Ideal Profile Method: A comparison between rating and ranking technique

Nguyen Quang Phong, Nguyen Hoang Dzung *

***Abstract*—Ideal profile method (IPM) has been proved to be an effective and useful method in product development. This method is similar to QDA® except that the samples are not rated by trained panelists but naïve consumers. However, the rating technique is often found to be difficult for consumers. This study proposed a new variant of IPM using ranking technique to facilitate the data collecting by naïve consumers. The samples were five commercial lemon green teas available in Vietnam market. The participants were bottled tea consumers who were randomly assigned into two groups of 60. The first group performed the conventional IPM (aka "IPM-QDA") using rating technique, in which the samples were presented in randomized monadic order and the participants rated both the perceived and ideal intensities of the attributes on the 10-cm line scales. The second group, on the other hand, performed the new variant of IPM (aka "IPM-RDA") using ranking technique, in which the participants ranked the whole set of the products (ties allowed) for each attribute at the same time. An empty cup representing the ideal sample was then inserted into the ranked set of products at the most suitable position depending on the ideal intensity. The result showed that two product spaces were highly similar. However, compared to IPM-QDA, IPM-RDA better improved the discriminability, increased the consensus among the assessors and reduced the variability of ideal profile. These findings indicated that ranking was more efficient than rating in gathering descriptive data using naïve consumers.**

***Index Terms*—Confidence ellipses technique, Ideal Profile Method, Multiple Factor Analysis, Ranking technique, Rating technique.**

1 INTRODUCTION

IDEAL product is assumed as a product that would maximize the consumer appeal [1]. Based on its information, manufacturers can modify their current product or create a new product to maximize sales and marketing. That is the reason why most of manufacturers always try to identify the ideal product. There are two types of methods for that purpose: conventional method and rapid method.

Conventional method is the so-called external preference mapping (PrefMap). Its data is a combination of hedonic data and descriptive data. Hedonic data are obtained by consumers, whereas descriptive data are obtained by a trained or expert panel. From statistical point of view, PrefMap focuses on the sensory profiles of products, then hedonic data will be regressed on the sensory dimensions. Ideal product will belong to the area where a maximum proportion of consumers would like [2, 3].

Due to training session about the vocabulary and the scale using, trained panel provides good quality data. However, it can take few weeks to several months to complete a study. Because vocabulary and scale using must be adapted on the new product space when it is changed. Therefore, the shortcoming of the conventional method is time consuming [4].

Rapid method is in fact a group of methods that collect descriptive data using consumers, such as: JAR, CATA, Napping, etc. Among these methods, Ideal Profile Method (IPM) has been widely used by researchers and practitioners. From the perspective of the task, for each product, consumers are asked to rate both perceived and ideal intensities on each attribute using a 10 cm line scale, before rating their overall liking using a 9 point scale [5]. As a result, three blocks of data are collected: sensory profiles, ideal profiles, and the hedonic scores. This method provides the profile of the ideal

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product and the relative position of the real products compared to the ideal [6].

By using consumers to profile products without training session, IPM as well as other consumer-based methods are less time consuming. In addition, when hedonic and descriptive descriptions are obtained from the same consumers, the link between the appreciation to the sensory perception of the products for each consumer is more directly [7].

However, in the conventional IPM which is based on Quantitative Descriptive Analysis-QDA®, rating technique is applied to profile products. The limitation of this method (aka IPM-QDA) could be that the products are evaluated independently and rating task is difficult to consumers, especially when the number of attributes is high [6]. In recently studies, several methods are developed to identify the ideal product in which QDA® is replaced by other consumer profiling methodologies. Ares *et al.* applied Napping®, Check-All-That-Apply (aka CATA) in comparison with intensity scale [8]. Brard *et al.* proposed IPaM as a variant of IPM which is based on Pairwise Comparisons to apply to children panel [6]. Ruark *et al.* proposed CATA-I as a variant of IPM which is based on CATA to apply to adults panel [9].

In this study, we propose a new variant of IPM in which the ranking technique will be used instead of rating technique in the frame of IPM procedure. This method is so-called IPM-RDA which is based on Ranking Descriptive Analysis [10]. The objective of this study is making a comparison between IPM-RDA and IPM-QDA in terms of gathering descriptive data for profiling both the real and the ideal products using consumers.

2 MATERIALS AND METHODS

2.1 Samples

Five commercial teas were selected from local supermarkets for testing. These samples were bottled lemon green teas corresponding to different brands in Vietnamese market, which were coded by letters from A to E for confidentiality reasons. Although the ingredients, sensory characteristics of these product were quite different, this was not a concern for the study. This highlights that the focus of this research was not on the particular results, but on the participants' view on the methods.

All tea bottles were stored in refrigerator (0-4°C) for at least 24 hours before testing session to ensure sample consistency. At the beginning of the test, 20 milliliters of each sample were dispensed into lidded transparent plastic cups and stored in refrigerator for at least five minutes before serving to consumers. The maximum evaluation time was 10 minutes and new samples were supplied if necessary to make sure that the serving temperature was 5-10°C. The samples were presented to consumers coded with 3-digit random numbers, following Williams' Latin square design.

2.2 Participants

Participants were recruited from the consumer database of the research team. They were bottled tea consumers who consumed bottled lemon green teas at least once a week. Most of them were students at HCMC University of Technology who were aged between 18 and 23 years old.

2.3 Procedure

2.3.1 Study 1: Recruiting panels

Preference of consumers is an important issue that should be concerned when comparing their ideal products. That is the reason why two independent panels should be similar in preference before making a comparison between two methods (ie. IPM-QDA and IPM-RDA).

In the study 1, 120 participants evaluated the overall liking of 5 products. Samples were presented in sequential monadic order. The participants were asked to try samples and rating their overall liking scores on a 9-point hedonic scale.

Hedonic data was collected in which liking scores were presented in a table crossing the participants in rows and the products in columns. To identify groups of consumers with different preference patterns, Principal Component Analysis (PCA) and Hierarchical Clustering on Principle Components (HCPC) were performed. Then participants in each clusters were assigned into two panels randomly and equally. Multiple Factor Analysis (MFA) was performed to re-checking the similarity in preference of two panels.

2.3.2 Study 2: Comparing two methods

To compare rating technique applied in IPM-QDA and ranking technique applied in IPM-RDA, the same protocol was applied for each panels. In study 2, assessors were asked to profile both 5 real products and ideal product in their mind. The same list of descriptors was given to both of panels. Nine descriptors which attached their definitions were *Color*, *Overall odor*, *Tea flavor*, *Lemon flavor*,

Sweetness, *Sourness*, *Bitterness*, *Astringency* and *After-taste* (cf. table 1).

In IPM-QDA method, samples were presented in sequential monadic order. For each product, assessors rated both the perceived and ideal intensities of all attributes on the 10-cm line scales.

In QDA-RDA method, a whole set of five samples were presented with an empty cup representing the ideal sample. Assessors were asked to try each of five samples and ranked them (ties allowed) for each attribute. The ideal sample was then inserted into the ranked set of products at the most suitable position depending on the ideal intensity.

The descriptive data provided by two panels were collected into two blocks of data for each panel:

- Sensory data including profiles of 5 real products was used to compare the quality of descriptive data. The product maps were compared by performing MFA. The sensory profiles quality was compared about the discriminability and the consensus among assessors by performing Confidence ellipses technique for each panel.
- Ideal data includes not only the profiles of real products but also the profiles of ideal products given by each assessors. Ideal maps were plotted together to compare the variability of ideal profile by performing Confidence ellipses technique.

Table 1. List of 9 descriptors using for lemon green tea profiling

Descriptor	Definition
Color	How dark/light the color of tea is
Overall Odor	How strong/weak the overall odor in the nose (orthonasal) is
Tea flavor	How strong/weak the tea flavor in the mouth and the nose (retronasal) is
Lemon flavor	How strong/weak the lemon flavor in the mouth and the nose (retronasal) is
Sweetness	How strong/weak the sweetness on the tongue is
Sourness	How strong/weak the sourness on the tongue is
Bitterness	How strong/weak the bitterness on the tongue is
Astringency	How strong/weak the astringency in the mouth is
After-taste	How strong/weak the remained feeling in the mouth after tasting is

2.4 *Data analysis*

All statistical analyses were performed using R language.

- FactoMineR was used to perform the multivariate analysis (PCA, HCPC, and MFA) [11]. Similarity between the products spaces was evaluated using the RV coefficient between product configurations in the first two dimensions of the PCA [12].
- SensoMineR was used to perform the confidence ellipses technique [13]. P*anellipse* functions in SensoMineR was used to evaluate the sensory data quality of each panels [6]. *Panelmatch* function in SensoMineR was used to compare the the profiles provided by different panels [12].

3 RESULTS AND DISCUSSIONS

3.1 *Analyzing hedonic data*

The results of cluster analysis using PCA and HCPC on overall liking scores were presented in figure 1. The first plane of PCA factor map can explain 50.77% of the total variance of the experimental data. Three identified consumer segments with different preference patterns were indicated: Cluster 1 was composed of 35 consumers whose liking scores of 5 products were lower than other clusters; Cluster 2 was composed of 47 consumers who preferred A, B, and C; Cluster 3 was composed of 38 consumers who preferred E and D.

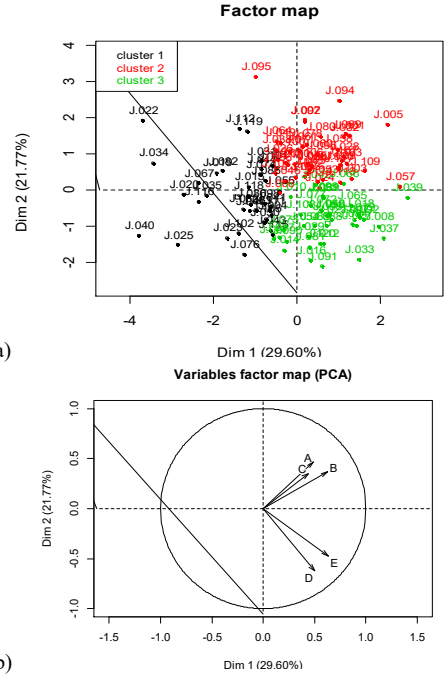


Figure 1. The plots in the first and second dimensions of PCA and HCPC on hedonic data: (a) Representation of the participants on the factor map, (b) Representation of the vectors of products on the correlation circle.

The participants then were assigned randomly into two panels. The number of participants from each clusters was shown in table 2.

Table 2. Number of consumers in each clusters and each panels

	Cluster 1	Cluster 2	Cluster 3	Total by panel
IPM-QDA panel	17	24	19	60
IPM-RDA panel	18	23	19	60
Total by cluster	35	47	38	120

The results of comparing the preference of two panels using MFA was presented in figure 2. The two first dimensions of the MFA can explain 60.87% of the total variance of the experimental data. Both groups share a large structure in common (RV = 0.944). From these results, the preference patterns of two panel were concluded similar.

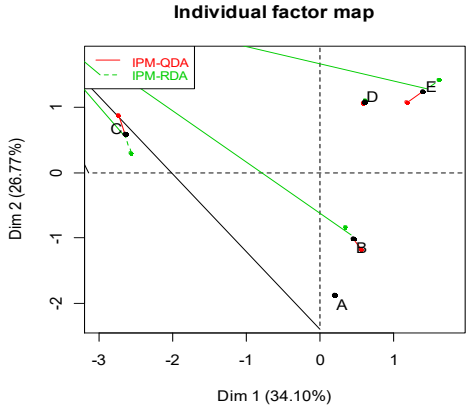


Figure 2. The plots of products on the two first dimensions of MFA on hedonic data of two panels.

Discussions: Although the consumers' preferences were not highly heterogeneous (cf. figure 1), the preference patterns of two panels were highly similar (cf. figure 2). Because of the method to recruiting panel, two independent panels in this study can be used to compare two methods. However, the number of consumers in each cluster is too small that we cannot make comparisons in each clusters. In further studies, the sample size could be enlarge to make the comparisons between homogenous groups of consumers.

3.2 Comparing sensory data

The results of MFA were presented in figure 3. The two first dimensions of the MFA can explain 85.53% of the total variance of the experimental data. Both groups shared a large structure in common (RV = 0.962). The representation of partial individuals in figure 3a indicated that the structure of the product space established by the IPM-RDA is very close to the IPM-QDA s' one. On the other hand, the representation of the vectors of descriptors on correlation circle in figure 3b indicated that two panels used attributes in the same ways. From these results, the sensory profiles established by two panels were concluded similar.

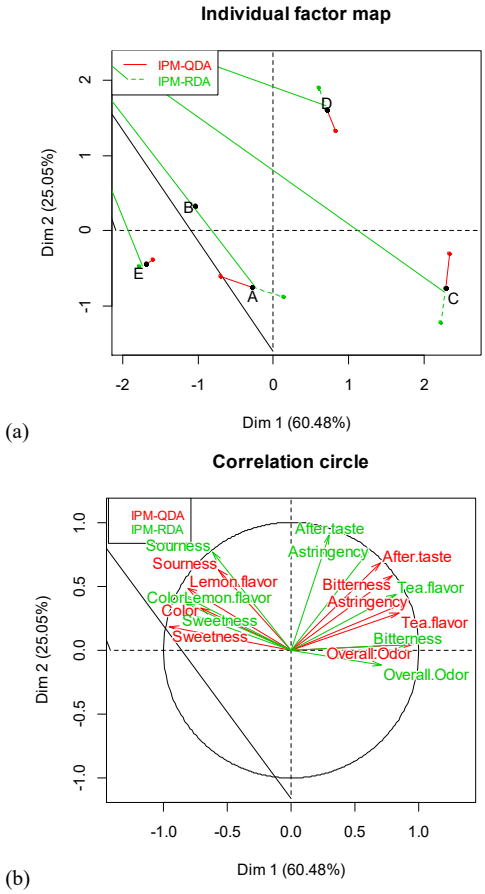


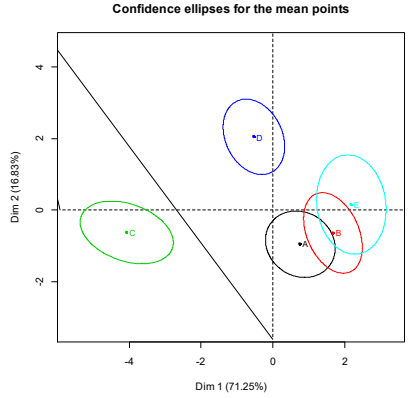
Figure 3. The plots in the first and second dimensions of MFA on sensory data: (a) Representation of the products on the factor map, (b) Representation of the vectors of descriptors on correlation circle.

To assessing the quality of sensory data of each panels, 1000 virtual panels of 60 were generated using Bootstrap techniques. The p-value of 0.05 was set as the threshold above which a descriptor is not considered as discriminant according to AOV model "*descriptor=Product+Panelist*". In figure 4, each real product was circled by its confidence ellipse generated by virtual panels. In figure 5, the variability of each descriptor was drawn on the correlation circle graph.

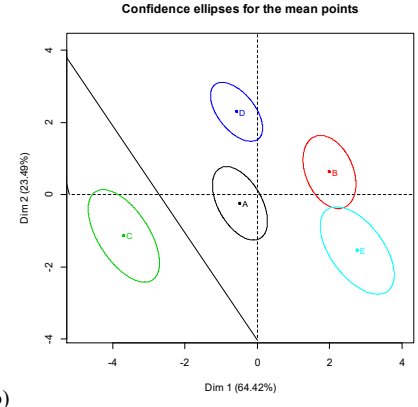
As shown in figure 4, ellipses of products profiles established by IPM-RDA panel did not overlap and we can consider that the products were well discriminated by IPM-RDA panel, whereas the ellipses of products profiles established by IPM-QDA panel (A, B, and E) overlapped and we cannot affirm that the sensory evaluations are different. These findings suggested a better discrimination by the IPM-RDA panel.

As shown in figure 5, the variability between the vectors of descriptors *color*, *sweetness*, *lemon flavor*, *sourness*, and *overall odor* established by the IPM-RDA panel was lower than which established by IPM-RDA panel. The variability the vectors of descriptors *tea flavor* and *astringency* established by two panels was high, as well as the variability the vectors of descriptors *bitterness* established by the IPM-RDA panel was also high. With the p-value of 0.05 was set, the descriptor *after-taste* was removed from the simulation of two both panels, whereas the descriptor bitterness was removed from the simulation of IPM-QDA panel. These findings suggested a higher consensus among assessors in IPM-RDA panel.

Discussions: Ranking task in IPM-RDA method helped to improve the discriminability, increase the consensus among the assessors. In IPM-QDA procedure, assessors evaluated one product at a time on all attributes. In IPM-RDA procedure, a whole set of products were presented, assessors focused on only one attribute at a time to rank them. It may lead to the better using of descriptions by IPM-RDA panel. We can notice that the vectors of descriptors used by IPM-QDA panel highly correlated together and correlated with dimension 1 (71.25%), whereas the vectors of descriptors used by IPM-RDA panel dispersed and correlated with both dimension 1 (64.42%) and dimension 2 (23.19%). The IPM-QDA panel mainly discriminated products on the first dimension which "tea related" attributes towards the negative side and "non-tea related" attributes towards the positive side. Moreover, the variability between the vectors of descriptors used the IPM-RDA was lower than which established by IPM-QDA panel. However, IPM-RDA is not suitable for a large number of products. It also requires careful temperature control or have persistent sensory characteristics [4].

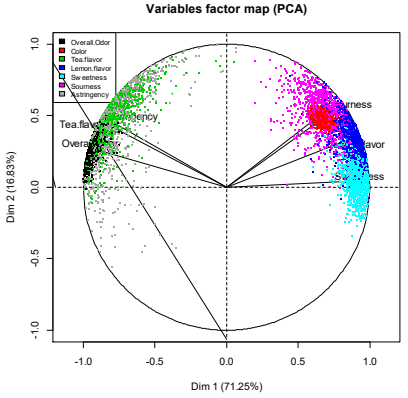


(a)

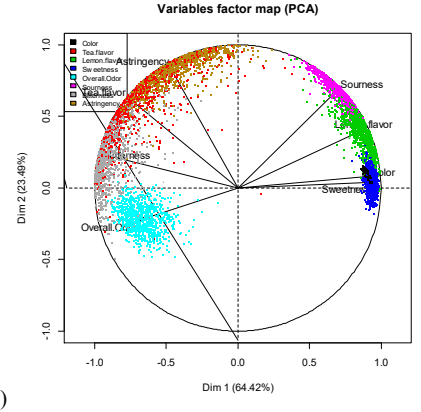


(b)

Figure 4. Confidence regions around the real products: (a) IPM-QDA panel, (b) IPM-RDA panel.



a)



(b)

Figure 5. Confidence regions around the descriptors: (a) IPM-QDA panel, (b) IPM-RDA panel.

3.3 Comparing ideal data

To compare the variability of ideal profile, ideal profiles of two panels were plotted together with profiles of real products (cf. figure 6). With respect to the MFA partial points representation, one ellipse per product and per panel can be estimated.

The two first dimensions of the MFA can explain 82.69% of the total variance of the experimental data. The structure of product spaces established by two panels was similar in common. The ideal product was near the product D which is the most appreciated product of two panel (cf. table 3).

The ellipses related to the ideal products of IPM-RDA panel was smaller than which of IPM-QDA. In other word, the variability of the description of the ideal product given by IPM-RDA panel is smaller than IPM-QDA panel.

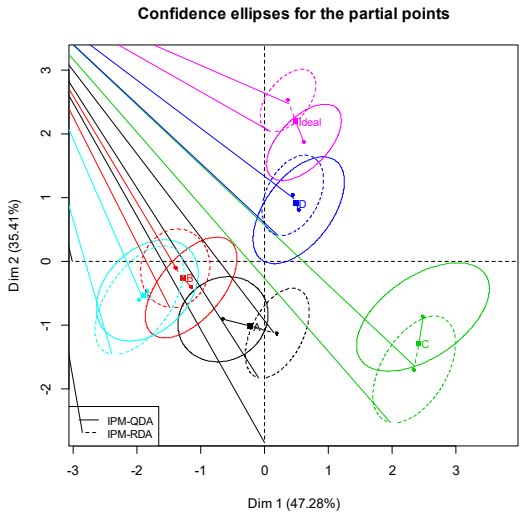


Figure 6. The plots in the first and second dimensions of MFA on hedonic data of two panels.

Table 3. Mean of overall liking scores evaluated by each panels for each products

Panel	A	B	C	D	E
IPM-QDA	5.67^{ab}	5.72^{ab}	5.18^{b}	6.07^{a}	5.43^{ab}
IPM-RDA	5.58^{ab}	5.65^{a}	4.82^{b}	6.12^{a}	5.58^{ab}

Different superscripts within a row indicate significant differences according to ANOVA and Tukey's test ($p<0.05$).

Discussions: In comparison with the conventional IPM, IPM-RDA is similar to CATA with Ideal, Napping with Ideal and Pairwise Comparison with Ideal in term of the single evaluation of ideal product [8, 6, 9]. Without the repeated rating to profile ideal, we cannot evaluated the variation of ideal, so that we cannot checking the multiple ideal [7]. In comparison with CATA with Ideal, nominal data collected in CATA-I was reported that have less power than ordinal data collected in IPM-RDA. In comparison with Napping with Ideal, difficulty to interpret precisely the descriptions provided by the assessors in Napping [4]. In comparison with Pairwise Comparison with Ideal, the experiment design in IPM-RDA was not complex because all samples were ranked at a time. However, the limitation of the IPM-RDA is also the ordinal data collected. In this study, the data collected from IPM-RDA was analysis as numeric data instead of ordinal data as its nature. In further studies, IPM-RDA data would be treated as an ordinal data and the data should be checked the consistency before using for products improvement and optimization.

4 CONCLUSION

By comparing IPM-RDA and IPM-QDA, the results showed that two product spaces obtained by the two methods were highly similar. Nevertheless, IPM-RDA was better in improving the discriminability among the products, in increasing the consensus among the assessors, and in reducing the variability of the ideal profile. These findings implied that ranking technique might be more efficient than rating technique in gathering descriptive data using naïve consumers when applying IPM. IPM-RDA might be useful for collecting consumer data in the context of the final stage of product optimization process where a small number prototypes were evaluated by a group of homogenous target consumers. For further studies, this method can be applied not only in various product categories but also in various stages of product development process to provide suggestions for improvement.

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Phương pháp sản phẩm lý tưởng: So sánh giữa kỹ thuật cho điểm và xếp hạng

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***Tóm tắt*—Phương pháp sản phẩm lý tưởng (IPM) đã được chứng minh là một phương pháp hiệu quả và hữu ích trong phát triển sản phẩm. Phương pháp này tương đồng với phương pháp QDA® ngoại trừ việc sử dụng người tiêu dùng để đánh giá cho điểm sản phẩm thay vì sử dụng người thử đã qua huấn luyện. Tuy nhiên, cho điểm thường được xem là một kỹ thuật khó đối với người tiêu dùng. Nghiên cứu này nhằm đề xuất một biến thể của phương pháp IPM; trong đó, kỹ thuật xếp hạng được sử dụng nhằm hỗ trợ cho việc thu thập dữ liệu mô tả từ những người tiêu dùng chưa qua huấn luyện. Các mẫu được sử dụng trong nghiên cứu là năm loại trà xanh hương chanh sẵn có trên thị trường Việt Nam. Những người tham gia trong nghiên cứu là người tiêu dùng sản phẩm trà đóng chai sẽ được chọn một cách ngẫu nhiên vào 2 nhóm gồm 60 người. Nhóm đầu tiên sẽ tham gia đánh giá bằng phương pháp IPM truyền thống (còn được gọi là IPM-QDA) sử dụng kỹ thuật cho điểm; trong đó, các mẫu sẽ được trình bày theo trật tự ngẫu nhiên, tuần tự và người tham gia sẽ đánh giá cho điểm cả cường độ cảm nhận và cường độ lý tưởng của các tính chất trên thang đo đoạn thẳng 10-cm. Trong khi đó, nhóm còn lại sẽ tham gia đánh giá bằng biến thể của phương pháp IPM (còn được gọi là IPM-RDA) sử dụng kỹ thuật xếp hạng; trong đó, người tham gia sẽ xếp hạng toàn bộ các mẫu cùng một lúc trên mỗi tính chất (cho phép xếp đồng hạng). Một chiếc cốc rỗng được xem như là sản phẩm lý tưởng sẽ được chèn vào vị trí thích hợp trong dãy các mẫu đã được sắp xếp sao cho phản ánh đúng nhất mức cường độ lý tưởng được mong đợi. Kết quả nghiên cứu cho thấy rằng các không gian sản phẩm có sự tương đồng cao. Tuy nhiên, khi so sánh với phương pháp IPM-QDA, phương pháp IPM-RDA giúp cải thiện khả năng phân biệt, nâng cao mức độ đồng thuận giữa các thành viên và giảm mức độ dao động trong kết quả mô tả sản phẩm lý tưởng. Những kết quả đạt được chỉ ra rằng, xếp hạng mang lại hiệu quả hơn cho điểm trong việc thu thập dữ liệu mô tả từ những người tiêu dùng không qua huấn luyện.**

***Từ khóa*—Kỹ thuật mô phỏng các elip biểu diễn độ tin cậy, Phương pháp sản phẩm lý tưởng, Phân tích đa nhân tố, Kỹ thuật xếp hạng, Kỹ thuật cho điểm.**