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A Study of Sensory Evaluation in Endangered Aromatic Orchid *Aerides odorata* from North-Eastern Himalayan

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ABSTRACT: *Aerides odorata*, an endangered aromatic orchid species belongs to the Orchidaceae family is a subtropical epiphytic orchid commonly grown in North Eastern Himalayan region. Its magnificent racemes of fragrant, pleasantly aromatic nature with long shelf life and colorful flowers are valued in horticulture sector and have a high demand in the local market. In the present investigation, the sensory evaluation study was conducted to identify the best fragrant collection of *Aerides odorata* from four distinct collections at ICAR-NRCO, Sikkim. The aroma score of collection 1 (5.60 ± 0.26) were significantly different from those of the other collections (C2, C3 and C4). Collection 3 scored the highest acceptability rating followed by Collection 2 and 4. Separate and overall recording of male and female acceptability showed that Collection 1 and 3 had the highest acceptability percentage. Pearson's Chi-squared test based on the perception of individual participants showed significant result and collection 3 scored highest perception rating. Overall sensory evaluation depicted that collection 3 is the best performed fragrant orchid (*Aerides odorata*) collection. Therefore, the present study revealed that the flowers of collection 3 has higher fragrance compared to other selected collections, which can be used as an aroma source raw material in the perfume based industries.

Keywords: Orchid, *Aerides odorata*, sensory evaluation, aroma.

INTRODUCTION

Arides odorata belongs to the family of Orchidaceae family also referred to as cattail or foxtail orchid. The word "Aerides" means “child of the air,” while “odorata” means “fragrant”. It is a genus of tropical epiphytic orchids that growing mainly in tropical valleys of Asia, India, Bhutan, Srilanka etc. (Kocyan *et al*., 2008; Preach and Cribb, 2002; Lucksom, 2007). In horticulture, they are prized for their spectacular, fragrant, and colourful flowers. These flowers usually bloom in the months of June to July. Favorable temperature varies species to species, ranging from cool to warm growing. The flowers of *Aerides odorata* are aromatic and long-lasting, which makes them popular as cut flowers and pot plants. The fragrance of the flowers makes them valuable and a potential source for scent/perfume extraction (Kocyan *et al*., 2008; Kishor *et al*., 2006). *Aerides* species are easily grown in hanging baskets, teak containers, or net pots (Kishor *et al*., 2006). These species are easy to cultivate and are used for ornamental decorative purpose, holistic purposes etc. The plants grow up to one meter length, with stout, branched stem and the leaves are oblong, incurved in nature. The flowers are fragrant, 1.5 to 2.5 cm long, purple to white in colour. The flowers survive for a long duration (6-8 weeks) and become quite fragrant after a few days of blooming (Preach and Cribb, 2002). In India, it is mostly grown in Sikkim, Darjeeling and Assam region (De *et al.*, 2015). Flowers have a significant role in our daily life, they represent purity, beauty, tranquility, love, passion and are also used for decoration in social occasions due to their charming beauties and pleasant fragrance (Randhawa and Mukhopadhyay, 1986). India's flower industry is estimated to be about 400 million dollars in retail sales. Thus, the floriculture business is diversifying and is gaining enormous importance from an artistic, social, environmental, and economic perspective. It has become a profitable agribusiness in recent years as demand for floricultural products has increased due to rising living standards, greater awareness among citizens about the importance of living in an environmentally friendly manner (Vahoniya *et al*., 2018). Flower production is one of the agriculture's fastest developing crop trends in agriculture and India's 'flower power' continues to evolve making the country second largest flower grower in the world after China (Senthil, 2017; Sundar, 2016). Diverse but agreeable agro-climatic conditions in India, make a way good opportunity for commercial cultivation of a wide variety of flowers and ornamental plants (Harisha,

2017; Roy, 2008). The Indian cut flower sector is primarily focused on the sale of fresh flowers, cut greens, and nursery products such as annual seed packets, foliage, propagating plant material, and plants for landscaping. The Indian government recognized floriculture as a rising sector and granted it 100 percent export-oriented status (APEDA). The globalization of the economy has encouraged Indian small entrepreneurs to establish world-class export-oriented floriculture enterprises. A large number of public and private companies have been set up in different parts of the country and have taken a proactive role in developing infrastructure facilities and logistic networks for the flower industry. According to APEDA, India's floriculture exports and imports accounted for 0.40 per cent and 0.12 per cent of the country's total revenue in 2018. The total value India's cut flowers exports was USD 81.94 million, while total imports reached USD 25.06 million in 2018–2019 (Anumala and Kumar, 2021).

Flower fragrance is crucial in the commercialization of flowering plants and considered one of the most important characteristics of cut flowers during their vase life (Raguso, 2008). However, this trait is underdeveloped in new flower cultivars because the inheritance of floral scent is complex and does not inherited across generations (Aros *et al*., 2015). Flower fragrance can be evaluated using sensory analysis, which is based on the perception of our olfactory/sensory system and is frequently employed to determine customer preferences (Veramendi *et al*., 2013), as it is the only method that can evaluate hedonic qualities. Numerous studies have demonstrated that our sensory system is much more sensitive and complicated than any other methods of evaluating scents (Hinterholzer and Schieberle, 1998). The sensory analysis study helps to identify the aroma to be evaluated in its entirety. Additionally, sensory analysis was performed to illustrate the beneficial effects of floral aroma on human health by analysing the psychophysiological responses of people exposed to the fragrance of Japanese plum flower (Jo *et al*., 2013). Recent research has integrated an olfactory system with GC-MS to create olfactometry, which enables the qualitative assessment of odorous chemicals in commodities such as meat and fruits (Wu *et al*., 2014, Ubeda *et al*., 2012). Although several research have examined the chemical evaluation of floral aroma (Kong *et al*., 2012; Yue *et al*., 2014; Li *et al*., 2017), relatively little information has been published on sensory evaluation of this quality which is most crucial for marketing of ornamental plants. Most sensory evaluations have been conducted on foods and beverages, including juice and wine (Amerine, 2013; Andreu-Sevilla *et al*., 2013; Aros *et al*., 2020). However, the purpose of this study was to identify the best floral aroma producing plant from four distinctly scented species of *Aereides odorata* with significant commercial value using sensory evaluation study. This investigation will help to prepare the documentary of best growing local *Aerides odorata* collections as a result farmers and breeders from this region can easily identify and grow this species. Due to pleasant aroma this identified collection can be exported to the perfume industry by the farmers of this region.

MATERIALS AND METHODS

A. Sample collection

The plants of *Aerides odorata* were grown under the poly house at ICAR-NRCO, Sikkim. The flowers were in full bloom during the months of May-July and after blooming the flower sample was collected for sensory evaluation investigation. Based on distinct aroma a total of four different collections of *Aerides odorata* i.e., Collection 1, 2, 3 and 4 were selected for sensory evaluation. Sensory evaluation study of the orchid flowers was conducted at training hall of ICAR-NRC for Orchids in room temperature (25-27°C) using a questionnaire containing nine-point hedonic scales (1 to 9) by 24 participants including 14 males and 10 females. The ratings included aroma (scent) and general acceptability on a scale of 1 to 9, whereas, 9 representing extreme liking and 1 representing extreme disliking (Hajmohammadi *et al*., 2016, Lim, 2011, Zheng *et al*., 2014). Fresh flowers were picked in the morning around 9.30 am and the experiment was performed between 10 am to 11.30am.

The study is exploratory and observational in nature. An in-depth sensory evaluation and, more importantly, comprehensive quantitative consumer research were outside the scope of this research. Therefore, a mixed method was used, in which the subjects performed both hedonic and free choice profiles, despite not having been properly trained. Prior to the assessments, participants were asked three questions about their perception and desire for fragrant samples (flowers). The questions were as follows":

A) Do you smell the aroma in this sample? (Yes/No)

B) Based on aroma, choose any scale? (Scale1: Dislike extremely, scale 2: Dislike very much, scale 3: Dislike moderately, scale 4: Dislike slightly, scale 5: Neither like/dislike, scale 6: Like slightly, scale 7: Like moderately, scale 8: Like very much and scale 9: Like extremely).

C) Overall acceptability of all collections based on their aroma? (Very good/ Good/ average).

Following the evaluations, panelists were asked to suggest acceptable collections for adding with *Aerides odorata* flowers.

After completion of the test, the participants were asked the best collections on free-choice. During the sensory evaluation the panelists were given with a long spike of clean flowers (about 50-70 flowers per spike). Repeated scoring was permitted and test has been done on in triplicate.

B. Statistical analysis

A Completely Randomized Design (CRD) was used for the experiment. Statistical analysis and mean comparisons were performed using the statistical R software and Microsoft Excel 2007. One-way analysis of variance (ANOVA) was used to evaluate the gathered data. The Duncan test was used to compare means and find out the significant levels at $p \leq 0.05$.

Table 1: Details of orchid sample collection.

Sr. No.	Orchid	Family	Collection code	Collection place	Latitude	Longitude
1.	*Aerides odorata*	Orchidaceae	C1	ICAR-NRCO, Sikkim	27.236510	88.592430
2.	*Aerides odorata*	Orchidaceae	C2			
3.	*Aerides odorata*	Orchidaceae	C3			
4.	*Aerides odorata*	Orchidaceae	C4			

Fig. 1. Distinctive collections of *aerides odorata* flowers for sensory evaluation.

RESULT AND DISCUSSION

Sensory evaluation test is one of the most important attributes to determine or identify the best performed quality of flower species, foods etc. The participants showed a positive feeling, and a genuine enthusiasm to identify the best collections of *Aerides odorata*. The people who participated in sensory evaluation were predominantly male (58.33%). The highest percentage of age distribution (Table 2) of male (42.86%) was above 40 years and the second highest percentage (28.57%) of age distribution was below 30 years, while the age distribution of female participants (41.67%), recorded that most of the participants (50%) were between 35 and 40 years of age. In the overall age distribution (both male and female participants), above 66.66% of the participants age were above 30 years. The overall aroma score by the male and female participants (Table 3) shows that Collection 1 is significantly different from the other three collections, which have low aroma scores and minimal acceptability compared to rest of the collections. The highest aroma score was recorded in Collection 3 (6.94 ± 0.22) followed by Collection 2 (6.93 ± 0.24) while the lowest score was recorded in Collection 1 (5.60 ± 0.26) of *Aerides odorata* flowers. According to the sensory preference of the participants, fragrances were present in all the four selected collections of *Aerides odorata* flowers. The percentage of aroma acceptability (Table 4) was calculated in three different ways such as overall acceptability, male and female acceptability. Total three category was used in preference choice list of acceptability category part i.e., 'very good', 'good' and 'average' category. The overall acceptability percentage has been revealed that Collection 3 had the percentage of highest acceptability in the 'very good' category (33.33%) followed by collections 2 and 4 (29.16%), while collections 1 and 2 had the same score in the 'good' category (50%) followed by collections 3 (45.83%). The percentage of male acceptability percentage revealed that collection 1 and 2 recorded maximum score in the 'very good' (42.85%) and 'good' (64.28%) category respectively, and collection 4 recorded 'average' category (42.87%). The female acceptability percentage showed that Collection 3 scored highest (50%) in 'very good' acceptability category whereas collection 1 and 2 shared maximum acceptability (50%) in 'good' category. In the terms of 'very good' category of acceptability, we can assume that the flowers of Collection 3 is the best performed aromatic orchid collection compared to other selected flower collection of *Aerides odorata* species. Differences in aroma fragrant among the selected flowers collections may be due to different expressions of aroma synthesis genes and differences in olfactory sense of male and female participants.

Table 2: Detailed age wise participants in sensory evaluation.

Age	Male %	Female %	Overall %
Below 30 years old (<30)	28.57	20	25
31 to 35 years old	7.14	10	8.34
35 to 40 years old (>35)	21.43	50	33.33
Above 40 years old (>40)	42.86	20	33.33
Total Participants	14 (58.33%)	10 (41.67%)	24 (100%)

Table 3: Aroma score from sensory evaluation.

Orchid Collection	Aroma score: Overall	Aroma fragrance (Yes/No)
	Mean ±SEm	
C1	5.60 ± 0.26^{b}	Yes
C2	6.93 ± 0.24^{a}	Yes
C3	6.94 ± 0.22^{a}	Yes
C4	6.74 ± 0.16^{a}	Yes
LSD (0.05%)	0.670	—
CV	5.427	
F value	9.778	

Table 4: Aroma acceptability score from participants in sensory evaluation.

Orchid Collection	Overall acceptability (%)			Male acceptability (%)			Female acceptability (%)		
	Very good	Good	Average	Very good	Good	Average	Very good	Good	Average
C1	8.33	50	41.67	42.85	50	7.42	10	50	40
C2	29.16	50	20.84	14.28	64.28	21.44	30	50	20
C3	33.33	45.83	20.84	35.71	42.85	21.44	50	30	20
C4	29.16	37.5	33.34	21.42	35.71	42.87	40	40	20

Pearson's Chi-square test was also done to find out the actual performed results of participants perception versus expected results of perception observation which relies with the differences between the collections (C1, C2, C3 and C4) and perception categories (very good, good and average) of participants (Table 5). The observed or actual performed perception of the participants were significantly higher than the expected perception score. Therefore, based on perception of the participants, each collections is different from each other by aroma quality. However, the observed and actual performed perception score of Collection 3 in the 'very good' category showed the highest score (8) than expected score (6) of the other collections and this result was correlated with the aroma score. The result of Pearson's Chi-square test suggested that collection 3 was the best performed (scored) fragrant collection based on participants perception score in 'very good' category.

Table 5: Pearson's Chi-squared test of perception in individual participants.

Collection	Chi-squared observed/actual performed score			Chi-squared expected score		
	Very good	Good	Average	Very good	Good	Average
C1	2	12	10	6	11	7
C2	7	12	5	6	11	7
C3	8	11	5	6	11	7
C4	7	9	8	6	11	7
Chi-squared = 6.7835, df = 6, p-value = 0.3413** (significant)						

Fig. 2 summarizes the aroma scoring by male, female and overall participants. In male category (Fig. 2A) showed that maximum participants preferred 'Like slightly' scale (score: 6) whereas female preferred 'like very much' scale (score: 8) and the overall performance (average score) by both male and female preferred 'Like slightly' scale (score: 6). Therefore, this result also indicated that female participants preferred higher aroma (score) in flower collections compared to male participants The difference between the male and female preference scale may be due to the presence of strong olfactory senses in the female participants as well as aroma gene expressions.

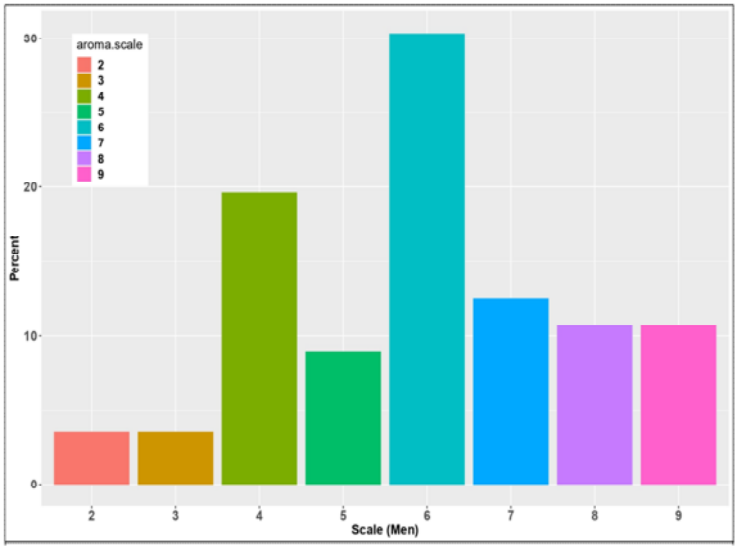

Fig. 2A. Graphical representation of aroma score performance by male participants.

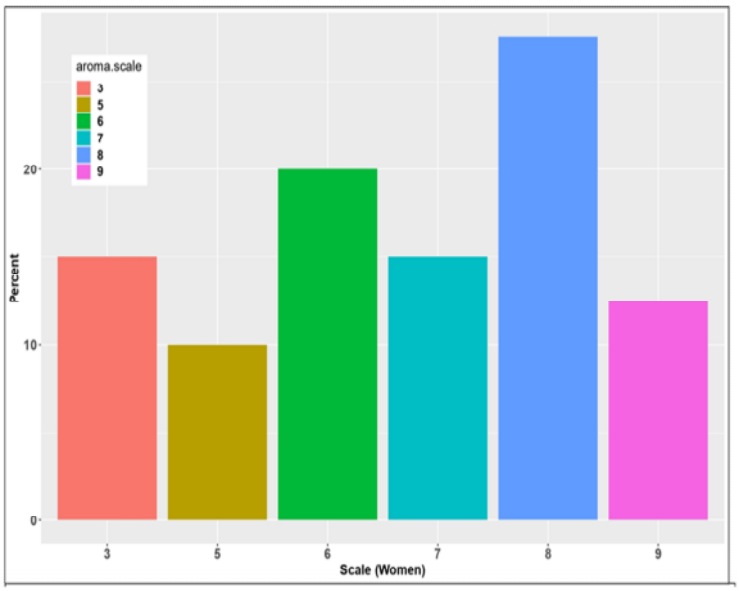

Fig. 2B. Graphical representation of aroma score performance by female participants.

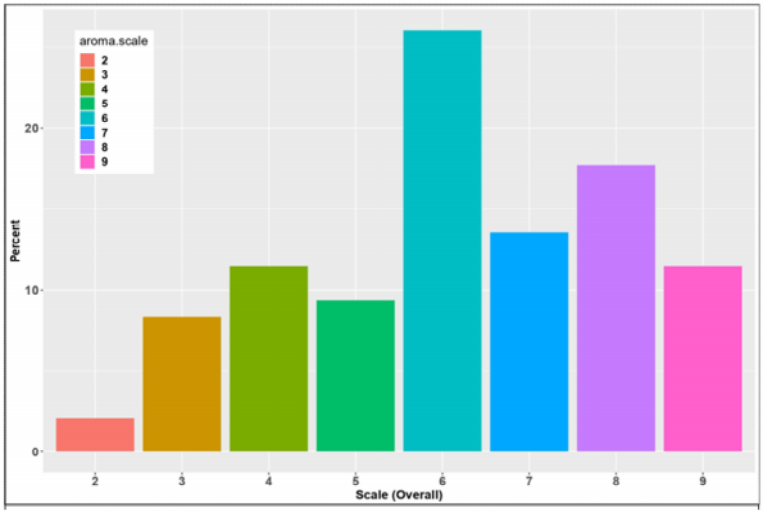

Fig. 2C. Overall graphical representation of aroma score performance by both male and female participants.

Fig. 3 shows the aroma scale of the each sample collections. In Collection 1 and 4, overall score of aroma recorded maximum in the 'Like slightly' scale (score: 6) whereas aroma scale 'like very much' (score: 8) and 'Like moderately' (score: 7) observed the highest for Collection 2 and 3. Graphical representation of aroma acceptability preference performance also explained in Fig. 4. Study revealed that overall, male and female category mostly preferred 'good' category as their free-choice. These four distinct collections of *Aerides odoata* have a distinct aroma, but based on aroma scaling, acceptability and perception of participants, collection 3 reported most pleasant aroma which making this collection an ideal source for supply of fragrant flowers for ornamental or as a source of perfumes in the industrial sector.

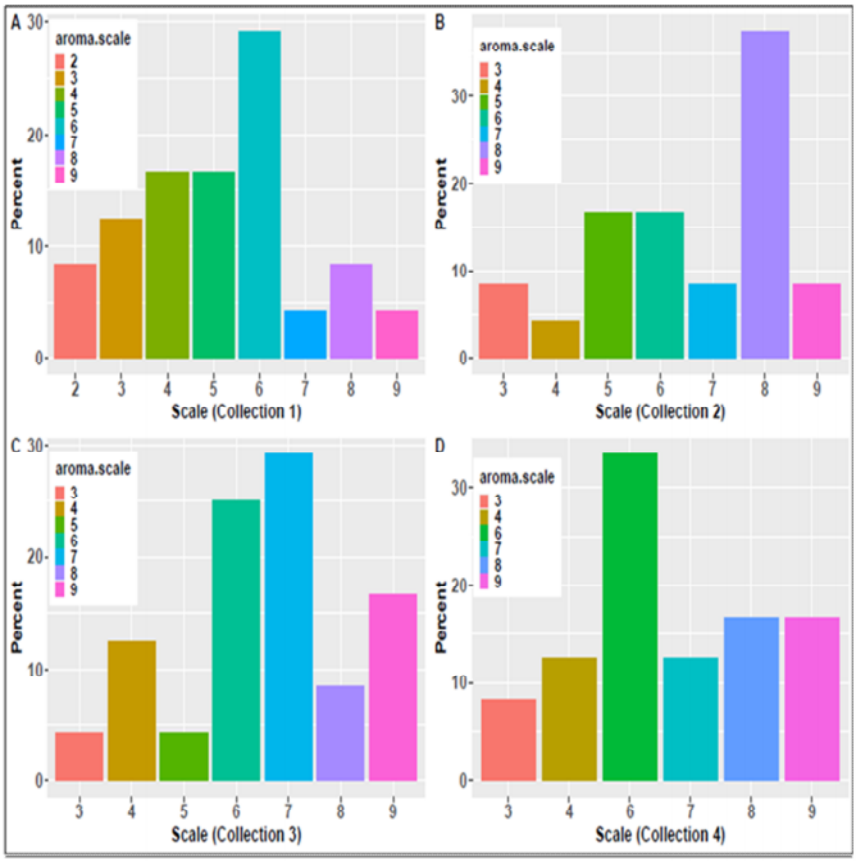

Fig. 3. Graphical representation of aroma scale of each flower collection (*Aerides odorata*)

The knowledge, understanding and positive attitude of the participants in our study did not significantly differ from the findings of Kelley *et al*. (2001). They reported that people interested in gardening during specific surveys for edible flower evaluation found close to our methodology, they appeared to demonstrate a significantly higher than average level of knowledge when compared to standard consumers (Kelley *et al*. 2002). Aros *et al*., (2015) also studied the floral scent evaluation in three different cut flowers namely Chrysanthemum, freesia and Lilium through sensorial system. In their investigation a total of 18 individuals participated and evaluated the best performed floral scent intensity among the selected flowers species. The aroma of flowers was scored as attractive for over all samples at variable levels of aroma strength. *Aerides odorata* was chosen as the most fragrant cut-flower (Mlcek *et al*., 2021). Whereas the aroma can boost consumers' attention in the flowers, the buds are often odorless, and thus only completely developed blossoms were harvested (Takahashi *et al*., 2020). As a result, the petals of many flowers are the primary source of aromatic chemicals, for example, the petals of *Rosa damascena* are utilized to create aromas and natural smells. However, considering the preference/opinion of participants, floral scent is one of the most important sensorial and economical attribute to characterize the best performed flowers species. Our findings also close the to the report observed by D'Antuono and Manco (2013) for edible flowers of wild ornamental *Allium* species, in this total 29 individuals participated in sensory evaluation experiment and they rated higher acceptability (visual and olfactory) in *A. roseum* flowers species whereas flowers of *A. neapolitanum* species were recorded lower flavour and olfactory preference. Their investigation report also suggested that critical importance of sensorial attributes to characterize the best quality flowers species.

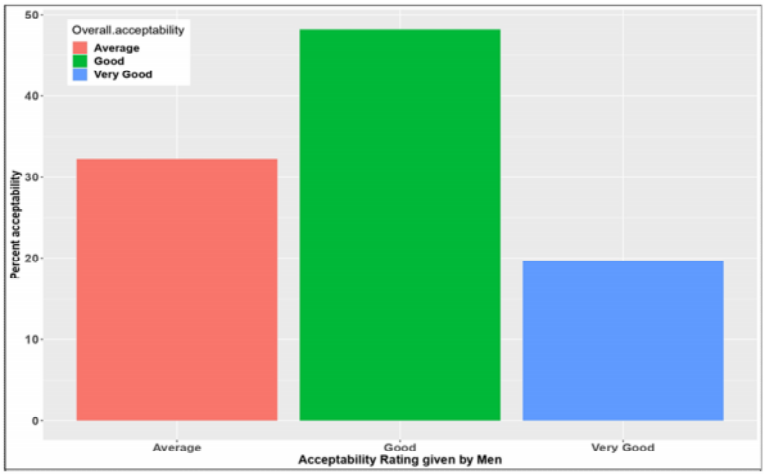

Fig. 4A. Acceptability performance of male participants.

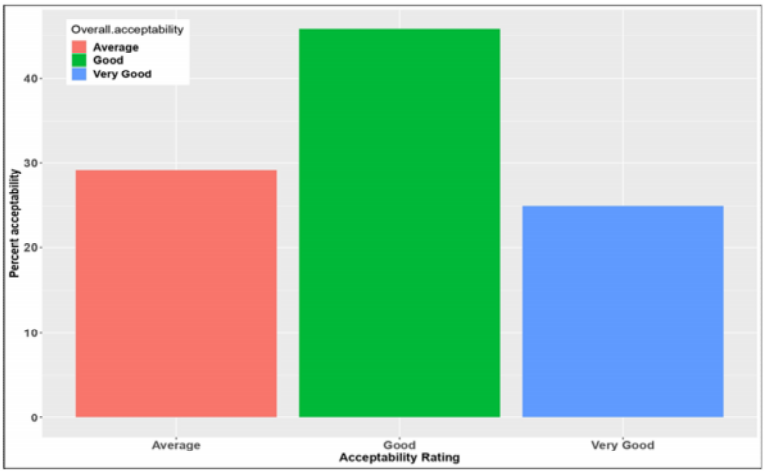

Fig. 4B. Overall acceptability performance of both male and female participants.

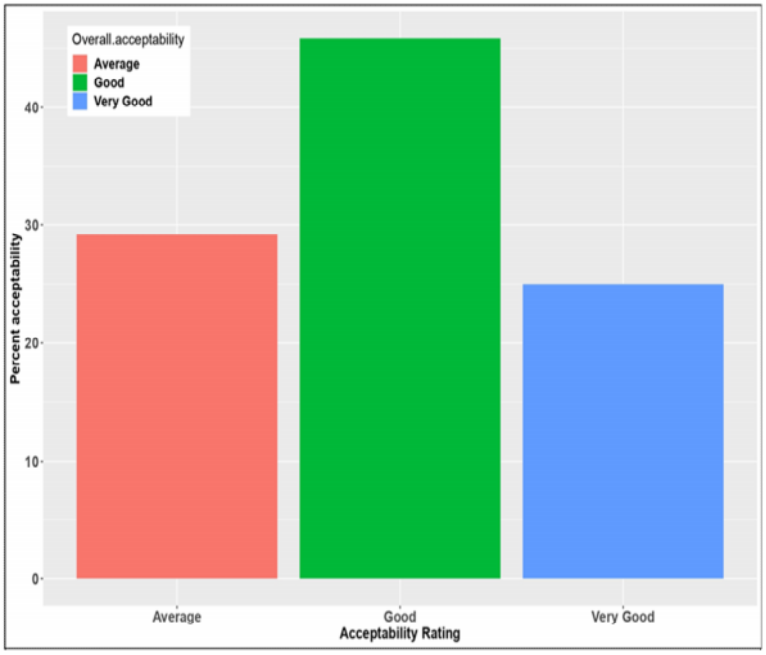

Fig. 4C. Overall acceptability performance of both male and female participants.

CONCLUSION

The floriculture sector is establishing itself as the most diverse and promising component of the horticulture industry at national and international level, given to its growth rate, rising asset value, and awareness among the people. This sector will boost income, revenue, and employment prospects for India's younger generation and also promote greater female participation and export growth. It will also help improve the livelihoods of the farmers in rural areas compared to other agri-horti crops/products and the trend in average unit price for exports indicates that floriculture products command a premium over fruit and vegetables in the market. The sensory evaluation of the aroma in the flowers of *Aerides odorata* is the first report on this aromatic orchid. In our study, the observed result of the sensory evaluation showed that four different collected flower samples of *Aerides odorata* differed from each other and Collection 3 recorded the highest acceptability and aroma rating by participants. The investigation has thus shown the flowers of Collection 3 are the best scented collections of *Aerides odorata.* Based on these results, the best collection sample can be used for better cultivation recommendations and can also be export as a raw material to perfume based industry for extraction of perfume. In addition, GCMS study is required for identification of aroma related volatile compounds from these samples. The identification of volatiles may reveal the chemicals nature as a result in future breeders can target the aroma biosynthesis genes for improvement of aroma quality in endangered *Aerides odorata* orchid species. Additionally, breeders have used negative selection to account for the apparent association between the presence of floral aroma and the flower's shorter vase life. Further, investigations are required to understand the aroma biosynthesis process, transcriptional regulation, and biochemical and physiological underlying mechanisms the various aromatic compounds of flowering *Aerides odorata*. The conservation, scientific cultivation and popularization through demonstration of this aromatic orchids collection with local farmers from North Eastern region will encourage and help them to supply their flower samples as a raw material to perfume based industry of other parts in India, as a result this approach may lead to improve their financial status and livelihood.

Author contribution. Conceptualization, supervision, writing original manuscript and draft preparation: Suman Natta, Statistical and software analysis: Bharath Kumar Alam, Review and editing: Ram Pal, Siddhartha Sankar Biswas and Kalaivanan N.S.

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Conflict of Interest. None.

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