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Chinese young people's perceptions and preferences with regard to various edible urban plants

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The World Health Organization (WHO) defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 2017), and mental health is defined as not only the absence of mental illness, but also the presence of psychological well-being. An expanding body of evidence highlights the relationship between nature (such as urban greenspace) and health (Li et al., 2019; Flaxman et al., 2020). However, human development and subsequent effects such as climate change and epidemic disease (COVID-19) lead to altered living environments and lifestyles. Expanding cities and urban residents have inequitable access to nature, particularly in areas of greater deprivation, where both public and private greenspaces are less available (Feng et al., 2021). In addition, young people spend more than 80% of their time indoors due to constant use of electronic devices for work, study, and entertainment (Klepeis et al., 2001). Mobile phones, personal computers, and video-game devices have become the main means for them to release stress. Excessive use of these electronic devices may affect normal brain activity, increasing the risk of Internet addiction and producing a range of physical and mental problems (Tran et al., 2017). These signal the pressing need for scientific investigation of efficient and convenient ways to increase contact with

nature, or alternatively, to better regulate emotions indoors.

Since plants are often the predominant elements in nature and public greenspace, people long ago introduced plants into the indoor environment. A growing body of literature has shown that plants and activities related to them can positively affect human emotional, physical, and social functions (Zuo et al., 2020; Poortinga et al., 2021). The traditional view is that because the environments where we would naturally live are rich in plants, we often exhibit positive psychological and physiological responses to them (Soga et al., 2017). Stress-recovery theory holds that viewing nature evokes a rapid emotional response (affect), which influences physical and psychological functions related to arousal (van den Bogerd et al., 2021). Plants can improve human psychological and physiological responses through the scenery formed by their colors and shapes, as well as the fragrance and negative oxygen ions they release; different intervention effects are produced by plants with different characteristics (Jang et al., 2014; Song et al., 2016). Therefore, scientists began to investigate people's preferences, attitudes, and ideas about various plants in order to use plants more effectively for their mental welfare. Furthermore, there are always considerable interindividual differences in emotion regulation (Weber et al., 2008). It was proposed that intervention with plants might be strongly linked to demographic information such as gender or education level, but this question remains unanswered.

Compared with ornamental plants, edible plants may be more suitable for home gardens and indoor cultivation in terms of benefitting the mental and physical

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health of people who cannot frequently access open greenspace. Edible plants, especially the dwarf leafy and fruiting plants (L&F), not only provide natural sensory stimulation through sight and smell, but also produce fresh vegetables and fruits for people in small spaces, and give them a sense of fulfillment in harvesting. Preliminary research by our group confirmed that L&F significantly improved young peoples' negative emotions, whether indoors or in isolated environments, and that large interindividual differences existed as well (Li et al., 2020, 2022; Zhang et al., 2021).

Here, we conducted a cross-sectional study to better understand youth perceptions and preferences with regard to some common dwarf leafy and fruiting edible plants. We investigated the relationship between respondents' preferences and their characteristics, such as gender, education level, plant knowledge, and plant-cultivation experience, and also explored the sensory reasons for their preferences through an online questionnaire based on plant characteristics such as color, shape, taste, and smell (Table S1). Twenty-two species of dwarf edible plants were presented in the questionnaire, with pictures of them at the harvest (leafy vegetables) or flowering and fruiting (fruiting vegetables) stages (Fig. S1). The results should provide a new basis for application of dwarf L&F in constructing biophilic environments to improve people's mental health in urban greenspace.

Four hundred and eighty-six participants from Beijing, China, made up the population of this study. Respondent demographics, such as gender, age, and education level, are summarized in Table 1. The respondents comprised 207 males (42.6%) and 279 females

(57.4%), with ages ranging from 17 to 38 years (average age: 23.64 years). Therefore, all of them could be classified as "young." All participants were either undergraduate students, postgraduate students, or university office workers. As for education level, 86.6% of respondents had bachelor or graduate degree, while 13.4% were undergraduate students.

The majority of the participants (74.9%) had experience in cultivating plants (Fig. 1a), but only 19.4% knew much or very much about plants, 75.7% just knew a little, and 4.9% did not have any plant-related knowledge (Fig. 1b). As shown in Fig. 1c, the main ways to acquire plant-related knowledge were daily experience, television (TV)/Internet, listening to others, and in the fourth place, books or courses. More than 77.4% said they liked plants or liked them very much, and less than 1.0% disliked plants (Fig. 1d). About 420 respondents (86.4%) reported that they felt relaxed around plants, and nearly half (42.6%) felt happy (Fig. 1e). More than five-sixths believed that plants decorated a space (90.5%), purified the air (89.9%), and regulated emotion (86.2%) (Fig. 1f). From these results, it was clear that the majority of respondents liked plants and had a sense of relaxation and happiness in environments that contained them, although few had much scientific knowledge related to plants. Therefore, their emotional response probably was not closely related to their experience or knowledge of plants.

The survey on preferences for different L&F showed that lettuce was the favorite leafy vegetable of 64.8% of respondents, out of eleven kinds (Fig. 2a), and strawberry was the favorite fruiting plant of 67.3% of respondents, out of three kinds (Fig. 2c). Of the eight herbs listed, male respondents (42.7%) liked chives best, and more than half of female respondents (50.9%) preferred peppermint (Fig. 2b). In addition, all participants were asked to indicate the main reasons for their preference for certain plants. We found that taste was the main factor in their preference for all three types of plants: leafy vegetables, herbs, and fruiting plants (Figs. 2d–2f). Next to taste, color was the second main factor affecting preference for leafy vegetables (32.1%; Fig. 2d) and fruiting plants (24.9%; Fig. 2f), while smell was the second main factor for herbs (40.3%; Fig. 2e).

To further explore preferences with regard to vegetable color, we chose dwarf hot pepper (which has several varieties with different fruit colors but similar

Table 1 Demographics of respondents (n=486)

Variable	Number	Percentage (%)
Gender		
Male	207	42.6
Female	279	57.4
Age (years)		
<20	43	8.8
20–25	316	65.0
26–30	116	23.9
>30	11	2.3
Education level		
High school	65	13.4
Bachelor	217	44.6
Master	137	28.2
Doctor	67	13.8

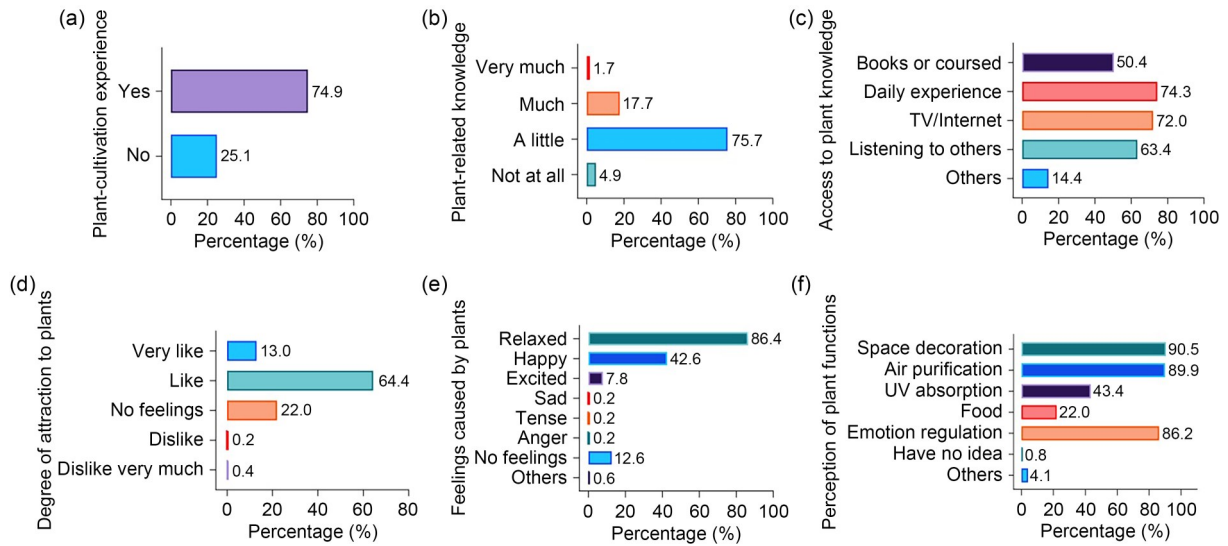


Fig. 1 Respondent demographics. (a) Respondents' plant-cultivation experience; (b) Respondents' plant-related knowledge; (c) Respondents' access to plant-related knowledge; (d) Respondents' degree of attraction to plants; (e) Feelings elicited in respondents by plants; (f) Respondents' perception of plant functions. TV: television; UV: ultraviolet.

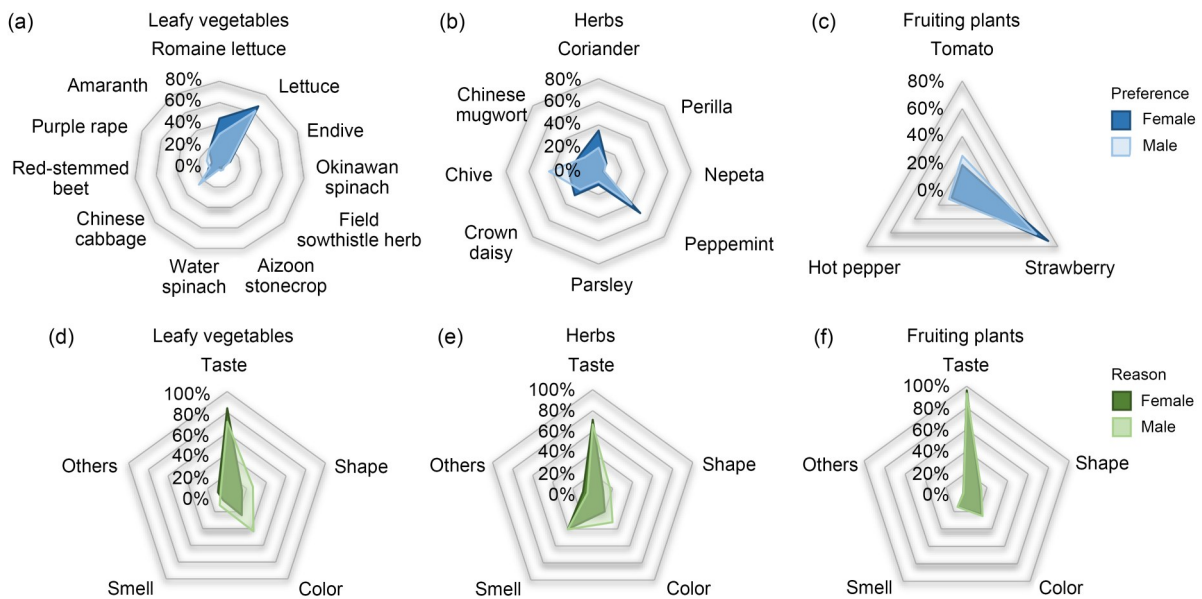


Fig. 2 Preferred leafy and fruiting plants (L&F) species and main reasons. (a–c) Preferred species among leafy vegetables, herbs, and fruiting plants; (d–f) Main reasons for preferences for leafy vegetables, herbs, and fruiting plants.

leaf and fruit shapes) for another question in the questionnaire. Six options were given: colorful (multi-color), white, green, red, orange, and purple. From the results (Fig. 3a), we could see that about one-third (33.1%) of respondents preferred multi-color plants which had green, red, yellow, purple, and white fruit; 31.9% of respondents preferred plants with only green fruit; and 22.0% of respondents preferred those with only red fruit. Gender-difference analysis (Fig. 3b) showed

that male respondents preferred the all-green plants (33.8%) most and colorful plants (28.0%) second. For female respondents, colorful plants were the most preferred (36.9%), followed by all-green ones (30.5%). Red was the third preference for both males (25.1%) and females (19.7%). These results suggested that vegetable or fruit plants with multi-color, green, or red fruits would probably be considered more generally pleasing than the other colors.

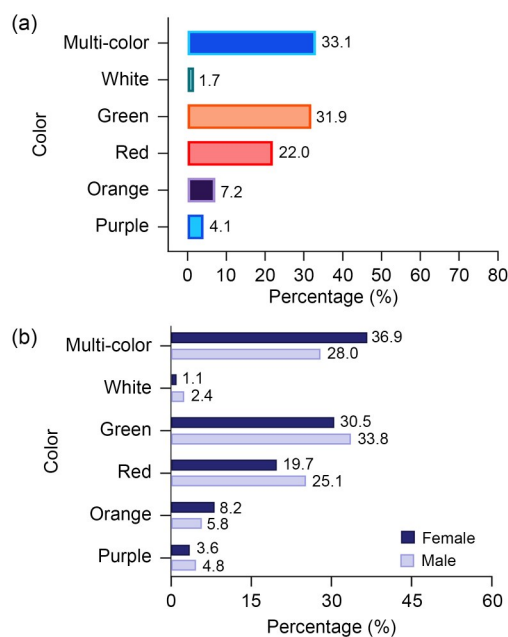


Fig. 3 Preference for leafy and fruiting plants (L&F) color and gender difference. (a) Respondents' preference for L&F color; (b) Gender difference in color preference.

Human preference for different plants is often closely related to sensory characteristics such as color, shape, taste, and smell. Emotions and color perception are controlled by the right brain, and human emotions and colors are related to each other (Sonnier and Dow, 1985). Meanwhile, plant color is an important indicator for improving physical and mental health in the natural environment. Different plant colors have different effects on human physiology and psychology (Jang et al., 2014). In our data, color was ranked second among plant sensory characteristics in influencing participants' preference for leafy vegetable and fruiting plants, and ranked third for herbs (Figs. 2d–2f). The olfactory system is also closely related to the emotional area in the brain, and there are brain structures common to emotion and odor processing (Soudry et al., 2011). A number of previous studies have shown that the volatile organic compounds (VOCs) released by plants can improve people's mental and emotional state (Song et al., 2016). Smell experiences with plants also have an effect on like or dislike of plants. In this study, smell was also indicated as one of the main sensory factors influencing preference for edible plants, whether leafy vegetables, herbs, or fruiting plants, although participants did not actually smell plants during the study. Interestingly, plant taste has not been

discussed previously in terms of horticultural intervention in human mental health. In this research, we demonstrated that taste was the top factor in participants' preference for dwarf L&F plants, although the respondents did not actually taste the 22 edible plants when completing the questionnaire. In daily life, the L&F plants included in this research are common and widely eaten breeds; hence most respondents were familiar with them, and it was easy to associate their names and pictures with their taste and smell. Many previous studies have reported that basic tastes and smells of foods and beverages can evoke emotional changes, and the emotional responses depend on the perception of specific taste and smell, not just on the mere presence of the foods and beverages (Spinelli and Jaeger, 2019). Our results provide a preliminary indication that edible plants have the potential to play an important role in emotional regulation through taste and smell experiences. It also appears that edible plants might use different emotional regulation pathways compared to ornamental plants, which would make it necessary to control sensory experiences and stimulation in future research to avoid complicating cross-modal interaction effects.

To check the possible role of gender, education level, plant knowledge, and plant-cultivation experience in respondents' preference for various plant species, we conducted the Chi-square test on the data. According to the results, most of these factors had no significant influence on respondent preference (Figs. 4d–4l). However, a significant influence of gender was evident in respondent preferences for leafy vegetables and herbs ($\chi^2=21.35$, $P<0.01$, Fig. 4a; $\chi^2=18.46$, $P<0.01$, Fig. 4b). Gender also had an influence on preferences for fruiting plants, but it was not statistically significant ($\chi^2=4.80$, $P=0.07$; Fig. 4c). In their research on ornamental plants, Gilboa and Rafaei (2003) reported a significant difference in flower selection between males and females. People of different genders also had different levels of interest in and demand for a green environment. The demand for green space seemed to be larger and more sensitive for females (Larcher et al., 2021). These results suggest that gender could be an important factor affecting the results of mental intervention with plants, and should be fully considered in future studies.

This study analyzed young people's preferences for various species of leafy and fruiting edible plants

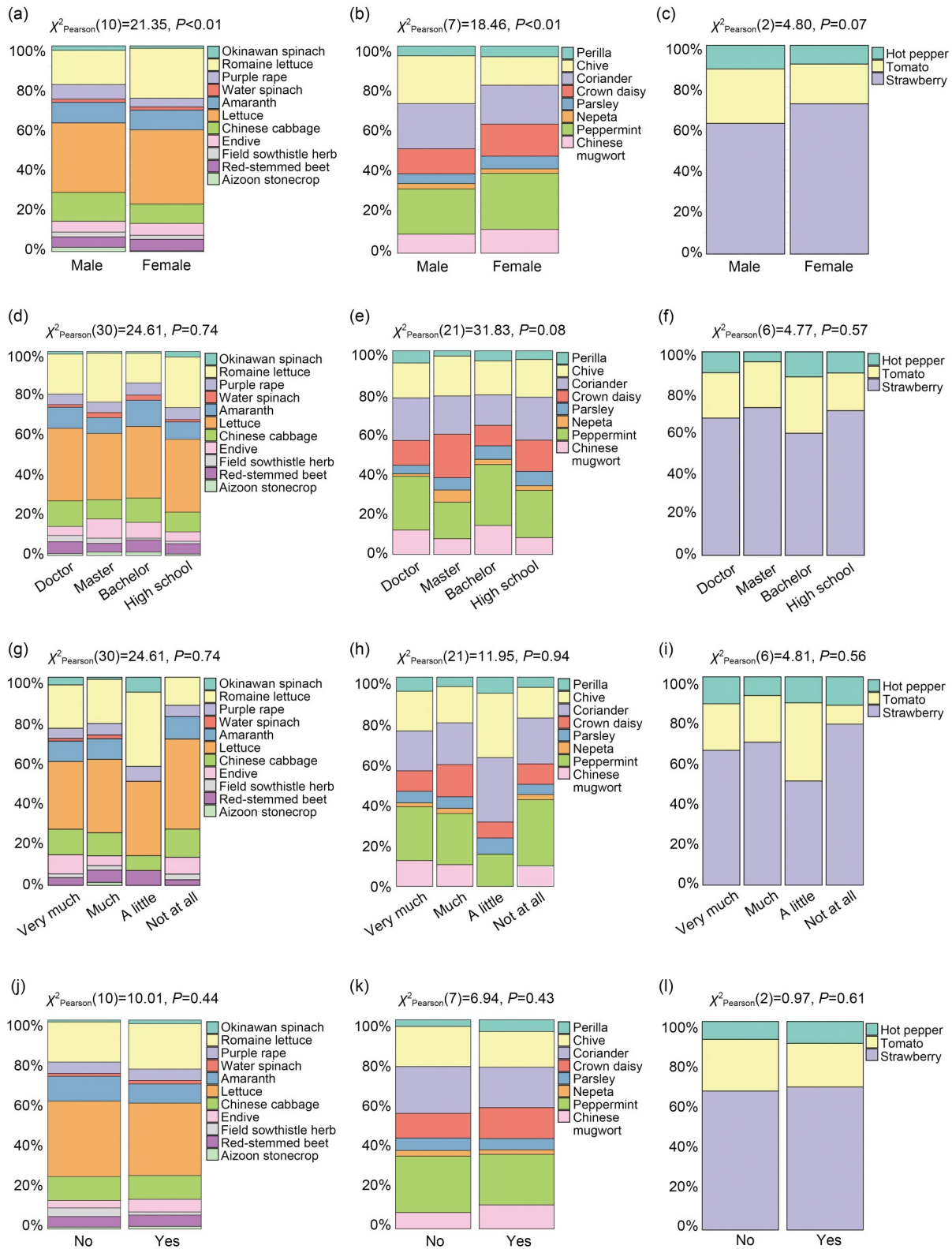


Fig. 4 Effects of respondent demographics on leafy and fruiting plants (L&F) preference. (a–c) Effects of gender on preferences for leafy vegetables, herbs, and fruiting plants; (d–f) Effects of education level on preferences for leafy vegetables, herbs, and fruiting plants; (g–i) Effects of plant-related knowledge on preferences for leafy vegetables, herbs, and fruiting plants; (j–l) Effects of plant-cultivation experience on preferences for leafy vegetables, herbs, and fruiting plants.

(L&F) and the factors influencing their preferences by using cross-sectional data from 486 young people. We also investigated the main potential pathways of L&F to regulate emotion. The results showed that 77.4% of participants liked plants, and the majority reported a feeling of relaxation when they saw them. The most preferred L&F color (for pepper plants) was multi-color, followed by green and red. Participants' favorite leafy vegetable was lettuce and favorite fruiting plant was strawberry. There was a significant difference between male and female participants' favorite herb choices, with chives chosen by males and peppermint by females. Furthermore, taste was reported to be the main reason for participants' preferences. Despite the novelty of these findings, this study had some limitations. Firstly, the sample was narrow in scope (mostly university students), and the sample size was not large enough. Secondly, more detailed information about respondents, such as place of family residence or family size, was lacking. Thirdly, the data were collected via an online questionnaire in which participants answered the questions based on pictures and names of plants, as well as their existing experiences. Future studies would ideally recruit more diverse subjects, and be conducted in person with real edible plants.

In conclusion, this research gives an initial indication of the choice of food plants potentially suitable for urban cultivation, and emphasizes the importance of plants in maintaining young people's mental health. The study indicates that edible plants might use different emotional regulation pathways compared to ornamental plants, and that it is important to control sensory experience and stimulation to avoid complicating cross-modal interaction effects in future research. Moreover, gender should be fully considered in the design of home gardens. We hope the information presented here will be useful for better design of home gardens and other urban greenspace with edible plants to satisfy the mental health needs of urban residents.

Materials and methods

Detailed methods are provided in the electronic supplementary materials of this paper.

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Author contributions

Wenzhu ZHANG, Zhaoming LI, Hui LIU, and Hong LIU designed the study. Wenzhu ZHANG and Zhaoming LI performed the experiments and analyzed data. Jingxian CUI and Lingshan WANG collected materials and helped in manuscript preparing. Wenzhu ZHANG, Zhaoming LI, and Hui LIU wrote the manuscript. All authors have read and approved the final manuscript, and therefore, have full access to all the data in the study and take responsibility for the integrity and security of the data.

Compliance with ethics guidelines

Wenzhu ZHANG, Zhaoming LI, Jingxian CUI, Lingshan WANG, Hui LIU, and Hong LIU declare that they have no conflict of interest.

The study was approved by the Science and Ethics Committee of School of Biological Science and Medical Engineering, Beihang University, Beijing, China (Approval ID: BM20200116). Informed consent was obtained from all respondents for being included in the study.

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Supplementary information

Table S1; Fig. S1; Materials and methods