Chapter

Azerbaijan Tea (*Camellia sinensis* L.): Chemical Components, Pharmacology and the Dynamics of the Amino Acids

Mikayil Akbar Maharramov,
Muhendis Mammadhuseyn Jahangirov
and Sevinc Ismail Maharramova

Abstract

The carried out researches show that tea (*Camellia sinensis* L.) is the most unique and complex plant for its chemical component. The ingredients in the component of tea have a physiological activity and could be used in the treatment and prophylactics of a number of diseases. The obtained results prove that the new aspects of the utilization of tea could be used in the prophylactics of a number of pathological processes. Taking into consideration the extraordinary biological activity of amino acids in the component of tea and its effects on human body, the amino acids and their dynamics in the component of green tea leaves which was grown and processed in Lankaran-Astara region have been studied. It has been basis of total quantity determined that tea extractives contain 16 amino acids, including irreplaceable amino acids. Theanine contains the basis of the total quantity of amino acids. The highest of theanine was observed in the tea varieties of Azerbaijan-4 (16.90 ± 0.46) and the least quantity in Azerchay brand (9.96 ± 0.35). Theanine quantity is 41.3% of the total amino acids in the content of the tea-Azerbaijan-1 grade, and contains 38.8% of amino acids in Kolkhida variety.

Keywords: tea leaf, chemical component, health, amino acid, theanine, caffeine

1. Introduction

Tea growing is the agricultural and food industry field which is engaged in planting of tea plantations, cultivation of tea planting materials, the production, and processing of green tea leaves. Tea is a perennial evergreen subtropical plant, which is consumed as a tea drink after processing leaves, buds, and elegant trunks [1].

Although the history of the tea plant goes back to an ancient periods, the history of this plant dates back to the late nineteenth century in Azerbaijan. As a result of investigations, the possibility of the development of tea growing in various regions of Azerbaijan, especially Lankaran geographical region had been mentioned in the works of scientists such as I. N. Klingen (1888), K. Begichev (1893), and S. N. Timofeyev (1897). Still in 1875, a prominent biologist I. V. Voyeykov in his work, emphasized about the development of tea growing in Sukhumi, Georgia, Zugdudi, Alazan Valley, Karabakh, and Lankaran, which was published in Trans Caucasus [2].

At the same time, it should be noted that the first tea bushes were planted in Lankaran by some ambitious villagers, including M. O. Novoselov, who had been removed from Russia. At this time, much more planted tea bushes were brought from neighboring Georgia. M.O. Novoselov had planted the first small tea plantation near 12 km from Lankaran in 1896 [3].

The first experiments for tea cultivation by industrial method were carried out in the Hirkan experimental field in Lankaran support station of the All-Union Institute of new plants and Applied Botany, initiated and organized by Academician N. Vavilov in 1928. According to the obtained positive results, the first tea state-farm (former "Kirov" state farm) was established in 1932. In 1933, the second "Avrora" tea state-farm was established in the large tracts of forest in the southern part of Lankaran, and since 1934, it had been expanded to the collective farms of Astara, Lankaran, Masalli districts, and since 1936 to the collective farms of Zakatala and Balakan regions. Already in 1936 over 500 hectares of tea plantations were established in the republic. In 1937, the first tea processing plant was constructed and put into operation in Lankaran, and 44 tons of green tea leaves were processed at this factory in the same year.

In 1975, the total area of tea plantations were 8500 hectares, the harvest of green tea leaves was 13100 tons, the productivity was 26.7 centner for per hectares, and the total area of tea plantations in 1988 was 13.4 thousand hectares, tea leaf harvest was increased to 34500 tons and the productivity was 48.5 centner for per hectares. Although the introduction variant of the Kolkhida tea was widely spread in tea plantations, but "Azerbaijan - 2" and "Azerbaijan - 4" tea varieties begun to spread in tea plantations for its high yield, drought, and relatively frost resistant [3].

Already in the 90s of the XX century, production of green tea leaves in Azerbaijan exceeded 34000 tons, the number of primary tea processing plants was 14, and the number of tea-making factories was 2. Top quality "Bouquet of Azerbaijan," "Extra" and others tea varieties were produced in these factories.

According to the plans of the former USSR and the Government of the Republic of Azerbaijan, the total area of the tea plantation in the regions of Azerbaijan was considered up to 16000 hectares in 1995 and 21000 hectares in 2005 [4]. Unfortunately, since the end of the twentieth century, the area of tea plantations, as well as the production and processing of green tea leaves, fell sharply in the territory of the Republic of Azerbaijan. As can be seen from the statistical data, the peak of tea development in the Republic of Azerbaijan dates back to 1980–1990 (1988) [5].

Since 1990, the area of tea growing plantations, tea leaf harvesting, and the productivity of tea fields had been declined year by year. Although the lowest extent for tea plantations area was 600 hectares in 2010, but the lowest extent of green tea leaf harvesting was 320 tons in 2008 [5].

As a result of targeted measures undertaken by the government and local executive powers, since 2000, the total area of agricultural crops in the republic had increased again and reached 1583.9 thousand hectares in 2010 and 1738.0 thousand hectares in 2018. The tea planting area had been increased year by year and reached up to 1136.0 thousand hectares in 2018, of which 0.7 thousand hectares were in the harvesting age. The total tea leaves harvesting in the same year was 870 tons, but the productivity was 11.1 centner/hectares. Increase, in both cultivation area and production of green tea leaves was completely shared on Lankaran economic region [5, 6].

Such alteration will have a significant positive impact on the production of green tea leaves, its productivity, cost, profitability, and other economic indicators.

The State Program on Tea growing Development in the Republic of Azerbaijan for 2018–2027 [7] plays an important role in emerging the positive dynamics in tea growing development. According to the State Program, the tea plantation areas in the Republic will be increased up to 3.0 thousand hectares and production of green tea leaves will be increased up to 8500 tons by 2027, which will increase the self-sufficiency level of the population from 40.2% up to 73.6% by 2015 and will allow to reduce the import dependence level from 87.6 to 52.6% and to reduce the import of tea by 2000.0 tons.

2. The chemical components of tea and its effects on human body

Tea (*Camellia sinensis* L.) is the most unique and complex plant for its chemical composition. The number of chemical components, included in the structure of tea had been reached 300 and separated by the beginning of the twenty-first century. Some of them have not been identified yet, and their biochemistry role has not yet been studied. It should be noted that the chemical component of freshly harvested green leaves and tea is not the same. Ready-made dry tea has a more compound chemical component, which is formed during its processing [8].

The modern interest in the chemical component of the tea is due to the fact that many of the ingredients in the tea have physiological activity and can be used in the treatment and prevention of many diseases. The main three group phytochemicals are separated in the tea leaves: alkaloids, flavonoids, and tanned substances of purine group [9].

Alkaloids are highly heterocyclic nitrogen components and have high functional activity. These include three major groups of components – caffeine, Theo bromine and theophylline. It is interesting that the amount of caffeine in the tea is much more than coffee, but the affect is more mild [10].

It is due to the fact that the caffeine in the component of tea is connected with tannins and produces theine or tannate. Theine causes acne in the tea and has a tonic effect on the body, improves mental capacity, stimulates the cardiovascular and central nervous system, and increases activity [11]. Different sorts of tea contain varying amounts of caffeine in the average amounts of 1–4%, but in dark tea sorts, it is up to 5% [12]. According to its association with tannin, caffeine is expelled from the body much faster than alkaloids, thus eliminating the risk of poisoning in people who consume too much tea. High-grade teas contain more caffeine than green tea. At the same time, there is such an information that theine is formed during the growth and development of the plant and accumulates in the young grass of the high-grade green teas [13]. However, there is information that caffeine does not determine the color of the tea [14]. For example, the amount of caffeine in the Ceylon tea is lower than that of the weaker Chinese teas. In addition to theine, there are small amounts of other alkaloids such as vasopressin and diuretic properties, which contain up to 0.5% of the weight of dry tea leaves: theobromine and theophylline [15]. It is transferred into guanine toxic properties due to the long-term remaining of the brewed tea [16]. Natural flavonols are campesterol, quercetin, and myricetin. Tea is the main source of these components [17].

Flavonoids are mainly represented by catechins in the tea, which determine the quality and useful properties of tea drinks, especially green tea [10]. 20–30% of catechins falls to the share of dry substances of tea, and if the higher content of polyphenols are much more in the dry tea, then the quality of the flavor, the color, the aroma, and the smoothing properties of the drink is better [18]. There have been existed eight catechins in the component of the tea leaves, which are more predominant than gallocatexin, epigallocatexin, and epigallocatechingallate [19]. Tea leaf catechins reduce the capillary sensitivity and permeability, normalize tissue respiration, prevent atherosclerosis, participate in complex protein metabolism, in particular, it affects telomerase, which regulates cell division [20].

The epigallocatechingallate in green tea increases the activity of the main enzymes of osteogenesis, enhances bone tissue mineralization, and blocks osteoclast activity [21]. It is effective during the period of sepsis and rheumatoid arthritis [22]. Moreover, tea catechins are powerful antioxidants in neutralizing the effects of free radicals [23]. They contribute to the binding and expulsion of various toxic substances and have a bacterial and bacteriostatic effect [10]. Catechins also impede the development of Alzheimer's and Parkinson's diseases. The wide range of pharmacological features such as immunostimulation, cardio-, radio-, hepato-, geroprotective, antithrombotic, antiallergic, antitumor, and antiviral properties are available in the component of tea and belong to tea bioflavonoids in modern condition [24–26]. Green tea preserves the chemical composition of fresh tea leaves, which also contain catechins, giving an irritating taste and a bright golden color to the black tea. The stereoisomers of the catechin group in the amount of 0.32 g/g [18, 27]. Black tea contains smaller amounts of monomeric catechins as their polymerization occurs during the fermentation process and during oligomeric theaflavins (yellow-pink color) and tearubigines (red-brown color), which determine the quality of the tea [28]. Theaflavins is the first oxidizing product of catechins amount of theaflavins varies in the range of 0.29–1.25%. The small amount of theaflavins indicates that the fermentation is not complete and that the tea is stored for a long time [29]. Thearubigins are the products of the conversion of theaflavins, and while making tea, it gives a full, rich flavor with a reddish color, anti-inflammatory, and anti-tanning effect.

Teabraunins are the products of thearubigins oxidation, give a dark brown color to the tea, and negatively affect the quality of tea. For assessment the quality of black tea, the ratio of theaflavins in the content of thearubigins should be used. The amount of theaflavins in fresh black tea should be more than 1.0%, and the amount of thearubigins should be up to 10% and their proportion should be >0.1 [28].

Tea is one of the richest plants with full of antioxidants, and it is a part of the drinks as one of the most common sources of polyphenols [23, 30]. The experimental researches on animals and grown human cells have shown the role of polyphenols in the prophylactics of cardiovascular diseases, cancer, neurodegenerative diseases, diabetes, and osteoporosis. As an antioxidant, polyphenols can protect the components of cells from oxidative damage and thus reduce the risk of various degenerative diseases associated with oxidative stress. In comparison with other antioxidants, studies on the effects on human health have been carried out later. This late interest in polyphenols is explained mainly by the complexity of their chemical structures [30].

The catechins give main effect on the antioxidant activity of green tea, and the black tea is shown by theaflavins and thearubigins. The antioxidant activity of black and green tea reduces the level of atherogenic form of lipoproteins and increases the level of antiatherogenic fraction and thus effectively prevents the development of atherosclerosis [20].

Soluble condensed tannins are a mixture of polyphenols and their derivatives, which account for 15–30%. They impede the development of oncological processes, reduce arterial pressure, and have antimicrobial, antioxidant, and disinfectant effects [31]. White and green teas are rich with soluble condensed tannins [27]. One of the main representatives of soluble condensed is tannins or teotanin. Its amount is twice as large as green tea compared to black tea. Tanned substances oxidation products – quinones are formed during the processing of tea, oxidize other substances of tea leaves, and produce aromatic products involved in the aroma of tea.

Tea saponins are assorted saponins belonging to olean-triterpene. Unlike tea polyphenols, saponins have been poorly studied. As these substances are learned, their number grows. At present, saponins such as A1- A9, E1-E9, C1-C4, and H1 have been identified. Saponins, being high-molecular organic compounds, contain carbohydrate components and have a surface-active nature. The saponin molecule consists of glucose, rhamnose, fructose which is called sapogenin, etc. residuals and the carbohydrate portion represented by the aglicone. Triterpene saponins contain 10 or more glucose residuals that form two hydrocarbon chains. These chains can be linear and branched. Experimental experiments have shown that a mixture of E1 and E2 saponins isolated from oolong (white) tea and delays pancreatic lipase in vitro. Teasaponin, which is called tea saponins, has antioxidant and anti-microbial effects. Recently, it has been established that phytochemicals have anti-allergic, hypotensive, hypolipidemic, anticancerogenic, and anti-inflammatory effects. The obtained data indicate new aspects of the use of tea in the prevention of a number of pathological processes [32]. The tea contains an average of 25% protein and amino acid [9]. Green tea is rich in protein, but its' high content does not adversely affect the quality of the tea, but it reduces the quality of the black tea and worsens its taste [27].

The most important amino acid in the tea is theanine, which creates sweet, delicious taste of green tea and is an indicator of the tea quality. The tea contains almost all the essential vitamins [23]. Tea contains vitamins B, especially provitamin A-carotene, which maintains the functional state of the eyelid, nose, throat, and respiratory tract, as well as the normal functioning of the inner secretions, nervous system, and skin and hair. At the same time, tea contains ascorbic acid, which has antimicrobial properties, stimulates the immune system, protects the body, and affects the synthesis of proteins and the bleeding process in connective tissues. Green tea contains 2–3 times more vitamin C than lemons and tangerine. A, K, D, and E vitamins have been found in the extraction oil of tea leaves which are soluble in fat [33]. Although tea contains a relatively small amount – about 0.8%, the fragrance of tea is related to ether oils. There are various macro- and micronutrients in tea and the amount contains about 4–7%. These are mainly, iron, magnesium, manganese, sodium, silicon, calcium, potassium, phosphorus, as well as iodine, fluorine, copper, gold, and other micronutrients. All these have been presented in colloidal form, soluble in water, and dissolved in tea (especially fluorine and iodine). Due to the rich content of fluorine compounds in the tea, this drink can be used as a source of fluoride [27].

Although numerous studies are currently devoted to the study of the chemical composition and biological activity of the tea, it must be pointed out that many issues related to the study of tea biochemistry have not yet been investigated and sometimes further refuse to investigate these issues in the future.

3. The modern condition of the study of the amino acid and theanine compound of tea

It is mentioned that protein and amino acids are one of the main chemical compounds determining the taste and aroma of tea [8, 27].

It is known that proteins have an optical activity, that is, they can manipulate the polarization of light. This property is connected with the optical activity of amino acids with the symmetric molecules they contain, since they contain four different substitutions (excluding glycine) carbon atoms (called "asymmetric") [34].

Optical active substances, optical antipodes pairs – are found like isomers, their physical and chemical properties are the same, with the exception of their ability to rotate the polarized beam. The direction of polarization is indicated by the sign "+" (right rotation) and "−" (left rotation). Optical activity is measured by the help of polarimeters device. The measured rotation angle is recalculated for special rotation [∝]. [∝] – Rotation angle of 1 g of optical active substance in 1 ml of liquid or 1 dm (10 cm) in solution. Amino acids differ in forms D- and L-. The amine group located in the left corresponds to the L-configuration and the D-configuration on the amino acid projection formula [34].

The natural amino acids (about 150) contained in proteins and are differed much more among proteinogenics (20 amino acids). All proteinogenic amino acids are represented by L-forms.

The content of protein and amino acids in tea is about 25% [9]. Green tea is rich with protein, and at the time do not compromise the quality of the tea, but also reduce the quality of the black tea and impede its taste [27].

According to a number of sources, there are 26 types of amino acids in the tea, and these amino acids is about 50% [35, 36], and according to some data [37], even 60–70% are only theanine. The overall flavor and aroma of green tea (i.e., flavoring, 5 taste elements) are shown to be specific to amino acids, especially theanine [38].

The highest content of amino acids in green tea leaves, i.e., 45.9%, is in theanine. Glutamic acid (12.7%), asparagine (10.8%), arginine (9.2%), and others are in the following places.

At the same time, it is shown in the part of 2 the tea leaf contains several amino acids (γ-ethylamine-L-glutamine acid), which are found in tea leaves, along with many other valuable chemical compounds. It has been determined that theanine has a psychological, physiological, and pharmacological effect on humans and recently there is more attention to this combination [39]. Even in a number of developed countries, the level of tea on tea bags is shown, which is the manifestation of increased attention to the substance. There are sufficient experimental results on the positive effects of theanine on human health, including the elimination of problems caused by excessive caffeine intake. That is why research concerning theanine is expanding [40].

4. Chemical structure of theanine

Theanine is one of the essential amino acids found in the tea, which determines the sweet and tasty taste of green tea drinks and is the indicator of tea quality [8]. Theanine (γ-ethylamine-L-glutamic acid) is a specific amino acid of green tea (*Camellia japonica* and *Camellia sinensis*) and has a positive effect on the human body in recent years [9, 27].

Theanine was first isolated from the green tea leaf by Sakato in 1949 [41]. The obtained substance is a crystalline mass, with a melting temperature of 217°C, which is not soluble in ethyl alcohol and diethyl ether, but is well soluble in water [42, 43]. Glutamic acid, known as γ-ethylamine or 5-N-ethylglutamine, is found solely in tea and in some kinds of mushrooms (fungus), (*Xerocomus badius*) [44, 45]. According to its chemical structure, it is similar to glutamine.

Chemical formula of theanine: $C_7H_{14}N_2O_3$, molar mass: 174.2 g/mol. The chemical structure of theanine is shown in **Figure 1**.

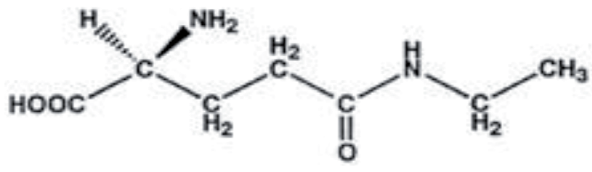

Figure 1.
Chemical structure of theanine (γ-ethylamine-l-glutamic acid).

Most of the amino acids in the green tea leaf are insignificant (in some cases only the traces of a number of amino acids are observed), but are approximately 50% of all amino acids of the theanine [45, 46]. Theanine contains for about 1–2% of the dry matter in tea leaves [45, 47]. It was revealed that tea contained an average of 1.37% theanine [46] has a high correlation between the quality of this compound and the quality of green tea [48]. The structure of theanine is similar to the glutamine and γ-glutamyl dipeptides found in plants. Glutamic acid and ethylamine are the primary substances of theanine biosynthesis [39, 46].

The main lines of the synthesis of theanine are shown in **Figure 2**.

Theanine is synthesized in the roots of tea bushes and is accumulated in the leaves through the trunk. The accumulated theanine in tea leaves is converted to polyphenols under the influence of sunlight [45].

Ethylamine is at the root of many plants and is synthesized by the way of decarboxylation of enzymes [41]. During the theanine biosynthesis, L-glutamic acid, ethylamine ligase or theanine, known as L-glutamate-ethylamine ligase is formed in the roots of tea plants by the help of enzyme synthetase [46]. The obtained theanine is gathered on the tips of the growing tea leaves and plays as a key role of nitrogen for the carbon skeletal components. Theanine is also an important starter substance for the biosynthesis of flavanols in tea leaves [46, 48].

The role of plant organs in the process of synthesis and metabolism of theanine in tea have been shown in **Figure 3**.

The theanine content of tea, produced in different countries has been studied in one of the carried out research works. According to the results of this research work, the lowest amount of theanine was found in the tea "Taiwan oolong" – 0.6%, and the highest amount was 2.38% in the tea "Yannan Kara" [46].

Theanine has two isomers, such as L- and D-theanine [42]. Depending on the assortment of the tea, the amount of L-theanine varies between 0.6 and 2.38 g/100 g in teas. Approximately 1.85% of total tea contains D-theanine, and the amount of D-theanine is inversely proportional to the quality of the tea [42]. Black teas with the lowest content of D- theanine, such as Ceylon Pekoe (0.21%) and Darjeeling FOP (0.45%), are considered to be of the highest quality [46].

It is known that the two main factors have a decisive role in the collection of tea-temperature and relative humidity [3, 4]. Due to the oxidation of lipids and oxidative reactions under high temperatures and humidity, amino acids, especially theanine, sugars and other flavonoids are reduced, causing bitterness and loss of

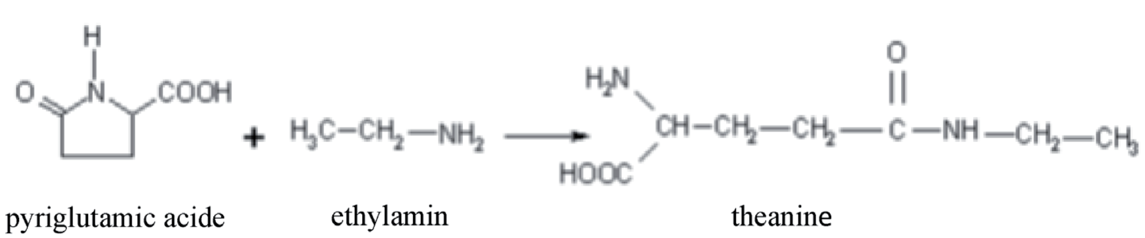

Figure 2.
Formation of theanine from pyroglutamic acid and ethanol [46].

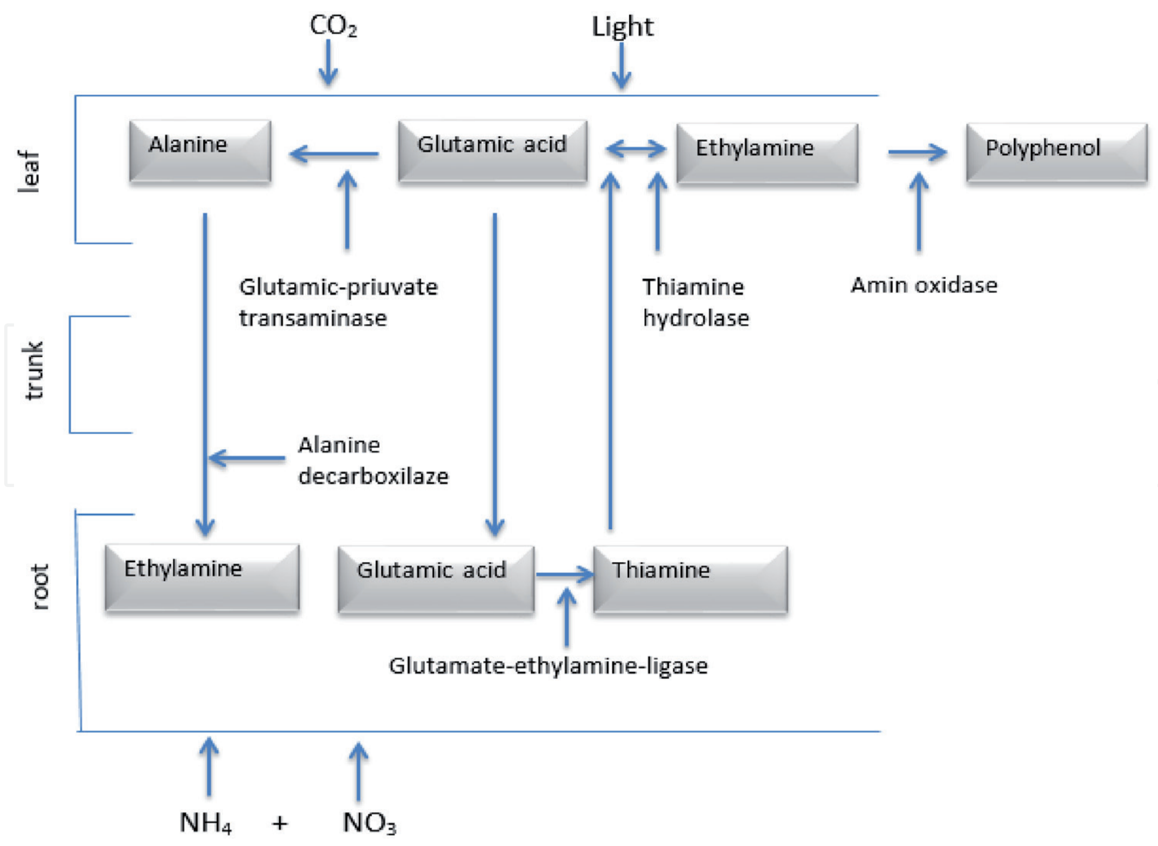

Figure 3.
Synthesis and metabolism of theanine in tea.

tea. The increase in the ratio of D-theanine to L-theanine indicates that the tea is collected at high temperatures. For this reason, the ratio of theanine isomers can be used as an indicator for long shelf life or as a means of determining tea rates [46].

Green tea has characteristic bitterness, curled, and a general taste and aroma. The common taste is amino acids, especially theanine. The amount of theanine is high in the production of green tea due to un application of withering and fermentation processes [38, 45].

In the production of black tea, amino acids combine with O-quinones, an oxidation form of catechins, which subsequently undergo Strecker breakdown, resulting in a new fragrance component. These have a significant impact on the flavor of the tea. The effect of theanine on the black tea is very small as it is broken down into glutamic acid and ethylene in the process of solubility and fermentation. Other amino acids are grown during the process of tea leaves dehydration because they are the hydrolysis products of tea proteins. There is no typical fragrance for black-green or oolong teas. On the contrary, fragrances and flavonols are made up of many volatile compounds and amino acids. Free L-theanine and glutamic acid make the overall flavor of green tea. The D- and L-isomers of theanine and the rosemic (equally entomeric) mixture are sweet and do not create a strong bitter taste [46].

Existing literature review shows that the vast majority of recent studies on theanine in the world have focused on the effect of theanine on human health and on the study of the amount of various types of tea [48]. At the same time, it was found out that there were no researches on the study of theanine in our country. The amino acid of green tea leaves grown in Azerbaijan and amino acid of the finished product, including theanine content, haven't been studied.

In our opinion, such a situation is relatively new, the availability of theanine only in tea plants and in small quantities, the complexity and difficulty of the research methods, the high cost of the devices and reagents used in the research period and there was also recession and stagnation in tea industry in the 90s of XX century in our Republic [48].

As a result of carried out research in the territory of Azerbaijan, especially the amount of theanine in green tea leaves grown in Lankaran-Astara economic region and the quantity of finished products and production processes of various technological parameters have been considered advisable to study the impact of changes in the amount of theanine. At the same time, the importance of the study of the amount of theanine in a number of tea varieties imported by the Republic of Azerbaijan and used by the population have been compared.

5. Amino acid composition of tea raw materials and the influence of technological parameters to their variation

Taking into consideration the extraordinary biological activity of amino acids in the tea and its impact on human body, we studied the amino acids and their dynamics of green tea leaves and their processing products grown in the Lankaran-Astara region. At the same time, the content of amino acids of several tea brands imported to the consumer market of the Republic and widely used by the population was studied for comparison. Such research is conducted for the first time in our Republic.

As a research object, the tea raw materials grown by farms of Lankaran region and imported to the "Lankaran Tea processing Ltd." for processing in May–September 2014–2019. The samples have been prepared from Kolkhida, Azerbaijan-1, Azerbaijan-2, and Azerbaijan-4 varieties of tea and were zoned and introduced in the Republic.

The method for determining the amino acid content of tea leaves and tea extracts is interpreted in [48].

The amino acid composition of freshly harvested and introduced green tea leaves of Azerbaijan-1 and Kolkhida are shown in **Table 1**.

Sixteen amino acids, including eight irreplaceable amino acids, have been identified in the tea extract. Irreplaceable tryptophan and methionine amino acids were not found in the tea leaves extractions. As can be seen from the table, the major part of the total amount of amino acids is theanine. The amount of theanine in the Azerbaijan-1 variety is 41.3% of total amino acids and 38.8% in the Kolkhida variety.

The amino acids are involved in the formation of the tea aroma, the particular value of amino acids in the process of making black velvety tea, that is, solubility, curling, fermentation, and drying of tea leaves, is of particular interest. For the determination of the amino acid content of tea leaves and tea extract, acid hydrolysis was conducted up to their free amino acids and their quality and quantity were determined.

Experiments in production and laboratory conditions from 2014 to 2019 show that the two types of green tea leaves are dissolved, the amount of all amino acids, except serine, threonine, and glutamine, increases by 25.0–1.40%. This increase is due to hydrolysis of protein substances and partial evaporation of moisture, including chemically related water.

It is must be noted that quinine, which results from the enzymatic oxidation of catechins, forms aldehydes in interactions with amino acids (especially active at high temperatures) [48]. The latter is directly or indirectly involved in the formation of a characteristic tea aroma in the form of conversion products. Aldehydes, carbon dioxide, and ammonia are separated at high temperatures by the interaction of amino acids and absorbent substances. For example, as a result of the interaction of the body with the valve, isooil aldehyde, alanine – acetaldehyde, and leucine – isoleutic aldehyde is interact. At the same time, some aldehydes interact

Amino acids	Before processing		After processing	
	Azerbaijan-1	Kolkhida	Azerbaijan-1	Kolkhida
Theanine	1018.4 ± 1.32	887.1 ± 0.96	804.3 ± 1.26	706.2 ± 1.14
Glutamic acid	279.6 ± 0.88	288.5 ± 1.37	283.2 ± 1.18	295.8 ± 2.05
Asparaginic acid	347.3 ± 2.26	310.9 ± 1.84	309.3 ± 2.35	279.4 ± 0.96
Arginine	190.5 ± 1.98	173.6 ± 0.85	176.3 ± 0.68	162.3 ± 2.40
Glutamine	167.8 ± 3.12	169.7 ± 1.11	183.8 ± 2.02	179.5 ± 3.26
Serin	97.6 ± 0.87	108.3 ± 1.67	81.4 ± 2.43	84.5 ± 0.98
Treonin	52.5 ± 2.28	50.2 ± 1.44	43.1 ± 0.67	44.7 ± 2.19
Alanine	44.9 ± 0.66	41.8 ± 2.18	59.3 ± 1.49	60.7 ± 0.83
Aspargin	56.2 ± 2.45	59.3 ± 1.87	94.5 ± 1.88	98.7 ± 3.10
Lysine + Histidine	42.9 ± 1.67	39.8 ± 2.23	46.9 ± 0.93	45.2 ± 2.42
Phenylalanine	28.6 ± 0.62	30.3 ± 3.06	64.7 ± 1.41	61.8 ± 1.92
Tyrosine	39.3 ± 1.87	41.2 ± 2.35	69.1 ± 2.08	72.0 ± 2.41
Lysine + Isolysine	31.4 ± 2.06	29.7 ± 1.78	62.5 ± 2.32	60.9 ± 1.98
Valin	68.5 ± 3.08	56.8 ± 1.68	123.7 ± 2.48	126.2 ± 3.16
Total of AA	2465.5 ± 1.80	2287.2 ± 1.74	2402.1 ± 1.56	2277.9 ± 2.03

Table 1.
Medium amino acid (AT) composition in tea leaves, mg/l.

with tannins at high temperatures. Thus, furfural and vinegar aldehyde form a dark product with tea tan, thus reducing the amount of catechins.

At the same time, it is important to take into account that the amount of amino acids decreases slightly during the fermentation process, which is mainly completed in the batch process. It should also be noted that during the fermentation, oxidative deamination of amino acids occurs [48]. As a result, the amount of amino acids should be abruptly reduced. However, the results of our analysis show that this is not observed. In our view, during the fermentation, partial hydrolysis of protein substances continues, resulting in the formation of a number of amino acids. Therefore, the reduction of amino acids during fermentation as a result of oxidative deamination is not acute. During heat processing, as expected, the amount of amino acids decreases more intensively. As it is mentioned above, the presence of amino acids in the formation of tea aromas has been proven [4]. However, the amount of amino acids gradually decreases during fermentation and intensively during drying.

Determination of the L-theanine was performed with the help of a highly efficient fluid chromatograph (CAD) according to the method described in [40, 46, 47] (with some of our corrections). At this time, the standard L-theanine was used to compare the chromatogram of tea leaf grown in the Lankaran-Astara region. Determination of the theanine was implemented based on both production regimes (solubility, curling, fermentation, and drying) and extraction conditions (particle size, duration, and temperature).

Extraction was performed as follows: 0.25 g tea sample was drawn in a test bottle, 50 ml of distilled water was added, and the samples were extracted in a water bath at 80° C for 25 min. At the end of extraction, tea samples were cooled on the water line for 5 min.

The cooled samples were transferred to centrifugation and stirred for 1 min at a rotation rate of 3500 cycles/min. The samples were first decanted (precipitated) and then transferred to a test bottle by passing a large paper filter and a membrane filter with a hole diameter of 0.22 μm. The extract was stored at 24°C until analysis.

It is noted that if most amino acids are present in the tea in small quantities or as traces, the theanine is at least 50% of all amino acids, indicating that there is a direct correlation between tea quality and the amount of theanine [45, 46].

As noted, the bulk of the total amount of amino acids in the tea leaves is the chromatogram shown in **Figure 4.** As seen from the chromatogram, the wavelengths of 340 and 450 nm are better observed at excitation (excitation) and radiation (emission), respectively. Although earlier experiments in some studies [40, 45] were performed at wavelengths of 330 and 418 nm; however, in our experiments [48], peaks were identified. Despite this, there is some increase in wavelength peaks after 25–30 minutes of testing in the study of chromatograms. Further research into the nature of wavelengths has not clarified this issue. We consider that such slight deviations are due to errors made during experiments and to contamination in the test equipment and containers (reagent and chemical residuals).

First of all, experiments were conducted on the tea Kolkhida at wavelengths of 330 and 418 nm. However, the results of subsequent experiments have shown that wavelengths of 340 and 450 nm show a much higher peak.

As noted, standard L-theanine substances were used to compare chromatograms of tea leaf extract of Kolkhida variety. The chromatogram of Kolkhida variety of the tea leaf extract is added to the standard substances L-theanine and is identical with the chromatogram given in [40].

Taking into account the role of theanine in the quality of the ready tea products, we have studied the theanine amount of the tea grown in Lankaran-Astara region of the Republic of Azerbaijan, as well as imported into the consumer market of the Republic, depending on its brand, grade, type, country of origin.

The study of the variation of the tea composition of L-theanine depending on the brand, type, and country of origin of the tea showed that local teas Azerbaijan-1, Azerbaijan-2, Azerbaijan-4, Farmanchay and Lankaran bouquets, and Ceylon Pekoe (Sri-Lanka) from imported tea. Teas such as Lanka, Yunnan (China), and Sencha (Japan) have the highest content of L-theanine. Relatively low amount of theanine is found in Kolkhida, Azercay, and Lankaranchay tea varieties, as well as imported Ceylon Broken (Sri Lanka), Assam FOP and Darjeeling FOP (India), and Georgian FOP tea (Georgia).

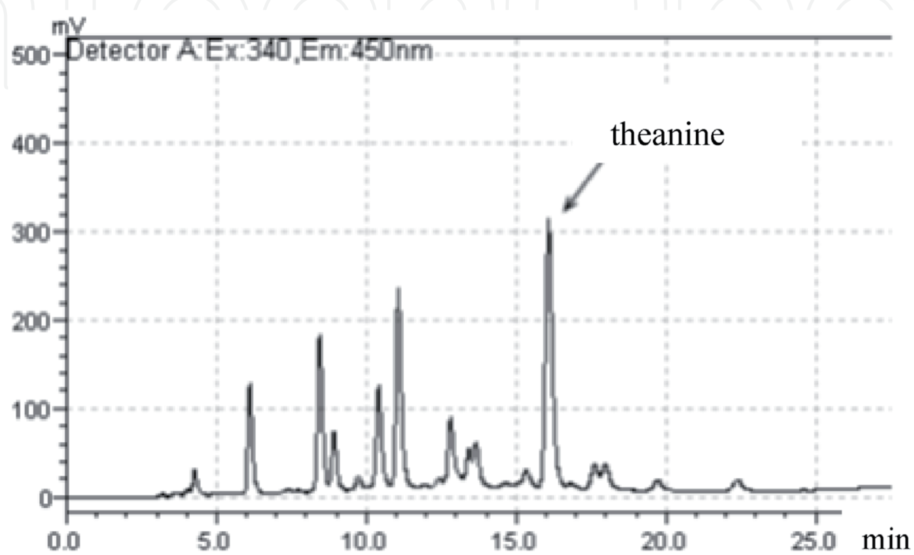

Figure 4.
Chromatogram of fresh green leaves of Azerbaijan-1 tea variety [48].

Types of tea	L-theanine initial value, mg/100 ml	Changes in the amount of L-theanine mg/100 ml				L-theanine total loss, %
		Fading period	Curling	Fermentation	Drying	
Azerbaijan-1	15.42 ± 0.34	13.96 ± 0.48	13.72 ± 0.16	13.41 ± 0.31	12.38 ± 0.27	19.72 ± 0.26
Azerbaijan-2	13.12 ± 0.28	11.81 ± 0.35	11.63 ± 0.18	11.37 ± 0.24	10.50 ± 0.38	19.97 ± 0.52
Azerbaijan-4	16.68 ± 0.46	14.80 ± 0.21	14.54 ± 0.38	14.20 ± 0.19	13.00 ± 0.42	22.07 ± 0.37
Kolkhida	12.21 ± 0.32	10.93 ± 0.47	10.76 ± 0.33	10.54 ± 0.25	9.65 ± 0.18	20.96 ± 0.25

Table 2.
Variation of L-theanine in the amount of tea leaves during processing.

Our studies show that at all stages of tea leaf processing there is a decrease in the amount of theanine and an increase in the amount of glutamic acid, with significant loss of the tea at the fading (up to 50% of total losses) and drying stages (up to 34% of total losses). These results have also conformity with the studies of other authors [40, 46]. Apparently, as a result of the breakdown of theanine – its component, and glutamic acid have been formed. The results of the variation in the amount of L-theanine in tea leaves during processing are shown in **Table 2**.

As it is shown in **Table 2** that the total loss of L-theanine depending on the grade of the processed tea leaves ranges from 19.72 ± 0.26 to 22.07 ± 0.37 mg/100 ml. The largest losses are observed in the Azerbaijan-4 tea (22.07 ± 0.37 mg/100 ml), and the least losses are in the Azerbaijan-1 tea (19.72 ± 0.26 mg/100 ml). During processing of Azerbaijan-4 varieties the loss of L-theanine compared to the initial raw material while fading is 11.27%, while curling is 1.56%, during fermentation is 2.04% but during drying is 7.20%. Experiments also show that the loss of L-theanine in tea leaf curling is 6–8% on average, and 18–21% at crunching and curling, i.e., the loss of pruning is almost three times higher.

In addition to the above, we investigated the effect of tea leaf particle size, extraction temperature, and duration and theanine impact on the extraction process. Similar work has also been done by the other authors [38, 46, 47]. As a result of our work, it was found that the amount of tea leaf particles, the temperature and the duration of the extraction are influenced by the extraction process. The optimal ones: tea leaf particles size – 200–450 μm, extraction temperature – 80–85°C and extraction time – 20–25 minutes. Our results are close to the data of the above mentioned authors.

At the same time, along with the analysis of the tea content of the leaves, we investigated whether the amount of caffeine in the leaves, the impact of technological processes on the content of theanine and caffeine, and whether there was any dependence between the amount of tea and the amount of caffeine in the leaves. The content of theanine and caffeine in fresh tea leaves (shoots) is given in **Table 3**.

As can be seen from **Table 3**, the amount of theanine was most commonly observed in the Azerbaijan-4 tea varieties (16.90 ± 0.46) and the least in the Azerchay brand (9.96 ± 0.35). Carried out experiments have shown that the content of theanine in tea leaves varies considerably. Taking into consideration the high content of theanine on young leaves, the use of fresh and young herbs for the production of high quality tea is required. The highest amount of caffeine in tea leaves grown in Lankaran-Astara region of the Republic is in the component of

Tea brand (variety)	The amount of theanine100 mg/ml	The amount of, caffeine, mg/g dry weight (mg/100 ml)	Caffeine theanine
Azerbaijan-1	16.47 ± 0.51	29.08 ± 0.42	1.76
Azerbaijan-2	12.63 ± 0.18	24.34 ± 0.27	1.93
Azerbaijan-4	16.90 ± 0.46	30.16 ± 0.56	1.78
Kolkhida	11.72 ± 0.23	22.85 ± 0.31	1.95
Azerchay	9.96 ± 0.35	27.08 ± 0.23	2.72
Farmanchay	12.88 ± 0.74	23.52 ± 0.64	1.86
Lankaran	10.75 ± 0.29	25.47 ± 0.18	2.42
Lankaran bouquets	14.93 ± 0.62	28.29 ± 0.36	1.94

Table 3.
The results of changes in the amount of L-theanine in tea leaves (shoots) during processing.

Azerbaijan-4 varieties (30.16 ± 0.56 mg/g (mg/l)) and the smallest in the Kolkhida variety (22.85 ± 0.31 mg/g dry weight).

Our carried out researches have shown that there is a significant difference in the amount of caffeine presented in different types of tea leaves. At the same time, there seems to be a correlation between the tea leaves and the caffeine content of tea leaves, which will be more detailed after the mathematical processing of the obtained results.

6. Results

The results of the analysis of amino acid content of green tea leaf extract grown in the Republic of Azerbaijan showed that 16 amino acids, including irreplaceable amino acids, were found in the extract of tea leaves. Theanine forms the basis of the total amount of amino acids. Tea content in Azerbaijan-1 grade is 41.3% of total amino acids and 38.8% in Kolkhida sorts. In the dehydration of both types of green tea leaves, the amount of all amino acids increase (averagely 25.0 ± 1.40%), except serine, threonine and glutamine. This increase is due to the hydrolysis of protein substances and the partial separation of moisture, including chemically related water. However, the amount of amino acids gradually decreases during curling, fermentation, and drying, which is more intense during drying. Tea depletion occurs at all stages of tea leaf processing and the amount of glutamic acid increases, with significant loss of theanine occurring in the dehydration (up to 50% of total losses) and drying (up to 34% of total losses). Obviously, as a result of the breakdown of the theanine content, glutamic acid is formed.

It has been found that L-theanine loss during tea leaf rolling is on average 6–8% while at the same time for crunching (cutting) – 18–21%, i.e., the loss of pre-rolling increases approximately 3 times.

The highest amount of theanine was observed in the Azerbaijan-4 varieties (16.90 ± 0.46) and the lowest in the Azercay brand (9.96 ± 0.35). Experiments have shown that the content of theanine in tea leaves varies considerably. Given the high content of theanine on new leaves, it is advisable to use fresh and new herbs for the production of high quality tea.

At the same time, carried out studies have shown that the highest amount of caffeine in tea leaves grown in the Lankaran-Astara region of the Republic is in Azerbaijan-4 varieties (30.16 ± 0.56 mg/g) and the lowest in Kolkhida variety (22.85 ± 0.31 mg/g dry weight).

As it is seen, our carried out research has revealed that there is a significant difference in the amount of caffeine contained in various varieties of tea leaves, as well as the interrelationship between theanine and caffeine.

Author details

Mikayil Akbar Maharramov[1]*, Muhendis Mammadhuseyn Jahangirov[1,2] and Sevinc Ismail Maharramova[3]

1 Lankaran State University, Lankaran, Azerbaijan

2 Lankaran Ltd. Tea Company, Lankaran, Azerbaijan

3 Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan

*Address all correspondence to: mikailbyst@mail.ru

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