Straight
⑤	Nagano	Cooking tomato	From concentrate
⑥	(Brend)	Cooking tomato	From concentrate
⑦	Hida Gifu	Eating tomato(Momotaro)	Straight
⑧	Nagano	Cooking tomato	Straight
⑨	Hida Gifu	Eating tomato(Momotaro)	Straight
⑩	Tokushima	Cooking tomato	From concentrate
⑪	California U.S.A	Cooking tomato	From concentrate
⑫	Matsumoto Nagano	Cooking tomato	From concentrate
⑬	(Brend)	Cooking tomato(Ririko)	Straight
⑭	Matsumoto Nagano	Cooking tomato	Straight

3. Results and Discussion

3・1 Results of Nourishments Analysis

Table 2 shows results of nourishment analysis. This data is indicated by the content per 100g except for the data of sugar content. There are no big dispersions in the sugar content, the total nitrogen, and the iron content. However, there are great variabilities among results of the vitamin C content.

3・2 Cluster Analysis

Fig.2 shows the result of our cluster analysis. We found out samples could be classified into at least four groups. Here, we classified samples into four groups for descriptive purposes and each was named A, B, C and D.

We considered the causes that created the first big division, namely the deviations between group AB and group CD. There are differences in sugar content and total nitrogen content between these two groups. Data on group AB shows high nitrogen content and low sugar content. On the contrary, the data of group CD shows low nitrogen content and high sugar content (Fig. 3). So we took the concept of C/N ratio, and calculated ratios of sugar to nitrogen content. Moreover, we paid attention to the solar radiation, which is the most important climatic element influence C/N ratio. And we got the solar radiation data from databases of NEDO (New Energy and Industrial Technology Development Organization. The normal value, 1961-1990.) and NCDC (National Climate Data Center. Average value, 2002-2007, Sacrament.) (Table 3) [4) 5) 6)]. Samples ⑥ and ⑬ have more than one producing district, and produced as a blended juice, so are not shown. There are a large amount of solar radiation in Matsumoto City, Tokushima City and Sacrament City. Fig. 4 shows the relationships between Sugar-Nitrogen ratio (obtained by dividing sugar content by total nitrogen content) and annual mean solar radiation. Sugar-Nitrogen ratio is proportional to the amount of solar radiation. In general, photosynthesis becomes active under the condition of the strong sunshine, so the C/N ratio becomes greatly enhanced. There are similar tendencies in Fig. 4.

There were many production districts with a large amount of solar radiation in group CD (samples ⑨ to ⑭). In addition, in almost production districts, group CD, cooking tomatoes are produced mainly. Cooking tomatoes are high in sugar, but cooking tomatoes

Table 2. Results of nutrient analysis.

Sample	Sugar Content (Brix %)	Total Nitrogen (T-N g/100g)	Iron (mg/100g)	Vitamin C (mg/100g)
①	4.9	0.13	0.36	13.9
②	4.9	0.12	0.50	7.5
③	5.1	0.16	0.83	13.0
④	5.4	0.18	0.47	0.7
⑤	4.6	0.14	0.44	3.2
⑥	5.2	0.11	0.52	2.2
⑦	5.1	0.12	0.78	3.8
⑧	5.6	0.11	0.66	0.7
⑨	5.3	0.13	1.02	3.5
⑩	5.7	0.11	0.86	7.7
⑪	4.7	0.12	0.85	7.9
⑫	6.8	0.10	0.70	7.9
⑬	7.0	0.13	0.66	11.7
⑭	7.8	0.12	0.89	10.1

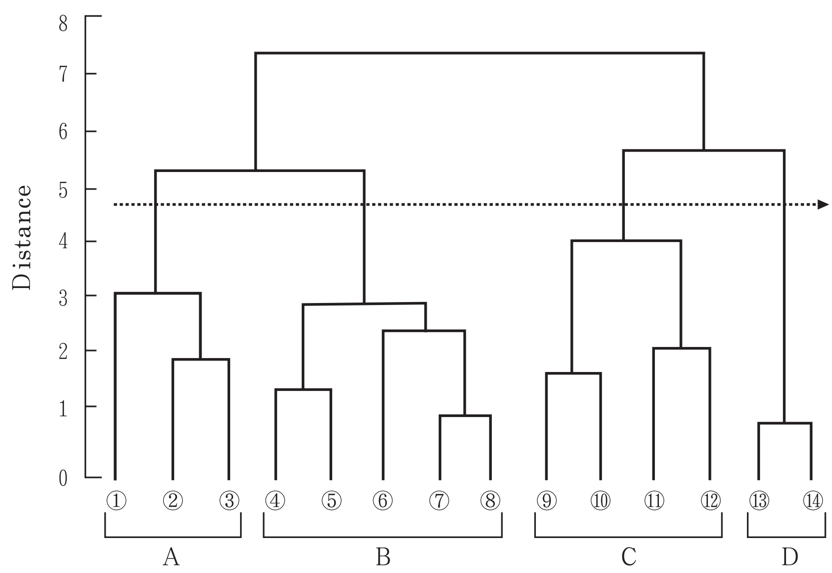

Fig. 2 Results of cluster analysis. Here, we classified a result into four groups and named A, B, C and D. The order of each result of the samples is same as the order of the Table 1.

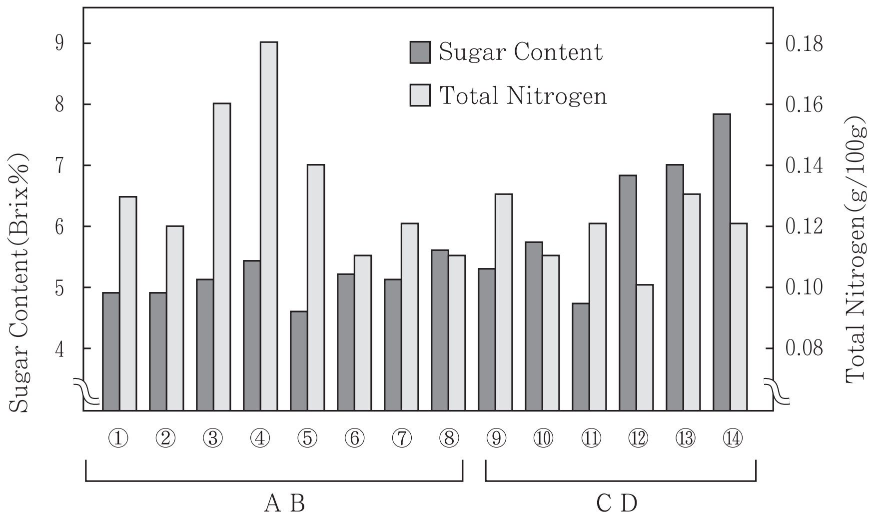

Fig. 3　Relationships between sugar content and nitrogen content. The order of each bar of the graph is same as the order of the cluster analyses.

Table 3. Annual mean solar radiation.

Sample	Production District	Observation Point (City)	Annual Mean Solar Radiation (MJ/m²/day)
①	Iwamizawa Hokkaido	Iwamizawa	12.28
②	Kamo Gifu	Kurokawa(Gifu)	12.40
③	Asahikawa Hokkaido	Asahikawa	11.89
④	Yame Fukuoka	Kurume(Fukuoka)	12.67
⑤	Nagano	Nagano	12.88
⑥	(Brend)		
⑦	Hida Gifu	Takayama(Gifu)	12.15
⑧	Nagano	Nagano	12.88
⑨	Hida Gifu	Takayama(Gifu)	12.15
⑩	Tokushima	Tokushima	13.47
⑪	California U.S.A	Sacramento	15.52
⑫	Matsumoto Nagano	Matsumoto	14.04
⑬	(Brend)		
⑭	Matsumoto Nagano	Matsumoto	14.04

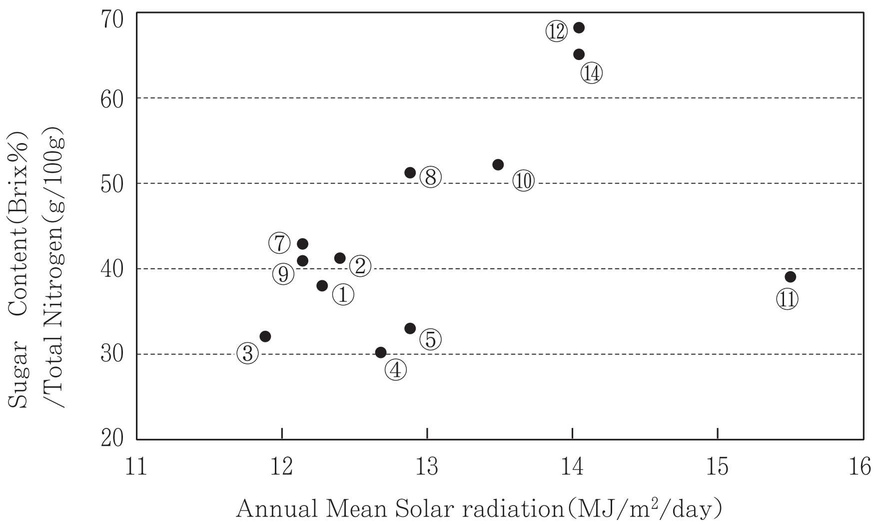

Fig. 4 Relationships between Sugar-Nitrogen ratio (obtained by dividing sugar content by total nitrogen content), and annual daily mean solar radiation. Samples ⑥ and ⑬ have more than one producing district, and produced as a blended juice, so are not shown.

are unable to grow in weak sunlight for the reason of photosynthetic ability [7].

Thus, sweet tomatoes are made under strong sunshine, and the quality of the tomato juices are different depending on the sunshine in the environment of the production district.

Next, we considered the cause that made the division between group A and B. There is a big difference in the vitamin C content between group A and B, and this is one of the big reasons that group A and B are divided.

The reason for this difference is uncertain. But in general, the content of the vitamin C changes by the processing method or the preserving method [8) 9) 10)]. All three samples included in group A (samples ① to ③) are not from-concentrate juices, and high in vitamin C content. On the other hand, some samples included in group B (samples ④ to ⑧) are from-concentrate juices, and have quite low vitamin C content. Thus, it may appear several differences in the processing method that affect the content of vitamin C.

The differences between group C (samples ⑨ to ⑫) and group D (samples ⑬ and ⑭) are not so clear, but two tomato juices included in group D are relatively high in sugar content and vitamin C. These two kinds of tomato juices (samples ⑬ and ⑭) are produced by major enterprises respectively. These enterprises are using cooking tomatoes that are produced by the contract farming. Moreover, these enterprises are working on breeding their own tomato races that suit for tomato juices. Perhaps these companies have excellent food processing technologies, and these technologies are related to the production of high-quality tomato juices [7].

The scales of enterprises processing eating tomatoes are relatively small [7]. Some of these enterprises are processing tomatoes that are not suitable for shipping. Perhaps such circumstances are also having an influence on the difference of the quality of the tomato juices.

4．Conclusions

We performed simple analysis to determine nourishment of 14 various kinds of tomato juices. In consequence, we found the tendency that tomato juices produced in areas with a large amount of solar radiation were high in sugar content and low in nitrogen content. As for the causes of this tendency, we suggested the increase of photosynthetic efficiency of tomatoes under the strong sunshine and the difference of varieties of tomatoes such as for eating or cooking.

In addition, we found there was great variability of vitamin C content among 14 kinds of samples. As for the cause of this variety, the differences in processing method and preserving method are suggested.

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References

1）Hiroshi Namiki： Testing methods for industrial wastewater JIS K 0102： Japanese Standards Association, Tokyo,1999.（In Japanese）.
2） Association of Agricultural Education in Gifu prefecture: Instruction on experiment of Food Chemistry： Gifu, 1992.（In Japanese）.
3）Tsuyoshi Yamada, Taketoshi Sugisawa, Jun'ichiro Murai： Introductory Statistics With R： Ohmsha, Tokyo, 2008.（In Japanese）.
4） New Energy and Industrial Technology Development Organization：METPV3 Display Manual： Kawasaki, 2006.（In Japanese）.
5） New Energy and Industrial Technology Development Organization：MESH-METPV Display Manual： Kawasaki, 2006.（In Japanese）.
6） New Energy and Industrial Technology Development Organization： Fundamental Common Technology Research and Development for Photo Voltaic System Basic Study for Improvement of Geographical Resolution of Meteorological Standard Data to Promote Photovoltaic System

FY2004 Report（1）： Kawasaki, 2004.（In Japanese with English summary）.
7）Koji Nakamura： The Production Trend and Problem of the Processing Tomato, Norinchukin Research Institute Report, 2002-8, 42-56, 2002.（In Japanese）.
8）Kazuko Yamazawa, Mako Goto, Michiko Kato, and Shuichi Watanabe: Studies on the Vitamin C in Foods ： Part1. Change of V.C Contents of Cucumber and Tomatoes in Different Harvesting Season and Storage, Bulletin of Tokai Women's Junior College, 13, 15-26, 1987.（In Japanese with English summary）.
9）Miyoko Murakami, Yoko Sano and Nagae Harue： On the Nourishment of Juices. Sonoda Women's College studies, 10, 9-15, 1975.（In Japanese）.
10）Maki Wakebe, Chiaki Murakami, Takenori Maruyama, and Isao Niiya： Changes of Ascorbic acid and Dehydroascorbic acid Content during the Process of Vegetable Juice. Journal of cookery science of Japan, 33, 2, 221-228.（In Japanese with English summary）.

要　旨

国内各地で市販されている14種類のトマトジュースを集め、それぞれに含まれる、糖分（Brix 糖度)、全窒素、ビタミンC、鉄分量を測定した。この測定結果に対してクラスター分析を行なったところ、集めたトマトジュースは糖分が多く全窒素量が少ないグループと、糖分が少なく全窒素量が多いグループからなることが示唆された。そこでCN比（植物体における炭素量と窒素量の比率）という見地に立ち、CN比に最も大きな影響を与える気象要素である日射量の多寡と、糖分と窒素量の比の関係について調べたところ、日射量の多い産地のトマトジュースほど糖分と窒素量の比率が大きくなることがわかった。この原因として、一般的に日射量が多くなるほど果実などの糖度が増すということ以外に、日射量の多い地域でなければ加工用の完熟トマトを生産しにくいという事実が関係していると考えられた。すなわち、今回集めたトマトジュースの成分の違いは、第一義的には生産地による日射の多寡とそれに伴う栽培品種の違いによるものであると考えられた。２つのグループに大別されたトマトジュースはそれぞれさらに２つの小さなグループから成っていたが、それにはビタミンC含量の違いが大きく関わっていた。中にはビタミンCがほとんど検出されないトマトジュースも存在し、これらはいずれも濃縮還元によって加工されたものであった。一般にビタミンCは加工法や貯蔵法によって含量が大きく異なってくる成分である。すなわち、トマトジュースの成分の違いに影響する２つ目の大きな要因として、加工法や貯蔵法の違いがあり、これには生産メーカーの規模や加工技術が大きく関係していることが示唆された。