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Tea-making technology by using quinoa raw materials

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Abstract

Quinoa is a kind of pseudocereal with rich nutrient, unique flavor and antioxidant ingredients. In recent years, it has received widespread attention all over the world, however, the problem of single quinoa product is increasingly prominent. Tea is one of the most popular functional beverages globally, so the development of quinoa tea has a broad market prospect. In the present review, the preparation methods of quinoa seed tea, quinoa malt tea, quinoa leaf tea, quinoa whole plant tea, quinoa fermented tea and quinoa compound tea were summarized, and the current situation and existing problems were analyzed. Based on the above investigations, some suggestions for improving the product performance were put forward.

Keywords: quinoa; tea-making technology; research progress.

Practical Application: This review provides the tea-making technology by using quinoa raw materials, discussing the current situation and problems, with the aim to improve the applications of quinoa tea in food industry.

1 Introduction

Tea is one of the most popular functional beverages globally (Wang et al., 2022a). As one of the three major non-alcoholic beverages in the world, tea not only has the effect of quenching thirst and relieving heat, but also contains rich chemical components and various trace elements, which has high nutritional value. With the improvement of living standards, people have a higher pursuit of life quality, which promotes the production and consumption of tea in China and other countries. In 2020, the domestic sales of tea in China reached 2.20 million tons, up 8.69% over the previous year (Weng, 2021). In 2021, the total domestic sales of tea in China reached 2.30 million tons, which increased 4.56% compared with the previous year (Mei & Liang, 2022). It is expected that the world tea market will gradually expand in the next few years, and the sales of tea will reach 70 billion dollars by 2024 (Wen, 2020). In addition to the traditional tea, the cereal tea is also popular with consumers and has gradually occupied a position in the market (Li et al., 2008; Niu et al., 2022; Shi et al., 2022).

Quinoa as a kind of *Chenopodiaceae* plant native to South America, has the characteristics of rich nutrition and fragrant taste, so it is a high-quality material for making new type health tea. At present, the planting area of quinoa in China has exceeded 20,000 hectares (Zhou et al., 2021; Chen, 2021), so the quinoa materials are in plentiful supply. Under such circumstance, the development of quinoa tea can not only extend the original industrial chain of quinoa and enhance its market competitiveness, but also improve the added value of quinoa products and increase the economic benefits. In order to better understand and evaluate the development prospect of quinoa tea, the current research status and existing problems of quinoa tea were summarized. Some suggestions on improving the processing technology of quinoa tea were also put forward.

2 Product types and preparation technology of quinoa tea

Compared with quinoa grain, the quinoa tea has the advantage of convenient consumption and strong market competitiveness. Up to now, people have tried to study several kinds of quinoa teas, such as quinoa seed tea, quinoa malt tea, quinoa leaf tea, quinoa whole plant tea, *Monascus* fermented quinoa tea and quinoa compound tea. However, since quinoa has not been planted in China for a long time, there are still some deficiencies in the preparation technology of quinoa tea, therefore, it needs to be improved further.

2.1 Quinoa seed tea and its preparation technology

The protein in quinoa seed is not only rich in content, but also has good solubility, so it is easy to be absorbed and utilized by human body (Yan et al., 2018; Feng et al., 2022). Quinoa seeds also contains sterols, polyphenols, flavonoids, lunasine and other bioactive substances (Jin et al., 2018), the existence of these functional active substances makes the quinoa seeds have a certain capacity of antioxidation, inhibiting the increase of blood sugar and lowering cholesterol level. After baked or stir-frying, the Maillard reaction occurs between amino acids and reducing sugars at high temperature, which makes the quinoa seeds have a special fragrance. The temperature for making quinoa tea by baking method is generally controlled between 150 °C and 180 °C. Li (2017) investigated the effects of heating temperature and heating time on the nutrition of quinoa tea. The result showed that when quinoa seeds were baked at 160-190 °C for 29-36 min, the nutritional ingredients of protein, fat and minerals in quinoa seeds were preserved to a greater extent, but the content of dietary fiber and vitamin B_1 decreased, in which the percent loss of dietary fiber and vitamin B_1 was

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about 15% and 20%, respectively. Wei (2019) reported that quinoa tea had the highest sensory evaluation score when quinoa was baked at 180 °C for 1 min.

In order to eliminate the effect of saponins on the taste of quinoa tea, Yang et al. (2014) used the following processing method. The quinoa seeds with shell were soaked in water for 8-10 h, and then were treated by stir-fry and shelling processing. The results indicated that the content of saponins and bitterness of quinoa tea reduced significantly. In the study of Dong et al. (2015), the quinoa seeds were soaked in 20-40% ethanol aqueous solution. After drained of solution, the quinoa seeds were dried and stir-fried. The quinoa tea prepared by the above method can be brewed with water at 60-80 °C, which has a mellow taste and ginseng flavor.

Although the shelling of quinoa helps to eliminate the bitterness of quinoa tea, it will bring about the loss of anthocyanins and cellulose. Xing (2019) put forward a modified method for preparing the quinoa tea with shell. Firstly, the diluted dandelion enzyme was evenly sprayed on the quinoa raw seeds, then quinoa seeds were soaked in warm water at 40 °C for 4-8 h. The mass ratio of water to quinoa was 0.75-1:5 so as to soak the shell through. Secondly, the soaked quinoa seeds were drained of water and then stir-fried in a traditional iron pot over low heat for 15 to 18 min. During the stir-frying process, the quinoa shell should not be burnt. When the inside of the quinoa was completely done, the stir-fry was stopped. After cooling and sterilization, quinoa tea with shell can be sealed and filled. The quinoa tea processed by the above method not only contained the nutrients well, but also the bitterness reduced greatly. Moreover, the wheat aroma produced in the process of stir-frying can mask the bitter flavor of the saponins from the quinoa shell, therefore, customers are willing to accept this kind of quinoa tea.

Stir-frying is a traditional method of making tea. For quinoa tea, because the quinoa grains were directly contacted with the high-temperature frying pan, the temperature required should be lower than that of the baking temperature, otherwise, the quinoa tea is easy to become scorched. The preparation of quinoa tea by direct baking or stir-frying is simple and easy to achieve large-scale production. Li et al. (2021a) studied the method of stir-frying quinoa tea in a pan which was traditionally used to prepare the Longjing tea. It was found that the quality of quinoa tea prepared by stir-frying at 180 °C for 25 min was the best, and the flavor of quinoa tea was strong after brewing. Aroma analysis by electronic nose showed that sulfur compounds, aromatic compounds and alkanes may be the main components affecting the aroma of quinoa tea at different stir-frying temperatures. Currently, the design, processing and manufacture of processing equipment for quinoa tea have been greatly improved (Lv et al., 2019).

2.2 Quinoa malt tea and its processing technology

The method of making quinoa tea using the quinoa malt has been applied for patents (Sun, 2018a; Liu et al., 2019). Mäkinen et al. (2013) found that the germination of quinoa had no significant effect on the baking characteristics. Nutritional analysis showed that the nutritional composition of quinoa malt was different from that of quinoa grain (Fu et al., 2020). The internal metabolism of quinoa is active during the first three days of germination, and the contents of protein, reducing sugar, flavonoids and saponins in quinoa sprouts increases, while the fat content decreases. It was reported that the germination of quinoa increased the content of phenolic compounds, flavonoids, ascorbic acid and reducing sugar, improving the ability of antioxidation (Aguilar et al., 2019; Bhinder et al., 2021). Recent research showed that dietary polyphenols such as anthocyanins and catechins found in herbal teas might reduce starch digestion by inhibiting α-amylase and α-glucosidase thereby lowering the glycemic index of foods (Uğur et al., 2022). According to result of He et al. (2022a), the contents of free amino acids, vitamins, phenols, carotenoids and folic acid increased after quinoa germination, and the folic acid content reached the highest value at the sixth day (15.02-17.47 μg/g dry weight). It was recommended that quinoa sprouts in 6-day-old could be used as a functional food with nutritional value and health benefits in dietary supplements. Therefore, quinoa tea prepared by germinated quinoa can reduce the calorific value of food and improve the value of health care.

In order to prevent the loss of nutrients in the production of quinoa malt tea, a rapid germination method was used by Sun (2018a). The quinoa seeds were soaked in warm water for 1 h, then the temperature was gradually heated to 50-65 °C to activate the germination for 1-2 h. The germinated quinoa was cooked by atmospheric steam and dried by hot air at 130-180 °C to obtain the quinoa malt tea. Liu et al. (2019) indicated that the buds of quinoa became more visible after 25 hours of germination, so this kind of quinoa tea is more acceptable to consumers. On this basis, Liu et al. (2019) proposed the production process of quinoa malt tea as follows. Firstly, the germinated quinoa (the germination time was 25 h) was dried by cylinder type water-removing machine until the water content reached 55-65%, then they was bake at 125 °C for 5 min in order to promote the aroma of the product. Finally, the quinoa was dried at 100 °C until the water content is less than 5%.

2.3 Quinoa leaf tea and its processing technology

In the traditional tea-making process, the tender leaves of tea trees are used as the raw materials, and the leaf-like tea products are obtained after stir-frying. If quinoa leaves can be used to make tea, not only the material cost will be reduced, but also the appearance of quinoa leaf tea is closer to the traditional tea, so the acceptance of consumers will be further improved. In the process of quinoa plant growth, quinoa stems and leaves occupy a large part, therefore, the biomass of quinoa stems and leaves is far higher than that of quinoa grains. Since the quinoa leaves are high in protein, flavonoids, polyphenols, carotene, vitamin C and vitamin E (Cui et al., 2019; Stoleru et al., 2022), the leafy quinoa materials are suitable for making tea. In addition, the content of saponins in quinoa leaves is lower than that in grains, and the taste may be better.

A kind of manufacturing process of quinoa green tea was proposed by Zhou (2018). The green leaves of quinoa were left in the sun for 5-7 h, then they were desiccated at 180 °C for 1 min. The dried quinoa leaves were transferred into cylinder and dried at 100 °C until the water content was up to the standard. Zhou (2018) indicated that there was little difference in the composition between quinoa green tea and traditional green tea. Luo (2018) investigated the manufacturing technique of green tea and red tea by using quinoa leaves. The quinoa green tea was obtained by a series of processing of traditional airing, high temperature

fixing and drying; the quinoa red tea was obtained by a series of processing of withering, kneading, fermentation and drying. The contents of polyphenols, flavonoids, free amino acids and volatile compounds in both products were measured by chemical analysis. The results showed that the content of free amino acids in quinoa red tea was higher than that of quinoa green tea, while the activity of free radical scavenging of quinoa green tea was stronger than that of quinoa red tea.

Quinoa leaf tea can be processed by the traditional tea-making equipment, which has the advantages of low cost and mature technology. Moreover, the raw material of quinoa leaves is sufficient, so it has the advantage of market competition.

2.4 Quinoa whole plant tea and its processing technology

The plant height of quinoa is mostly between 1-3 m, and the exuberance degree of stems and leaves varies with varieties. In general, the proportion of culms of the forage quinoa is larger. Quinoa straw is rich in protein, which is not less than corn and oats (Luo, 2018). If the whole quinoa is made into tea, the roots, stems and leaves of quinoa can be used effectively (Gao et al., 2019). Because the content of saponins in tender branches of quinoa is the lowest during the branching stage and filling stage (Schmöckel, 2021), the stems and leaves of quinoa for making tea should be harvested in this period. From the perspective of quality and biomass, it is more economical to harvest the whole quinoa when the plant height is about 100 cm.

In order to make the quinoa tea more nutritionally balanced, the mixed processing of quinoa stems, leaves and grains can also be used. For example, firstly, quinoa grain was soaked in warm water for 8-12 h, then germinated after draining until the bud was 1-2 mm long. Secondly, the germinated quinoa was mixed with quinoa stems and leaves in a certain proportion, then these mixed materials were baked in a gradient heating equipment to remove green. Thirdly, quinoa materials were dried by microwave until the water content reached 6-10%. Fourthly, the quinoa materials were treated with ultrafine grinding machine to obtain the powder with fineness of 100-200 microns, which can be packed in a tea bag (Wang, 2017).

2.5 Monascus fermented quinoa tea

Fermentation may change the composition of food, thereby imparting new biological activity or increasing digestion and absorption. In order to improve the edible value of quinoa, He et al. (2020) studied the fermentation property of quinoa substrate by *Monascus*. The result showed that the species and content of flavor substances and sensory score of solid-fermented quinoa by *Monacus* were better than those of unfermented quinoa. However, as far as the color, aroma and taste of tea were concerned, the fermented quinoa is not ideal, especially the taste is not good. Therefore, He et al. (2022b) suggested that the fermented quinoa should be mixed with the baked quinoa to make a better quinoa tea. For example, the solid-fermented quinoa powder was mixed with the baked quinoa at the ratio of 1:25, the brewing result of tea was greatly improved. Moreover, the antioxidant activity of this kind of quinoa tea was obviously higher than that of the ordinary baked quinoa tea.

2.6 Quinoa compound tea and its processing technology

The compound tea can improve the nutrition of traditional tea and give new functions, so it has been paid attention by the market. For example, Sriharti et al. (2022) prepared the herbal tea drinks by aloe vera rind, mint leaves and cinnamon. Kayisoglu & Coskun (2021) prepare the kombucha tea by sage, linden and mint teas, which are highly valuable for health. In order to improve the taste of quinoa tea and make the nutrition of quinoa tea more balanced and comprehensive, some researchers explored the quinoa compound tea. The tartary buckwheat-quinoa tea was prepared by the juice of tartary buckwheat, quinoa powder and skim milk, which contains three flavors and nutrients. Chen et al. (2019) registered a patent and described the preparation method of *Cynomorium songaricum*-quinoa tea. The quinoa powder was mixed with the extract of *Cynomorium songaricum* and skim milk, then these materials were dried and granulated to obtain the quinoa compound tea. In order to let the quinoa tea has the taste of traditional tea, Zhang et al. (2019a) soaked the quinoa grain in black tea soup at 45 °C for 90 min. After baking and stir-frying, the quinoa compound tea was rich in phenols and flavonoids. Up to now, quinoa seeds has been mixed with rose, jasmine, chrysanthemum, green tea, baked red dates to prepare a series of quinoa compound tea.

3 The contribution of quinoa tea for the food industry

As a kind of pseudocereal with high nutritional value, quinoa has been concerned by countries all over the world. In order to improve the added value of quinoa products and enhance the competitiveness of quinoa in the market, a series of downstream products have been developed. So far, the downstream products of quinoa mainly include: instant quinoa grain (Zhou et al., 2023), instant quinoa powder (Le et al., 2020), quinoa pasta (Lorusso et al., 2017; Xing et al., 2023), quinoa noodles (Huang et al., 2022; Mu et al., 2022), quinoa bread (Cao et al., 2022a; Suárez-Estrella et al., 2020), quinoa biscuits (Sun, 2018b; Zhang et al., 2021a),quinoa cookies (Valenzuela-González et al., 2022), quinoa snacks (Kahlon et al., 2016; Acosta et al., 2022), quinoa muffins (Leland et al., 2020), quinoa yoghurt (Obaroakpo et al., 2020a, b), protein functional beverage (Meng et al., 2022; Dong et al., 2021; Zhang, 2021), quinoa beer (Ji, 2021; Kordialik-Bogacka et al., 2019), quinoa Chinese rice wine (Han, 2018; Zhang et al., 2019b), quinoa sesame crisp (Cao et al., 2022b) and quinoa vinegar (Liu, 2020), etc.

Despite the wide range of quinoa products, the quinoa tea seems to have attracted little attention. Quinoa tea as a kind of grain tea has the advantages of high nutritional value and unique flavor, which has great potential for the market. The development of quinoa tea not only can enrich the varieties of quinoa downstream products, but also promote the extension of quinoa industry chain and enhance the competitiveness of quinoa enterprises in the market.

4 Discussion

Although people have done a lot of research on the preparation of quinoa tea, its related products are still not common in the market.

Besides the fact that it takes a certain amount time for the market to accept the quinoa tea, the processing technology and product standards of quinoa tea also need to be improved. Currently, there are several problems need to be solved in the processing of quinoa tea.

4.1 Reducing the loss of active substances

Quinoa is rich in nutrition, but most of the nutrients and functional substances are unstable and easy to be destroyed in the process of processing, resulting in a loss of activity. Therefore, a reasonable processing method should be selected, and the processing parameters such as processing temperature and processing time should be further optimized to improve the quality of quinoa tea. Sharma et al. (2022) compared the effects of moist heating, boiling-autoclaving, and dry heating-roasting and microwave processing on total polyphenols, flavonoids, phytates and antioxidant activity of quinoa. The results showed that all treatments reduced the levels of phytates. Except that the moist heating process reduced the content of polyphenols, the other processes enhanced the content of polyphenols, flavonoids as well as the antioxidant activity. It is worth noting that the moist heating reduced saponin contents by 14-64% whereas dry heating increased them by 9-25%.

4.2 Enhancing the quality of quinoa tea

For a long time, the quinoa supply on the market has been white quinoa. Escribano et al. (2017) found that different colors of quinoa have different nutritional values. For example, they found that the red-violet varieties of quinoa contained betacyanin, and the yellow-orange varieties of quinoa contained up to four different betaxanthin. Both betacyanin and betaxanthin belong to betalaines, and their contents are highly related to antioxidation activity and free radical scavenging activity. Therefore, it is also important to choose different colors of quinoa for making quinoa tea. Gamma aminobutyric acid (GABA) is an important active substance in the functional foods, which can reduce the blood lipids and promote the cholesterol metabolism. Yang et al. (2020) investigated the method for enhancing the content of γ-aminobutyric acid in quinoa malt. They found that if the budding quinoa is placed in a magnetic field, the content of γ-aminobutyric acid of quinoa malt increased by 28-48%. As reported by Zhang et al. (2020), the content of γ-aminobutyric acid in germinated quinoa increased 2.26 times under the co-treatment of sodium glutamate and ascorbic acid.

Besides germination method, the fermentation treatment also can improve the quality of quinoa seeds. According to the result of Starzyńska-Janiszewska et al. (2016), the scavenging activity of quinoa seeds on hydroxyl radical increased 7 times (white quinoa) or 2 times (red and black quinoa) after 40 h solid-state fermentation of quinoa seeds with *Rhizopus oligosporus*. Moreover, the soluble phenols such as vanillic acid, protocatechuic acid and rutin levels in 40 h fermented quinoa were significantly higher than in cooked quinoa.

4.3 Increasing the leaching rate of nutrients

Quinoa tea as a new type of cereal tea drink, people mainly drink the tea soup whereas the insoluble fraction will eventually be discarded. However, quinoa seeds are naturally hard and not easy to soak, so there is a problem of insufficient utilization of nutrients. In order to solve this problem, it can be started by improving the processing technology. Li (2021) and Li et al. (2021b) reported that the bursting rate of quinoa seeds reached 90.42% and the apparent density of quinoa seeds decreased from 0.73 g/cm^3 to 0.20 g/cm^3 after an air puffing treatment (Figure 1). For the air puffed quinoa, the aroma components such as pyrazines, aldehydes and hydrocarbons increased, and the nut aroma was prominent (Zhang et al., 2022). Different from the extruded quinoa, the air puffed quinoa seeds can retain the particle shape, which improves the external beauty of tea products. As the shell has been cracked, the leaching degree of internal nutrients has been greatly enhanced.

4.4 Improving the taste and flavor

Quinoa tea has a bitter taste, and its bitterness is directly related to the content of saponins (Suárez-Estrella et al., 2018). Washing and mechanical shelling are the two most common ways to remove saponins. Quispe-Fuentes et al. (2013) investigated the leaching kinetics of saponins from quinoa seeds during water washing. The result showed that the dissolution flux of saponins could be described by Fick's second law, and the leaching rate increased with the increase of temperature. Han et al. (2019) found that the degree of saponins removal was related to the degree of milling. When the degree of milling increased from 0% to 27.23%,

Figure 1. Quinoa seeds before and after air puffing.

the content of saponins decreased by 41.8%, while the contents of polyphenols and flavonoids decreased by 31.5% and 41.4% respectively. Therefore, the degree of milling of quinoa seeds needs to be controlled. Besides washing and milling, the germination is also a way to reduce the content of saponins. Suárez-Estrella et al. (2021) used electronic tongue to evaluate the sensory changes of quinoa during germination. The results showed that germination treatment could reduce the bitterness and astringency of quinoa, and the main changes were observed within 48 hours of germination treatment. The authors also found that the content of phenolic compound also seems to play a role in the taste of germinated quinoa. It has been shown that the saponin content of quinoa decreased rapidly at the initial stage of germination, and then remained stable during the period of 6-42 h. Nevertheless, the saponin content of germinated quinoa increased sharply after 48 h (Chen et al., 2020; Huang et al., 2017). In addition to the germination treatment, fungal fermentation also has the effect of removing bitterness. Villacrés et al. (2020) confirmed that the heat treatment combined with *Rhizopus oligosporus* fermentation can effectively remove phytic acid, tannin, trypsin inhibitor and other anti-nutritional factors in South American lupin. This kind of research should arouse the attention of quinoa researchers.

4.5 The necessity of quality evaluation of quinoa tea

Sensory evaluation is a kind of method for tea quality indexes such as taste, smell, color and texture which can be perceived by specially trained personnel. According to the above method, the tea can be graded or quantitatively evaluated. The sensory evaluation can be divided into two aspects (Fu, 2005): (1) the appearance evaluation and (2) the endoplasmic evaluation. The appearance evaluation mainly refers to the observation of shape, color and gloss of tea, while the endogenic evaluation mainly refers to the type of aroma, color and brightness of tea soup, the freshness and intensity of tea taste, as well as the color and tenderness of tea base. At present, the sensory evaluation method of Chinese tea is mainly carried out according to national standard GB/T 23776-2018 (Methodology of sensory evaluation of tea). However, this standard is mainly used for the evaluation of traditional tea, but for the quinoa tea, there is a problem that it is not fully applicable. Therefore, the sensory evaluation of quinoa tea requires to solve the following technical issues.

Improving the evaluation index system

In general, the evaluation index system of tea mainly includes the classification of species, quality characteristics, evaluation factors and weighting coefficient, evaluation terms and the quantitative description, etc. The corresponding evaluation system of quinoa tea should be established according to the above principles. Specifically, the flavor wheel and sensory quantitative description of quinoa tea should be established. The concept of the flavor wheel was firstly developed by the American Coffee Association in 1995 (Spencer et al., 2016), and then was gradually used in the field of tea, wine, spice and other products (Zhang et al., 2021b). The flavor wheel is a kind of visual practical tool to describe different flavor characteristics of tea (Dai et al., 2021). Through the collection, classification, summarization and arrangement of specific sensory terminology, the flavor characteristics of tea are formed (Zhang et al., 2019c; Koch et al., 2012). Therefore, the construction of flavor wheel for quinoa tea enables the consumers to obtain the intuitive information of product flavor. The sensory quantitative description analysis (SQDA) is a comprehensive sensory analysis method which combines the qualitative and quantitative methods (Zhang et al., 2021b). It requires the appraiser to evaluate the intensity of the sensory indicators as completely as possible by using the principal component analysis and other multivariate statistical methods so as to get more objective results. In addition, in order to make the evaluation results more accurate and scientific, the fuzzy mathematics method can be used to analyze the multiple factors or even multiple levels of sensory quality (Ye et al., 2021).

Exploring the correlation between quinoa tea quality and biochemical components

Comparing with the sensory evaluation, it is more objective and accurate to explore the correlation between tea quality and biochemical components. The biochemical components in tea can be analyzed by UV-visible spectrophotometer (Johnson et al., 2022), high performance liquid chromatography (HPLC) (Beer et al., 2021), liquid chromatography-mass spectrometry (LC-MS) (Alnaimat et al., 2019), gas chromatography-mass spectrometry (GC-MS) (Wang et al., 2022b), nuclear magnetic resonance spectroscopy (NMR) (Zhang et al., 2019d) and other instruments. In recent years, some emerging technologies such as computer vision system (Rahman et al., 2021), near infrared spectroscopy (Liu et al., 2022a), hyperspectral imaging (An et al., 2022), electronic nose (Lu et al., 2019; Ou et al., 2019) and electronic tongue (Zhou et al., 2022) have been used in tea quality analysis. The quality assessment of quinoa tea can be performed by using a combination of traditional and emerging technologies (Liu et al., 2022b; Figure 2).

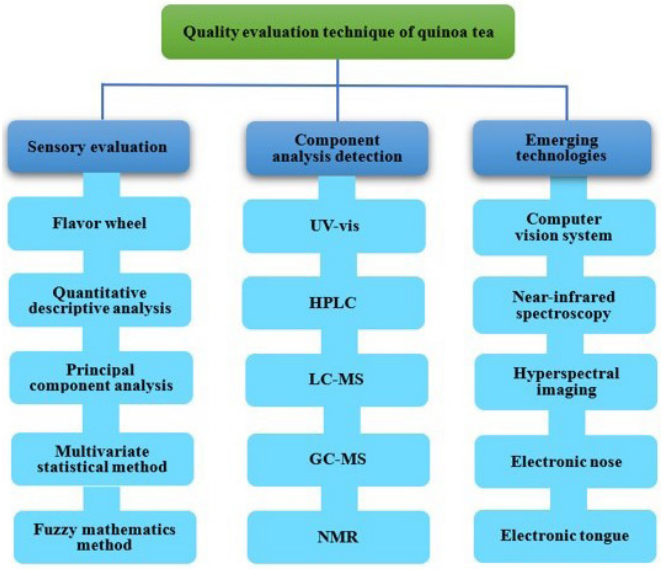

Figure 2. Schematic diagram of research on the quality evaluation of quinoa tea.

5 Conclusion

Quinoa tea has been studied in China for nearly 10 years, and there are many varieties of products, such as seed tea, malt tea, leaf tea, whole plant tea, fermented tea and compound tea. Quinoa tea has a promising market, but its preparation technology needs further improvement. Based on the past experience, the preparation cost of quinoa seed tea, quinoa malt tea and quinoa fermented tea is high, therefore, the combination technology is very important. Quinoa compound tea balances the nutrients and efficacy, and it is easily to develop into a variety of products. In comparison, the quinoa leaf tea and whole-plant tea have the advantages of low cost, good taste and full efficacy, and have broad development prospects.

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References

Acosta, D. F. R., Gómez, J. E. B., Duque, J. F. S., Galindez, J. Z. Z., & Cruz, J. A. M. (2022). Antioxidant potential of extruded snacks enriched with hyper-protein quinoa flour and vegetable extracts. *Food Science and Technology*, 42, e74621. http://dx.doi.org/10.1590/fst.74621.

Aguilar, J., Miano, A. C., Obregón, J., Soriano-Colchado, J., & Barraza-Jáuregui, G. (2019). Malting process as an alternative to obtain high nutritional quality quinoa flour. *Journal of Cereal Science*, 90, 102858. http://dx.doi.org/10.1016/j.jcs.2019.102858.

Alnaimat, A. S., Barciela-Alonso, M. C., & Bermejo-Barrera, P. (2019). Determination of bisphenol A in tea samples by solid phase extraction and liquid chromatography coupled to mass spectrometry. *Microchemical Journal*, 147, 598-604. http://dx.doi.org/10.1016/j.microc.2019.03.026.

An, T., Huang, W. Q., Tian, X., Fan, S. X., Duan, D. D., Dong, C. W., Zhao, C. J., & Li, G. G. (2022). Hyperspectral imaging technology coupled with human sensory information to evaluate the fermentation degree of black tea. *Sensors and Actuators B, Chemical*, 366, 131994. http://dx.doi.org/10.1016/j.snb.2022.131994.

Beer, D., Preez, B. V. P., & Joubert, E. (2021). Development of HPLC method for quantification of phenolic compounds in *Cyclopia intermedia* (honeybush) herbal tea infusions. *Journal of Food Composition and Analysis*, 104, 104154. http://dx.doi.org/10.1016/j.jfca.2021.104154.

Bhinder, S., Kumari, S., Singh, B., Kaur, A., & Singh, N. (2021). Impact of germination on phenolic composition, antioxidant properties, antinutritional factors, mineral content and Maillard reaction products of malted quinoa flour. *Food Chemistry*, 346, 128915. http://dx.doi.org/10.1016/j.foodchem.2020.128915. PMid:33418417.

Cao, H. W., Wang, X. X., Wang, X. X., Guan, X., Huang, K., & Zhang, Y. (2022a). Effect of storage conditions on the textural properties and *in vitro* digestibility of wheat bread containing whole quinoa flour. *Food Bioscience*, 49, 101921. http://dx.doi.org/10.1016/j.fbio.2022.101921.

Cao, X. J., Zhou, M. S., & Li, A. H. (2022b). Processing technology of quinoa, purple sweet potato and sesame seed crisp biscuit. *Food Industries*, 43(11), 74-78.

Chen, W. D., Chen, Y. L., & Cui, S. C. (2019, Mar 12). A kind of *Cynomorium songaricum*-quinoa granule tea and its preparation method. *Chinese Invention Patent* 201910182401.6.

Chen, X. Q. (2021). Cultivation techniques of *Chenopodium* on plateau. *Agricultural Technology and Information*, 13, 62-63. http://dx.doi.org/10.15979/j.cnki.cn62-1057/s.2021.13.023.

Chen, Y. S., Shu, L. P., Xv, X. M., Chen, Z. Z., Hong, T. T., Huang, C. H., Wei, X., Chen, Q. F., & Jin, Y. M. (2020). Changes of bioactive substances and antioxidant properties of three kinds of quinoa during germination. *Food and Machinery*, 36(3), 34-38. http://dx.doi.org/10.13652/j.issn.1003-5788.2020.03.00.

Cui, J. H., Wei, Z. M., Liu, M., Zhao, Y., Song, S. J., Li, H. P., Xia, X. Y., & Li, S. G. (2019). Nutrition and potential of a new leafy vegetable quinoa. *Journal of Hebei Agricultural Sciences*, 23(2), 57-59. http://dx.doi.org/10.12148/hbnykx.20190070.

Dai, Q. Y., Ye, Y. J., An, Q., Zheng, F. L., Xiao, M. J., Xiao, M. X., Wang, H. Q., & Zhang, H. W. (2021). Sensory characteristics of yellow large leaf tea by quantitative descriptive analysis and construction of flavor wheel. *Chaye Kexue (China)*, 41(4), 535-544. http://dx.doi.org/10.13305/j.cnki.jts.2021.04.007.

Dong, J. L., An, S. S., Shen, R. L., & Zhu, Y. Y. (2021). Development of quinoa compound high fibrin beverage. *Food Industries*, 42(2), 151-154.

Dong, Y. H., Yao, R. Q., Zhao, J., Qin, Y. J., Li, Y. L., Ren, Y. K., Tang, C. H., Wang, Y. X., Zhao, X. H., Wang, F., & Cao, Q. F. (2015, September 28). A kind of high-yield and dense-planting method of quinoa and the preparation method for tea. *Chinese Invention Patent* 201510625766.3.

Escribano, J., Cabanes, J., Jiménez-Atiénzar, M., Ibañez-Tremolada, M., Gómez-Pando, L. R., García-Carmona, F., & Gandía-Herrero, F. (2017). Characterization of betalains, saponins and antioxidant power in differently colored quinoa (*Chenopodium quinoa*) varieties. *Food Chemistry*, 234, 285-294. http://dx.doi.org/10.1016/j.foodchem.2017.04.187. PMid:28551238.

Feng, Y. L., Luo, W., Sun, J. M., Ma, G. H., Shi, S. J., & Wei, Y. M. (2022). Optimization of extraction technology of quinoa protein. *Food Industries*, 43(3), 10-14.

Fu, R. X., Zhou, X. Y., Xiao, J. Z., Cui, Y., Wu, H. Q., & Rajasab, A. H. (2020). Effects of germination temperature and germination time on nutritional components of quinoa. *Food Industries*, 41(5), 341-345.

Fu, Z. M. (2005). Shortcomings and suggestions for improvement in sensory evaluation of tea. *Tea Processing in China*, (1), 16-17. http://dx.doi.org/10.15905/j.cnki.33-1157/ts.2005.01.009.

Gao, R., Li, Z. J., Qin, P. Y., & Zhou, B. W. (2019). Analysis of development and application potential of quinoa in China. *Feed Research*, 42(12), 77-80. http://dx.doi.org/10.13557/j.cnki.issn1002-2813.2019.12.022.

Han, R. S. (2018). *Study on preparation process of quinoa Chinese rice wine* (Master's dissertation). Jilin Agricultural University, Changchun city, China.

Han, Y., Chi, J., Zhang, M., Zhang, R., Fan, S., Dong, L., Huang, F., & Liu, L. (2019). Changes in saponins, phenolics and antioxidant activity of quinoa (*Chenopodium quinoa* willd.) during milling process. *Lebensmittel-Wissenschaft + Technologie*, 114, 108381. http://dx.doi.org/10.1016/j.lwt.2019.108381.

He, S. L., Lin, Y. D., Deng, R. Y., Xiong, J., Zhou, L. N., Luo, L. L., & Zhou, Y. F. (2020). Study on adaptability of quinoa substrate fermented

by Monascus. *Zhongguo Tiaoweipin (China)*, 45(3), 92-97. http://dx.doi.org/10.3969/j.issn.1000-9973.2020.03.020.

He, S. L., Lin, Y. D., Tian, D., Zhou, L. N., Zhao, X. L., Luo, L. L., & Liu, H. (2022b). Study on the compound technology and antioxidant activity of *Monascus*-quinoa fermented tea. *Cereals and Oils (China)*, 35(5), 143-146.

He, Y. N., Song, S. H., Li, C., Zhang, X. D., & Liu, H. J. (2022a). Effect of germination on the main chemical compounds and 5-methyltetrahydrofolate metabolism of different quinoa varieties. *Food Research International*, 159, 111601. http://dx.doi.org/10.1016/j.foodres.2022.111601. PMid:35940794.

Huang, J., Qin, L. K., Shi, Q. N., & Wen, A. Y. (2017). Effect of quinoa saponins extraction and sprouting on saponins content. *Journal of the Chinese Cereals and Oils Association*, 32(17), 34-39.

Huang, R. H., Huang, K., Guan, X., Zhang, J. H., & Zhang, P. (2022). Incorporation of defatted quinoa flour affects *in vitro* starch digestion, cooking and rheological properties of wheat noodles. *Journal of Cereal Science*, 108, 103542. http://dx.doi.org/10.1016/j.jcs.2022.103542.

Ji, C. H. (2021). *Brewing technology of quinoa beer and its flavor substance analysis* (Master's dissertation). Qilu University of Technology, Jinan city, China.

Jin, Q., Yang, F. R., Huang, J., Wei, Y. M., & Liu, W. Y. (2018). Progress in research, development and utilization of *Chenopodium quinoa* seed in China. *Agricultural Science-Technology and Information*, 10, 36-41. http://dx.doi.org/10.15979/j.cnki.cn62-1057/s.2018.10.014.

Johnson, J. B., Thani, P. R., & Naiker, M. (2022). Detection of eucalyptus oil adulteration in Australian tea tree oil using UV-Vis and fluorescence spectroscopy. *Talanta Open*, 6, 100169. http://dx.doi.org/10.1016/j.talo.2022.100169.

Kahlon, T. S., Avena-Bustillos, R. J., & Chiu, M.-C. M. (2016). Sensory evaluation of gluten-free quinoa whole grain snacks. *Heliyon*, 2(12), e00213. http://dx.doi.org/10.1016/j.heliyon.2016.e00213. PMid:28054034.

Kayisoglu, S., & Coskun, F. (2021). Determination of physical and chemical properties of kombucha teas prepared with different herbal teas. *Food Science and Technology*, 41(Suppl. 1), 393-397. http://dx.doi.org/10.1590/fst.12720.

Koch, I. S., Muller, M., Joubert, E., der Rijst, M., & Næs, T. (2012). Sensory characterization of rooibos tea and the development of a rooibos sensory wheel and lexicon. *Food Research International*, 46(1), 217-228. http://dx.doi.org/10.1016/j.foodres.2011.11.028.

Kordialik-Bogacka, E., Bogdan, P., & Ciosek, A. (2019). Effects of quinoa and amaranth on zinc, magnesium and calcium content in beer wort. *International Journal of Food Science & Technology*, 54(5), 1706-1712. http://dx.doi.org/10.1111/ijfs.14052.

Le, L. Q., Wang, Y., Xiang, D. B., Yuan, H., Guo, P., & Zhao, G. (2020). Development and process optimization of quinoa and chia seed powder. *Food Industries*, 41(8), 81-85.

Leland, E., Nigg, J., & Olds, D. (2020). The partial substitution of quinoa flour for rice flour in muffins. *Journal of the Academy of Nutrition and Dietetics*, 120(10), A125. http://dx.doi.org/10.1016/j.jand.2020.09.011.

Li, F. (2017, Oct 24). A kind of preparation method of baked quinoa tea. *Chinese Invention Patent* 201711003263.8.

Li, P. (2021). *Effect of air puffing on the quality of quinoa, process optimization and preparation of meal mixing powder* (Master's dissertation). Tianjin Agricultural University, Tianjin city, China.

Li, L. X., Wang, B. Y., Li, X. H., Zhang, J. X., & Zhang, X. F. (2021a). Analysis of quinoa tea aroma at different baking temperatures using electronic nose technology. *Food Research and Development*, 42(22), 110-116. http://dx.doi.org/10.12161/j.issn.1005-6521.2021.22.017.

Li, P., Zhao, J. Q., Yang, H. P., Zhou, X. Y., & Fu, R. X. (2021b). Effects of air puffing process parameters on nutrient composition and physicochemical property of quinoa. *Food Science and Technology (China)*, 46(12), 166-172. http://dx.doi.org/10.13684/j.cnki.spkj.2021.12.027.

Li, X., Chen, G. M., & Wang, M. Q. (2008). Development and utilization of tea-substituting plant resources in China. *Beverage Industry (China)*, 11(12), 4-6. Retrieved from https://kns.cnki.net/kns8/defaultresult/index

Liu, H. X. (2020). *Study on brewing technology of quinoa vinegar* (Master's dissertation). Shanxi Agricultural University, Taigu city, China.

Liu, Q., Ouyang, J., Liu, C., Chen, H., Li, J., Xiong, L., Liu, Z., & Huang, J. (2022b). Research progress of tea quality evaluation technology. *Chaye Kexue (China)*, 42(3), 316-330. http://dx.doi.org/10.13305/j.cnki.jts.20220416.001.

Liu, W., Tao, H. T., Qiu, B., Liu, L. N., Zong, A. Z., Jia, M., & Xu, T. C. (2019, May 7). A kind of quinoa malt health tea and its processing method. *Chinese Invention Patent* 201910374404.X.

Liu, Z. Y., Zhang, R. T., Yang, C. S., Hu, B., Luo, X., Li, Y., & Dong, C. W. (2022a). Research on moisture content detection method during green tea processing based on machine vision and near-infrared spectroscopy technology. *Spectrochimica Acta. Part A: Molecular and Biomolecular Spectroscopy*, 271, 120921. http://dx.doi.org/10.1016/j.saa.2022.120921. PMid:35091181.

Lorusso, A., Verni, M., Montemurro, M., Coda, R., Gobbetti, M., & Rizzello, C. G. (2017). Use of fermented quinoa flour for pasta making and evaluation of the technological and nutritional features. *Lebensmittel-Wissenschaft + Technologie*, 78, 215-221. http://dx.doi.org/10.1016/j.lwt.2016.12.046.

Lu, X. H., Wang, J., Lu, G. D., Lin, B., Chang, M. Z., & He, W. (2019). Quality level identification of West Lake Longjing green tea using electronic nose. *Sensors and Actuators. B, Chemical*, 301, 127056. http://dx.doi.org/10.1016/j.snb.2019.127056.

Luo, X. X. (2018). *Studies on the nutritional and functional compounds of quinoa tea and its antioxidant activity* (Master's dissertation). Chinese Academy of Agricultural Sciences, Beijing city, China. Retrieved from https://kns.cnki.net/kns8/defaultresult/index

Lv, W., Wei, Z. M., Lei, X. K., Li, Y. Y., Liu, Y. M., Xu, S. J., & Wang, X. (2019, Mar 26). A drying device for quinoa tea production. *Chinese Invention Patent* 201920387667.X.

Mäkinen, O. E., Zannini, E., & Arendt, E. K. (2013). Germination of oat and quinoa and evaluation of the malts as gluten free baking ingredients. *Plant Foods for Human Nutrition*, 68(1), 90-95. http://dx.doi.org/10.1007/s11130-013-0335-3. PMid:23386201.

Mei, Y., & Liang, X. (2022). Analysis of China's tea production and domestic sales in 2021. *China Tea*, 44(4), 17-22. Retrieved from https://kns.cnki.net/kns8/defaultresult/index

Meng, F.-B., Zhou, L., Li, J.-J., Li, Y.-C., Wang, M., Zou, L.-H., Liu, D.-Y., & Chen, W.-J. (2022). The combined effect of protein hydrolysis and *Lactobacillus plantarum* fermentation on antioxidant activity and metabolomic profiles of quinoa beverage. *Food Research International*, 157, 111416. http://dx.doi.org/10.1016/j.foodres.2022.111416.

Mu, J. L., Qi, Y. W., Gong, K. X., Chen, Z. Z., Brennan, M. A., Ma, Q. Y., Wang, J., Gen, Y. L., Lv, W., & Brennan, C. S. (2022). Influence of substituting wheat flour with quinoa flour on quality characteristics and *in vitro* starch and protein digestibility of fried-free instant noodles. *Lebensmittel-Wissenschaft + Technologie*, 165, 113686. http://dx.doi.org/10.1016/j.lwt.2022.113686.

Niu, Q., Li, J., Messia, M. C., Li, X., Zou, L., & Hu, X. (2022). Selenium and flavonoids in selenium-enriched tartary buckwheat roasted grain tea: their distribution and correlation to antioxidant activity. *Lebensmittel-Wissenschaft + Technologie*, 170, 114047. http://dx.doi.org/10.1016/j.lwt.2022.114047.

Obaroakpo, J. U., Liu, L., Zhang, S. W., Lu, J., Liu, L., Pang, X. Y., & Lv, J. P. (2020a). *In vitro* modulation of glucagon-like peptide release by DPP-IV inhibitory polyphenol-polysaccharide conjugates of sprouted quinoa yoghurt. *Food Chemistry*, 324, 126857. http://dx.doi.org/10.1016/j.foodchem.2020.126857.

Obaroakpo, J. U., Liu, L., Zhang, S., Jing, L., Liu, L., Pang, X., & Lv, J. (2020b). Bioactive assessment of the antioxidative and antidiabetic activities of oleanane triterpenoid isolates of sprouted quinoa yoghurt beverages and their anti-angiogenic effects on $HUVEC_S$ line. *Journal of Functional Foods*, 66, 103779. http://dx.doi.org/10.1016/j.jff.2020.103779.

Ou, Y. L., Zhang, Y. N., Qin, L., Miao, Y. C., & Xiao, L. Z. (2019). Research advances on quality evaluation methods of tea color, aroma and taste. *Science and Technology of Food Industry (China)*, 40(6), 342-347. http://dx.doi.org/10.13386/j.issn1002-0306.2019.06.059.

Quispe-Fuentes, I., Vega-Gálvez, A., Miranda, M., Lemus-Mondaca, R., Lozano, M., & Ah-Hen, K. (2013). A kinetic approach to saponin extraction during washing of quinoa (*Chenopodium quinoa* willd.) seeds. *Journal of Food Process Engineering*, 36(2), 202-210. http://dx.doi.org/10.1111/j.1745-4530.2012.00673.x.

Rahman, M. T., Ferdous, S., Jenin, M. S., Mim, T. R., Alam, M., & Al Mamun, M. R. (2021). Characterization of tea (*Camellia sinensis*) granules for quality grading using computer vision system. *Journal of Agriculture and Food Research*, 6, 100210. http://dx.doi.org/10.1016/j.jafr.2021.100210.

Schmöckel, S. M. (2021). *The quinoa genome.* Cham: Springer. http://dx.doi.org/10.1007/978-3-030-65237-1.

Sharma, S., Kataria, A., & Singh, B. (2022). Effect of thermal processing on the bioactive compounds, antioxidative, antinutritional and functional characteristics of quinoa (*Chenopodium quinoa*). *Lebensmittel-Wissenschaft + Technologie*, 160, 113256. http://dx.doi.org/10.1016/j.lwt.2022.113256.

Shi, X. D., Hong, R., Lin, L. Z., Wang, X. Y., Li, Y. J., Wang, C., & Niu, B. (2022). Comprehensive characterization in different types of tartary buckwheat tea based on intelligent sensory technology. *Food Science and Technology*, 42, e27222. http://dx.doi.org/10.1590/fst.27222.

Spencer, M., Sage, E., Velez, M., & Guinard, J.-X. (2016). Using single free sorting and multivariate exploratory methods to design a new coffee taster's flavor wheel. *Journal of Food Science*, 81(12), S1-S9. http://dx.doi.org/10.1111/1750-3841.13555.

Sriharti, Andriansyah, R. C. E., Agustina, W., Indriati, A., Litaay, C., Luthfiyanti, R., Mayasti, N. K. I., Triyono, A., Tribowo, R. I., & Purwandoko, P. B. (2022). Optimization of herbal tea drink formula based on aloe vera rind (*Aloe barbadensis miller*). *Food Science and Technology*, 42, e69022. http://dx.doi.org/10.1590/fst.69022.

Starzyńska-Janiszewska, A., Duliński, R., Stodolak, B., Mickowska, B., & Wikiera, A. (2016). Prolonged tempe-type fermentation in order to improve bioactive potential and nutritional parameters of quinoa seeds. *Journal of Cereal Science*, 71, 116-121. http://dx.doi.org/10.1016/j.jcs.2016.08.001.

Stoleru, V., Jacobsen, S.-E., Vitanescu, M., Jitareanu, G., Butnariu, M., Munteanu, N., Stan, T., Teliban, G. C., Cojocaru, A., & Mihalache, G. (2022). Nutritional and antinutritional compounds in leaves of quinoa. *Food Bioscience*, 45, 101494. http://dx.doi.org/10.1016/j.fbio.2021.101494.

Suárez-Estrella, D., Borgonovo, G., Buratti, S., Ferranti, P., Accardo, F., Pagani, M. A., & Marti, A. (2021). Sprouting of quinoa (*Chenopodium quinoa* Willd.): effect on saponin content and relation to the taste and astringency assessed by electronic tongue. *Lebensmittel-Wissenschaft + Technologie*, 144, 111234. http://dx.doi.org/10.1016/j.lwt.2021.111234.

Suárez-Estrella, D., Cardone, G., Buratti, S., Pagani, M. A., & Marti, A. (2020). Sprouting as a pre-processing for producing quinoa-enriched bread. *Journal of Cereal Science*, 96, 103111. http://dx.doi.org/10.1016/j.jcs.2020.103111.

Suárez-Estrella, D., Torri, L., Pagani, M. A., & Marti, A. (2018). Quinoa bitterness: causes and solutions for improving product acceptability. *Journal of the Science of Food and Agriculture*, 98(11), 4033-4041. http://dx.doi.org/10.1002/jsfa.8980. PMid:29485194.

Sun, N. (2018a, August 30). Preparation method of quinoa tea. *Chinese Invention Patent* 201811001309.7.

Sun, F. (2018b). Study on the production technology of quinoa biscuit. *Cereals and Oils (China)*, 31(1), 49-52.

Uğur, H., Çatak, J., Özgür, B., Efe, E., Görünmek, M., Belli, İ., & Yaman, M. (2022). Effects of different polyphenol-rich herbal teas on reducing predicted glycemic index. *Food Science and Technology*, 42, e03022. http://dx.doi.org/10.1590/fst.03022.

Valenzuela-González, M., Rouzaud-Sández, O., Ledesma-Osuna, A. I., Astiazarán-García, H., Salazar-López, N. J., Vidal-Quintanar, R. L., & Robles-Sánchez, M. (2022). Bioaccessibility of phenolic compounds, antioxidant activity, and consumer acceptability of heat-treated quinoa cookies. *Food Science and Technology*, 42, e43421. http://dx.doi.org/10.1590/fst.43421.

Villacrés, E., Quelal, M. B., Fernández, E., Garcìa, G., Cueva, G., & Rosell, C. M. (2020). Impact of debittering and fermentation processes on the antinutritional and antioxidant compounds in *Lupinus mutabilis* sweet. *Lebensmittel-Wissenschaft + Technologie*, 131, 109745. http://dx.doi.org/10.1016/j.lwt.2020.109745.

Wang, J. L. (2017, July 11). Active quinoa whole plant bag tea and its preparation method. *Chinese Invention Patent* 201710561576.9.

Wang, S. Q., Gan, Z. T., Wang, B. C., Zhang, N., Li, K., & Yao, T. (2022a). Effect of brewing conditions on polyphenols in the dark tea (*Camellia sinensis L.*) infusions: content, composition and antioxidant activities. *Food Science and Technology*, 42, e36322. http://dx.doi.org/10.1590/fst.36322.

Wang, B., Meng, Q., Xiao, L., Li, R. L., Peng, C. H., Liao, X. L., Yan, J. N., Liu, H. L., Xie, G. H., Ho, C.-T., & Tong, H. R. (2022b). Characterization of aroma compounds of Pu-erh ripen tea using solvent assisted flavor evaporation coupled with gas chromatography-mass spectrometry and gas chromatography-olfactometry. *Food Science and Human Wellness*, 11(3), 618-626. http://dx.doi.org/10.1016/j.fshw.2021.12.018.

Wei, L. J. (2019). *Processing technology of quinoa (Chenopodium quinoa willd) noodle and tea* (Master's dissertation). Chengdu University, Chengdu city, China.

Wen, H. Y. (2020). Industrial economy of global tea and its development trend. *New Agriculturist (China)*, 17, 27-28.

Weng, W. (2021). An overview of China's tea market in 2020 and the first half of 2021. *China Tea*, 43(9), 74-76.

Xing, B., Zhang, Z., Zhu, M. L., Teng, C., Zou, L., Liu, R., Zhang, L. Z., Yang, X. S., Ren, G. X., & Qin, P. Y. (2023). The gluten structure, starch digestibility and quality properties of pasta supplemented with native or germinated quinoa flour. *Food Chemistry*, 399, 133976. http://dx.doi.org/10.1016/j.foodchem.2022.133976. PMid:35998497.

Xing, Y. H. (2019, December 30). Quinoa tea with shell and its production method. *Chinese Invention Patent* 201911399463.9.

Yan, S., Liu, X. X., Feng, C. P., Chen, Z. J., Yun, S. J., & Wang, X. W. (2018). Effects of hydrothermal treatments on the functional properties of quinoa protein. *Food Industries*, 39(3), 39-43.

Yang, J. B., Liu, X. J., & Wang, L. L. (2014, October 27). Quinoa tea and its preparation method. *Chinese Invention Patent* 201410580224.4.

Yang, N., Pan, S. M., Xv, Y., Jin, Y. M., Xv, X. M., Wu, F. F., Zhou, X., He, X. Y., Qian, H. D., & Dai, W. J. (2020, March 3). A method of improving γ-aminobutyric acid of germinated quinoa by magnetic field. *Chinese Invention Patent* 202010138416.5.

Ye, Y. J., An, Q., & Dai, Q. Y. (2021). Application of sensory evaluation analysis in tea. *Journal of Tea Business (China)*, 43(3), 115-119. http://dx.doi.org/10.16015/j.cnki.jteabusiness.2021.0029.

Zhang, Y. P., Zhang, T., Shi, Y. H., Yuan, Y. H., & Yue, T. L. (2019a). Optimization of processing conditions and phenolic composition analysis of quinoa tea. *Shipin Kexue (China)*, 40(12), 267-274. http://dx.doi.org/10.7506/spkx1002-6630-20180727-331.

Zhang, W. G., Zhang, J., Dang, B., & Yang, X. J. (2019b). Optimization on fermentation conditions and the antioxidant characteristics of Chinese quinoa rice wine. *Food and Machinery (China)*, 35(12), 174-178. http://dx.doi.org/10.13652/j.issn.1003-5788.2019.12.032.

Zhang, Y. B., Liu, X., & Lu, C. Y. (2019c). Study on primitive morpheme in sensory terminology and flavor wheel construction of Chinese tea. *Chaye Kexue*, 39(4), 474-483. http://dx.doi.org/10.13305/j.cnki.jts.20190530.001.

Zhang, M. M., Otake, K., Miyauchi, Y., Yagi, M., Yonei, Y., Miyakawa, T., & Tanokura, M. (2019d). Comprehensive NMR analysis of two kinds of post-fermented tea and their anti-glycation activities *in vitro*. *Food Chemistry*, 277, 735-743. http://dx.doi.org/10.1016/j.foodchem.2018.11.028. PMid:30502210.

Zhang, W. G., Lan, Y. J., Zhao, M. M., Dang, B., & Yang, X. J. (2020). Optimization of processes for γ-aminobutyric acid enrichment in germinated quinoa under co-treatment of sodium glutamate and ascorbic acid and its cholate adsorption capacity. *Science and Technology of Food Industry (China)*, 41(9), 144-149. http://dx.doi.org/10.13386/j.issn1002-0306.2020.09.023.

Zhang, D. (2021). Study on the production technology of quinoa and soybean polypeptide compound beverage. *Grains and Oils*, 34(8), 85-87.

Zhang, W. L., Yu, N. N., Qing, J., & Zhang, J. P. (2021a). Development and process optimization of quinoa meal replacement biscuits. *Food Industries*, 42(12), 95-98.

Zhang, M., Yu, J., Wang, Q. Y., Zhang, J. C., You, X. T., Yao, M. J., & Ma, C. J. (2021b). The quantitative analysis of the sensory characteristics of vine tea and the construction of flavor wheel. *Shipin Yu Fajiao Gongye*, 47(8), 134-139. http://dx.doi.org/10.13995/j.cnki.11-1802/ts.025759.

Zhang, W. G., Lan, Y. L., & Dang, B. (2022). Effect of different processing methods on the volatile flavor substances of quinoa. *Journal of the Chinese Cereals and Oils Association*. In press. Retrieved from https://kns.cnki.net/kcms/detail/11.2864.ts.20220410.1237.004.html

Zhou, B. X., Ma, B. S., Xu, C. C., Wang, J. C., Wang, Z. H., Huang, Y. Y., & Ma, C. Q. (2022). Impact of enzymatic fermentation on taste, chemical compositions and *in vitro* antioxidant activities in Chinese teas using E-tongue, HPLC and amino acid analyzer. *Lebensmittel-Wissenschaft + Technologie*, 163, 113549. http://dx.doi.org/10.1016/j.lwt.2022.113549.

Zhou, X. Y., Yu, X., Yang, L. Y., Wei, Z. F., Zhang, L. H., & Gao, J. Q. (2023). A new method for preparing the instant quinoa grain by piecewise gelatinization. *Food Science and Technology*, 43, e106822.

Zhou, X. Y., Yang, H. P., Fu, R. X., Xiao, J. Z., & Li, R. Q. (2021). Effects of cultivation methods on biomass and nutritional composition of quinoa seedlings. *China Seed Industry*, 11, 75-78. http://dx.doi.org/10.19462/j.cnki.1671-895x.2021.11.023.

Zhou, Y. H. (2018). *Analysis of nutrient composition of quinoa seedlings and development of quinoa green tea* (Master's dissertation). Jilin Agricultural University, Changchun city, China.