Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.45922

Effects of cooking method and storage temperature on quality of three green vegetable semi-finished products

Dongmei YANG[1], Guoping REN[1*], Xingyi ZHU[2]

Abstract

Green vegetable semi-finished products (SFP) are deeply welcomed in daily life, but their quality will change during cooking and storage. This study investigated the effects of cooking method and storage temperature on quality of three green vegetable SFP. Fresh broccoli, green pepper and French bean were selected as research materials. They were blanched, microwaved and stir-fried to prepare the SFP, respectively. Then, the SFP were stored at 4 °C and 20 °C for seven days, respectively. The sensory score, weightlessness rate and chlorophyll content were determined. Results indicate that, the comprehensive quality of three green vegetable SFP shows a downward trend during the storage. The cooking method and storage temperature have significant effect on the quality.

Keywords: green vegetable; semi-finished products; cooking method; storage; quality.

Practical Application: This study may provide a reference for processing and storage of green vegetable semi-finished products.

1 Introduction

With the development of society, the life pace of people is faster and faster, especially for the young people who are in the career rising period and have an unprecedented sense of time pressure. Therefore, all kinds of products that can improve the life happiness through simple operations are highly sought in the market. Food is the most important thing for the people. Food semi-finished products (SFP) are a variety of foods processed by standardized operation process and quantitative mechanical automation technology. They can meet the nutritional needs of people, and solve the problems of tight time and inability to cook (Makhoul et al., 2016; Rodolfi et al., 2022). Food SFP include vegetables, meats, soups, fruits, etc. Recently, affected by the COVID-19, many people have reduced their outdoor activities, and the food SFP have become a new favorite in the catering market (Kuang et al., 2020).

Green vegetables are the main components in prefabricated dishes. However, they are easy to lose their bright green and form brown when heated in the central kitchen. In addition, the cooling, transportation and reheating will not only cause the chlorophyll degradation, but also cause the increase of nitrite content, resulting in the decline of consumers' appetite and the safety (Heaton & Marangoni, 1996; Bahadoran et al., 2016). Broccoli, green pepper and French bean are the green vegetable deeply loved by the public due to good color, texture and nutrient (Kumar et al., 2020; Ríos-Fuentes et al., 2022; Zhang et al., 2022), and they are very suitable for food SFP. However, there is no study on the quality changes of these three green vegetable SFP during cooking and storage. Therefore, this study investigated the effects of cooking method and storage temperature on quality of these three green vegetable SFP, in order to provide a theoretical basis for their processing and transportation.

2 Materials and methods

2.1 Materials and instruments

Fresh broccoli, green pepper and French bean were purchased from RT-Mart supermarket in Xihu District, Hangzhou (China). 722-G visible spectrophotometer was provided by Shanghai Yidian Analytical Instrument Co., Ltd., (Shanghai, China). G70D0CSP-D2(SO) microwave oven and CH21203D induction cooker were purchased from Guangdong Galanz Living Appliance Manufacturing Co., Ltd., (Foshan, China). Acetone, sodium hydroxide, zinc acetate, glacial acetic acid, sodium nitrite, phenolphthalein, hydrochloric acid, diethylenediamine hydrochloride, p-sminobenzene sulfonic acid, sodium tetraborate, phthalic acid, potassium ferrocyanide and other reagent were provided by Sinopharm Chemical Reagent Co., Ltd. (Shanghai, China).

2.2 Cooking methods of vegetables

Blanched cooking

Under the conditions of normal temperature and normal pressure (induction cooker power, 2100 w), 100 g of pretreated vegetables (broccoli, green pepper and French beans) were placed in 4 kg of boiling distilled water for treatment for 130 s.

Received 29 Mar., 2022
Accepted 30 May, 2022
[1] Department of Health Rehabilitation and Tourism, Hangzhou Wanxiang Polytechnic, Hangzhou, China
[2] College of Pharmaceutical Sciences, Zhejiang University of Technology, Hangzhou, China
*Corresponding author: renguopingwx@163.com

Microwaved cooking

Under microwave power of 700 W, 15 g of distilled water was added to the microwave bowl containing 100 g of pretreated vegetables, followed by sealing the microwave bowl using preservative film. The microwave treatment was performed for 150 s.

Stir-fried cooking

A 10 g of corn oil was added to the dry pan. After heating on induction cooker with 1300 W power for 40 s, 100 g of pretreated vegetables was added to the pan, followed by stir-frying for 100 s.

2.3 Storage temperature experiments

The cooked vegetables were cooled using cold water. Then, they were stored at low temperature (4 °C) and room temperature (20 °C) for seven days, respectively. At different time point, the quality of vegetables was evaluated.

2.4 Evaluation of sensory score

The sensory score of vegetable SFP was evaluated using ten-point scale. The scale contented four items including color, texture, flavor and decay rate. The score of each item was ranked into four grades: 2.5 points, 2 points, 1 point and 0 point. The total score of four items was taken as the final evaluation result (Table 1).

2.5 Determination of weightlessness rate

At different time point of storing, the vegetable SFP were weighed. The weightlessness rate was calculated as follows: weightlessness rate (%) = [(weight before storing - weight after storing)/(weight before storing] × 100.

2.6 Determination of nitrite content

At different time point of storing, the nitrite content of vegetable SFP was determined by spectrophotometry. A 50 g of vegetable SFP sample and 50 g of distilled water were added to the tissue homogenizer, followed by homogenizing for 5 min. A 15 g of homogenate solution was taken, and added by 12.5 mL of saturated borax solution and 150 mL of 70 °C water. After fully mixing, the mixture was heated by boiling-water bathing for 15 min, followed by cooling to room temperature. A 5 mL of 106 g/L potassium ferrocyanide solution and 5 mL of 220 g/L zinc acetate solution were added the above mixture, followed by fixing the volume to 200 mL using water. After standing for 30 min, the upper fat was removed, and the supernatant was filtered. A 40 mL of filtrate was taken, and added to 50 mL colorimetric tube, followed by adding 2 mL of 4 g/L p-aminobenzene sulfonic acid, 1 mL of 2 g/L neethylenediamine hydrochloride and appropriate amount of water to the scale mark. After mixing well, the mixture stood for 15 min. The optical density was measured at wavelength of 538 nm in the visible spectrophotometer. The nitrite content in vegetables was calculated according to the standard curve of nitrite.

2.7 Determination of chlorophyll content

At different time point of storing, the chlorophyll content of vegetable SFP was determined by spectrophotometry. A 50 g of vegetable sample and 50 g of distilled water were added to the tissue homogenizer, followed by homogenizing for 5 min. A 2 g of homogenate solution was taken, and added by 10 mL of ethanol-acetone mixture (1: 1) and appropriate amount of water to 50 mL. After standing for 5 h, the mixture was filtered, and the supernatant was taken. The optical density of supernatant was measured at 645 nm in visible spectrophotometer, respectively. The content of chlorophyll in vegetable SFP was calculated according to the standard curve.

3 Results and discussion

3.1 Effects of cooking method and storage temperature on sensory score of vegetable SFP

Sensory quality of food is very important for raising the appetite of consumers (Acu et al., 2021; Tan et al., 2022). The sensory score is also an important parameter of vegetables (Lignou et al., 2014; Owureku-Asare et al., 2021). As shown in Figure 1, the sensory score of all vegetable SFP showed a downward trend during storage. On the day 1 and day 2, there was no significant difference of sensory score of each vegetable SFP between storage temperature 0 °C and 20 °C, respectively. On day 3 of storing at 20 °C, the vegetable SFP were seriously rotten. The sensory score of vegetable SFP stored at 4 °C showed a slow downward trend. From day 2, the sensory score of vegetable SFP stored at 4 °C was significantly higher than that stored at 20 °C. On day 7, there was serious decay. Under the same cooking method and storage environment, the variety of vegetables will also affect the storage effect. For example, in this experiment, the score of broccoli in the two treatments is significantly higher than that of green pepper and green knife bean on the days, and this trend is basically maintained in other storage times.

3.2 Effects of cooking method and storage temperature on weightlessness rate of vegetable SFP

Water retention is a significant parameter in food storage (Isola et al., 2022). For fresh vegetables, the weightlessness rate is one of the main indicators to reflect their freshness. It can

Table 1. Sensory scoring standard of vegetable semi-finished products.

Item	2.5 points	2 points	1 point	0 point
Color	Completely green	10% yellow	30% yellow	Completely yellow
Texture	Extremely brittle	Slightly brittle	Slightly soft	Extremely soft
Flavor	Unique fragrance	No fragrance	Mild odor	Obvious putrid smell
Decay rate	No decay	< 5% decay	5%-20% decay	> 20% decay

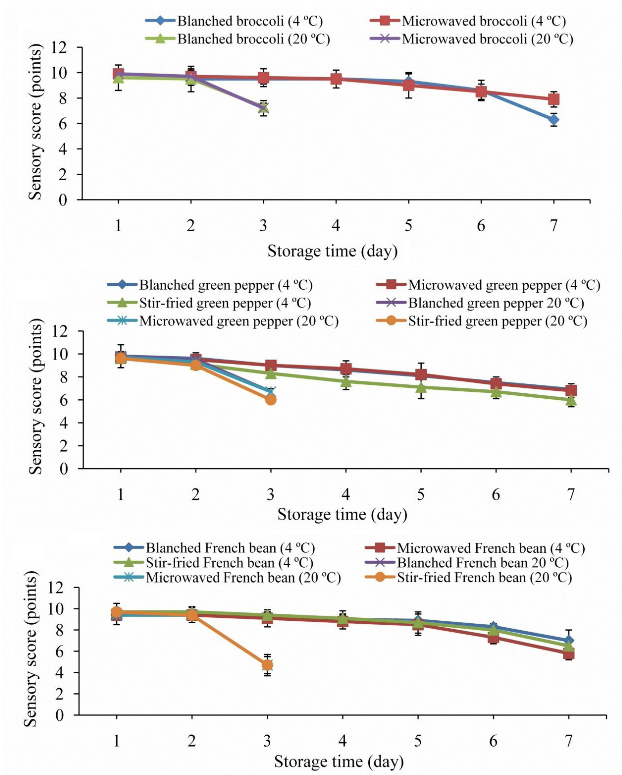

Figure 1. Effects of cooking method and storage temperature on sensory score of vegetable semi-finished products.

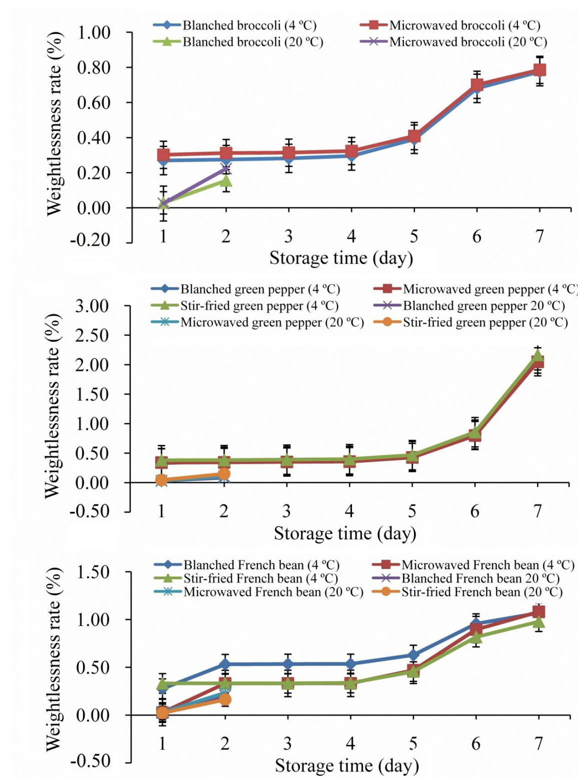

Figure 2. Effects of cooking method and storage temperature on weightlessness rate of vegetable semi-finished products.

also reflect the edible value of cooked prefabricated dishes (Greule et al., 2015). Figure 2 showed that, with the extension of storage time, the weightlessness rate of all vegetable SFP was increasing. On day 1, the weightlessness rate of all vegetable SFP under storage temperature 4 °C was higher than that under 20 °C. The reason for this needed to be further explored. The cooking method had little effect on the weightlessness rate for the same vegetable SFP under the same storage temperature. Moreover, the influence of vegetable kinds on the weightlessness rate was not great.

3.3 Effects of cooking method and storage temperature on nitrite content of vegetable SFP

Human body is poisoned or died due to ingestion of a large amount of nitrite in vegetables (Lidder & Webb, 2013). As shown in Figure 3, with the extension of storage time, the nitrite content showed an upward trend. Nitrate in vegetables can be reduced to nitrite under the action of nitrate reducing bacteria. With the extension of storage time, more nitrite is produced (Denktas et al., 2021). The nitrite content of each vegetable SFP stored at 4 °C was lower than that at 20 °C. Under low temperature, not only the metabolism of vegetables is reduced, but also the activities of microorganisms such as molds and bacteria are inhibited, which reduces the rate of nitrate to nitrite (Duan et al., 2020). No matter the storage temperature, the nitrite content in blanched broccoli was higher than that in microwaved broccoli.

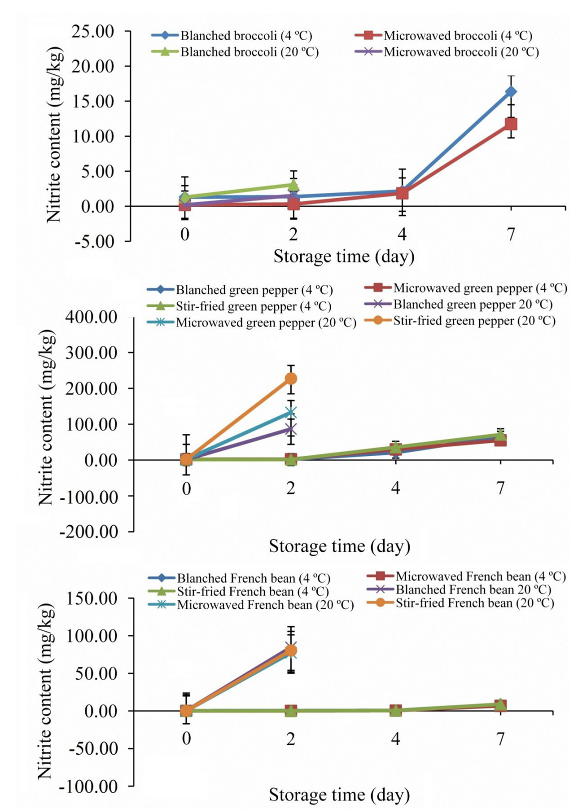

Figure 3. Effects of cooking method and storage temperature on nitrite content of vegetable semi-finished products.

3.4 Effects of cooking method and storage temperature on chlorophyll content of vegetable SFP

Color of green vegetables is the symbol of quality, and the factor producing green is the chlorophyll. When green vegetables are cooked or exposed to acid, the chlorophyll is destroyed, which changes the color (Li et al., 2022). The chlorophyll content is an important index of vegetables (Coswosck et al., 2021). Figure 4 showed that, with the extension of storage time, the chlorophyll content showed a downward. This is due to the decomposition of chlorophyll during storage (Makino & Amino, 2020). The degradation trend of chlorophyll under storage temperature 4 °C was relatively slower than that under storage temperature 20 °C. This was consistent with the change trend of sensory score, weightlessness rate and nitrite content.

It is found that different cooking methods have different effects on chlorophyll content of vegetables, which may be due to different energy transfer mechanisms caused by different processing methods (Chen & Roca, 2019). In this study, under storage temperature 4 °C, the chlorophyll degradation rate of stir-fried green pepper and French bean after was the fastest, while that of microwaved green pepper and French bean was the slowest. On day 2, the chlorophyll content of three treated green pepper decreased greatly, which was consistent with the change trend of sensory score.

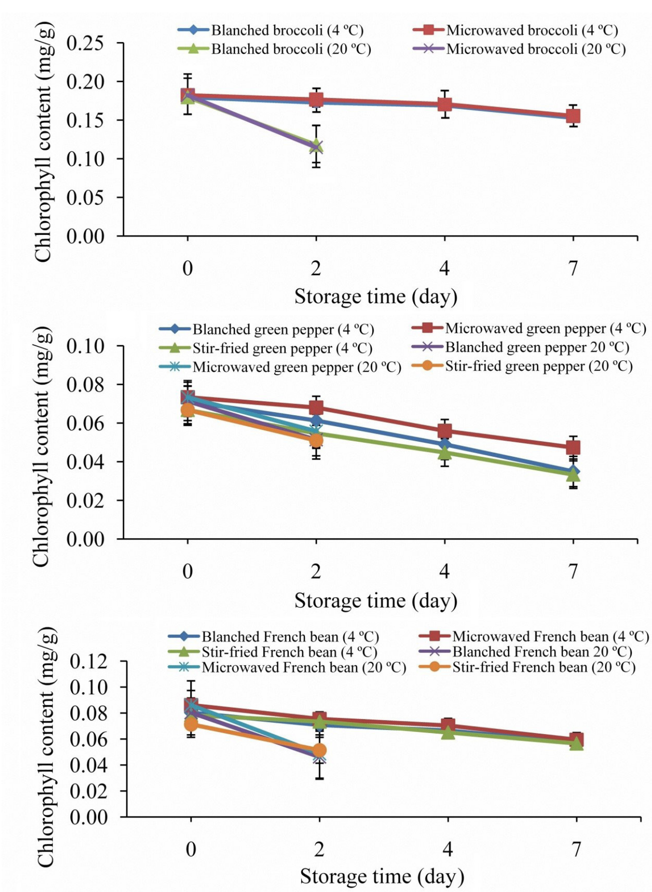

Figure 4. Effects of cooking method and storage temperature on chlorophyll content of vegetable semi-finished products.

4 Conclusions

In conclusion, the comprehensive quality of three green vegetable SFP shows a downward trend during the storage. The cooking method and storage temperature have significant effect on the quality.

Acknowledgements

This work was supported by A Project Supported by Scientific Research Fund of Zhejiang Provincial Education Department (Z32020004) and Hangzhou Scientific Research and Innovation Team Construction: Innovation Team for Accurate Detection and Management of Ecological Environment, 2019.

References

Acu, M., Kinik, O., & Yerlikaya, O. (2021). Probiotic viability, viscosity, hardness properties and sensorial quality of synbiotic ice creams produced from goat's milk. *Food Science and Technology*, 41(1), 167-173. http://dx.doi.org/10.1590/fst.39419.

Bahadoran, Z., Mirmiran, P., Jeddi, S., Azizi, F., Ghasemi, A., & Hadaegh, F. (2016). Nitrate and nitrite content of vegetables, fruits, grains, legumes, dairy products, meats and processed meats. *Journal of Food Composition and Analysis*, 51, 93-105. http://dx.doi.org/10.1016/j.jfca.2016.06.006.

Chen, K., & Roca, M. (2019). Cooking effects on bioaccessibility of chlorophyll pigments of the main edible seaweeds. *Food Chemistry*, 295, 101-109. http://dx.doi.org/10.1016/j.foodchem.2019.05.092. PMid:31174738.

Coswosck, K. H. C., Giorgette, M. A., Lepaus, B. M., Silva, E. M. M., Sena, G. G. S., Azevedo, M. C. A., & José, J. F. B. S. (2021). Impact of alternative sanitizers on the physicochemical quality, chlorophyll content and bioactive compounds of fresh vegetables. *Food Science and Technology*, 41(2), 328-334. http://dx.doi.org/10.1590/fst.02320.

Denktas, S., Yalcin, S., Kayaardi, S., & Sevik, R. (2021). Effect of starter culture type, cooking process and storage time at -18 °C on chemical, color and microbiological qualities of fermented sucuk doner kebab. *Food Chemistry*, 354, 129549. http://dx.doi.org/10.1016/j.foodchem.2021.129549. PMid:33770562.

Duan, P., Zhang, Q., & Xiong, Z. (2020). Temperature decouples ammonia and nitrite oxidation in greenhouse vegetable soils. *The Science of the Total Environment*, 733, 139391. http://dx.doi.org/10.1016/j.scitotenv.2020.139391. PMid:32446093.

Greule, M., Rossmann, A., Schmidt, H. L., Mosandl, A., & Keppler, F. (2015). A stable isotope approach to assessing water loss in fruits and vegetables during storage. *Journal of Agricultural and Food Chemistry*, 63(7), 1974-1981. http://dx.doi.org/10.1021/jf505192p. PMid:25674668.

Heaton, J. W., & Marangoni, A. G. (1996). Chlorophyll degradation in processed foods and senescent plant tissues. *Trends in Food Science & Technology*, 7(1), 8-15. http://dx.doi.org/10.1016/0924-2244(96)81352-5.

Isola, L. A., Mahmood, M. H., Yousif, A. Y., Al-Shawi, S. G., Abdelbasset, W. K., Bokov, D. O., & Thangavelu, L. (2022). A review on fermented aquatic food storage quality based on heat treatment and water retention technology. *Food Science and Technology*, 42, e77321. http://dx.doi.org/10.1590/fst.77321.

Kuang, Y., Shen, M., Wang, Q., Xiao, Y., Lv, C., Luo, Y., Zhu, W., & Chen, X. (2020). Association of outdoor activity restriction and income loss with patient-reported outcomes of psoriasis during the

COVID-19 pandemic: a web-based survey. *Journal of the American Academy of Dermatology*, 83(2), 670-672. http://dx.doi.org/10.1016/j.jaad.2020.05.018. PMid:32407741.

Kumar, R., Deka, B. C., Kumawat, N., & Anbazhagan, T. (2020). Effect of integrated nutrition on productivity, profitability and quality of French bean (Phaseolus vulgaris). *Indian Journal of Agricultural Sciences*, 90(1), 431-435.

Li, F., Zhou, L., Cao, J., Wang, Z., Liao, X., & Zhang, Y. (2022). Aggregation induced by the synergy of sodium chloride and high-pressure improves chlorophyll stability. *Food Chemistry*, 366, 130577. http://dx.doi.org/10.1016/j.foodchem.2021.130577. PMid:34293542.

Lidder, S., & Webb, A. J. (2013). Vascular effects of dietary nitrate (as found in green leafy vegetables and beetroot) via the nitrate-nitrite-nitric oxide pathway. *British Journal of Clinical Pharmacology*, 75(3), 677-696. http://dx.doi.org/10.1111/j.1365-2125.2012.04420.x. PMid:22882425.

Lignou, S., Parker, J. K., Baxter, C., & Mottram, D. S. (2014). Sensory and instrumental analysis of medium and long shelf-life Charentais cantaloupe melons (Cucumis melo L.) harvested at different maturities. *Food Chemistry*, 148(100), 218-229. http://dx.doi.org/10.1016/j.foodchem.2013.10.045. PMid:24262549.

Makhoul, S., Yener, S., Khomenko, I., Capozzi, V., Cappellin, L., Aprea, E., Scampicchio, M., Gasperi, F., & Biasioli, F. (2016). Rapid non-invasive quality control of semi-finished products for the food industry by direct injection mass spectrometry headspace analysis: the case of milk powder, whey powder and anhydrous milk fat. *Journal of Mass Spectrometry*, 51(9), 782-791. http://dx.doi.org/10.1002/jms.3801. PMid:27628758.

Makino, Y., & Amino, G. (2020). Digitization of broccoli freshness integrating external color and mass loss. *Foods*, 9(9), 1305. http://dx.doi.org/10.3390/foods9091305. PMid:32947874.

Owureku-Asare, M., Oduro, I., Agyei-Amponsah, J., Saalia, F. K., Tortoe, C., Ambrose, R. P. K., & Adjei, M. Y. B. (2021). Sensory profiling and consumer evaluation of solar dried tomato powder in Ghana. *Journal of the Science of Food and Agriculture*. Ahead of print. http://dx.doi.org/10.1002/jsfa.11707. PMid:34873683.

Ríos-Fuentes, B., Rivas-García, P., Estrada-Baltazar, A., Rico-Martínez, R., Miranda-López, R., & Botello-Álvarez, J. E. (2022). Life cycle assessment of frozen broccoli processing: Environmental mitigation scenarios. *Sustain Prod Consump.*, 32, 27-34. http://dx.doi.org/10.1016/j.spc.2022.04.001.

Rodolfi, M., Rinaldi, M., Caligiani, A., Paciulli, M., Lolli, V., Chiancone, B., & Ganino, T. (2022). Hop green sprouts preservation and valorisation as semi-finished and finished products: impact of different treatments on microstructural, physical and chemical traits. *European Food Research and Technology*, 248(5), 1203-1215. http://dx.doi.org/10.1007/s00217-021-03956-y.

Tan, C., Li, J. X., Xu, C., Meng, H. W., & Feng, Y. (2022). Effects of raw materials proportions on the sensory quality and antioxidant activities of apple/berry juice. *Food Science and Technology*, 42, e37621. http://dx.doi.org/10.1590/fst.37621.

Zhang, J., Xie, C., Cao, L. W., Zhou, H., Li, C. S., & Wang, L. H. (2022). Determination of physical and interaction parameters of green pepper (Zanthoxylum armatum): Investigation of the mechanism of significant factors against the repose angle. *LWT*, 162, 113409. http://dx.doi.org/10.1016/j.lwt.2022.113409.