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The Study of the Taste of Taiwanese Common Foods by Using Grey Clustering -Taking Taiwanese Sticky Rice, Tube Rice Cake and Braised Pork Rice as Example

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Abstract

Due to their migration from Taiwan to mainland China, Taiwanese people initially focused on basic sustenance in their diet, eventually developing affordable, everyday foods. Through practical exploration, Taiwanese sticky rice, rice cake, braised pork rice,and other similar dishes became the most representative examples. However, past research has primarily focused on packaging and traditional mathematical analysis, did not exist the analysis of taste. Therefore, the paper uses grey clustering with objective weighted analysis to analyze the relationship among factors influencing taste. First, based on expert opinions in this field, evaluation values for each influencing factor are obtained. Then, a mathematical model is used to calculate the degree of interrelationship among these factors. To being the new innovatiion in this research area, the paper also transforms the traditionally ordinal approach into a cardinal analytical framework.

Keywords: Taiwanese sticky rice, Rice cake, Braised pork rice, Taste, Grey clustering

1.Introducrion

Rice cake, oily rice, and braised pork rice are all famous Taiwanese snacks. What are the differences between them? At first glance, Taiwanese sticky rice, rice cake, braised pork rice are all made by cooking rice and then adding toppings or sauces. However, there are many differences among them. The article mainly focuses on the ingredients and production process, with taste as the main aspect, to explore the relationship among the influencing factors of the three types of Taiwanness snacks[1]

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1.1 Taiwanese Sticky Rice

Taiwanese sticky rice is a type of dry rice made from glutinous rice. The traditional way to make oil rice is to stir-fry the glutinous rice with oil over low heat until cooked. The main process is to steam the glutinous rice and then stir it with a variety of ingredients such as pork, squid, shrimp, chestnuts, shredded meat, lard, mushrooms, coriander and fried shallots to add richness and aroma. Currently, most of the processing methods are steaming, which has the advantages of being healthier and less greasy[2,3]. Taiwanese sticky rice is usually served as a banquet during festivals and when a child is one month old. It can be bought in traditional markets. For example, in Changhua city, the price of 300 grams was US$2.5 in 2025. There is also a derivative Taiwanese sticky rice with duck. In Changhua City, the price of 300 grams was US$1.8 in 2025[4]. Among the related products are zongzi (sticky rice dumplings). In Changhua city will cost US$1.5 for 300 grams in 2025. It contains pork, mushrooms and egg yolk, where the bamboo leaves account for about 3.5% of the price.

Fig. 1 Traditional Taiwanese sticky rice
(Thanks Changhua city He Family Taiwanese sticky rice for providing the photo)

1.2 Rice Cake

Rice cakes are also made from glutinous rice. After the glutinous rice is cooked, it is topped with minced meat, fish floss and peanuts when it is ready to eat. It is then garnished with pickled yellow slices and dried bamboo shoots. It is called salty rice cake. The price of 180 grams rice cake in Changhua is US$1.5 in 2025[5].

Besides, sweet rice cakes are made by steaming glutinous rice and then mixing it with sugar or red beans. They are used in Taiwan when worshipping. The sweet rice cake with dried longan in Figure 3 contains dried longan, brown sugar and goji berries. The price of sweet rice cake from Hualien City Farmers' Association Supermarket costs US$1.1 for 180 grams in 2025[6].

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Fig. 2 The salty rice cake
(Thanks Changhua city Ding Feng Ting Zhuang for providing the photo)

In addition, there is also tube rice cake in Taiwan. The ingredients are similar to those of regular rice cake, but the preparation method is slightly different. The main difference is that the ingredients are steamed in a small cylindrical container, then the rice cake is inverted onto a serving dish, topped with fish floss and pickled cucumber slices, and then drizzled with tomato sauce for flavor. Since all the ingredients are steamed together, it is greasier than regular rice cake. The rice cake from Changhua costs US$1.8 for 180 grams in 2025[7].

Fig. 3 The sweet rice cake
(Photo is from Hualien city Farmers' Association Supermarket)

Fig. 4 The tube rice cake and container
(Thanks Changhua city Chu Migao for providing the photo)

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1.3 Braised Pork Rice

Braised pork rice is made with regular cooked Penglai rice. After the Penglai rice is cooked, it is topped with pre-prepared minced pork belly and garnished with pickled yellow radish slices [8]. 180 grams of braised pork rice in Changhua city costs US$1.3[5]. In addition, there are also derivative takikomigohan, 200 grams of sweet potato rice in Douliu city will cost US$1.0 in 2025[9].

Fig. 5 Braised pork rice
(Thanks Changhua city Ding Feng Ting Zhuang for providing the photo)

2.Literature Review

In the relevant research of the paper, it can conclude as shown below: In the field of packaging design, based on literature and market practice data, a questionnaire was designed as a research tool, and used rolling sampling method to conduct a survey of general consumers. The traditional statistical method was used for analysis, whch totally 403 questionnaires, then obtained the characteristics of creating a happy image and the marketing strategy of packaging function diversity, which can be used as a reference for the industry in the design of Taiwanese sticky rice gift box packaging[11]. Taking a self-created brand of handmade traditional rice cake as an example, the concept of innovative brand image was used to create a local specialty food brand belonging to the local community[12]. And through the literature on food packaging and the collection of well-known domestic Taiwanese sticky rice brand packaging, the design elements of color, shape, visual presentation and information labeling were summarized and analyzed to the upper-middle class consumers [13].

About research in the field of production management related to mathematical models included comparing the differences in the production process and product texture of two types of rice, Taichung Glutinous Rice No. 1 and Taichung Glutinous Rice No. 70, under different frying temperatures and times, and finding the most suitable processing conditions for instant glutinous

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rice oil rice to obtain the optimal instant glutinous rice[14]. An open-ended questionnaire was conducted on 100 housewives using convenience sampling. They compared the differences between five types of rice, namely purple glutinous rice, fragrant rice, multigrain rice, Penglai rice and brown rice, based on four influencing factors, which are taste, appearance, aroma and purchase intention[15]. The relationship of six characteristics of long glutinous rice and Penglai rice products, namely color difference, expansion rate, whiteness, brightness, solubility and moisture content, was studied using the response surface methodology [16]. A ordianl research method was adopted, relying on expert interviews to collect data, and then using SWOT analysis to understand the impact of the declining birth rate on the industry and propose coping strategies[17,18]. According to mentioned above, using soft computational method for analysis the relevant field was seldom, Therefore, the paper can be said is the pioneer in the study.

3.Grey Statistical Clustering

If multiple factors are to be considered in a comprehensive manner for the system to be analyzed, it is necessary to comprehensively evaluate the decision object which according to multiple different decision indicators, that in order to determine whether the decision object meets the given selection criteria. The grey statistical clustering analysis is very suiable to meet this requirement and can be used in this field [19].

3.1 The Whiteness Weighting Function

Let $f(x)$ be a monotonically linear function of x, where x is the grey quantity, and $f(x) \in [0,1]$. Then $f(x)$ is called the whitening weight function of the grey quantity x, where $f(x) = 1$ is written as $f_{\max}$, and is generally divided into three forms, which are high, medium and low.

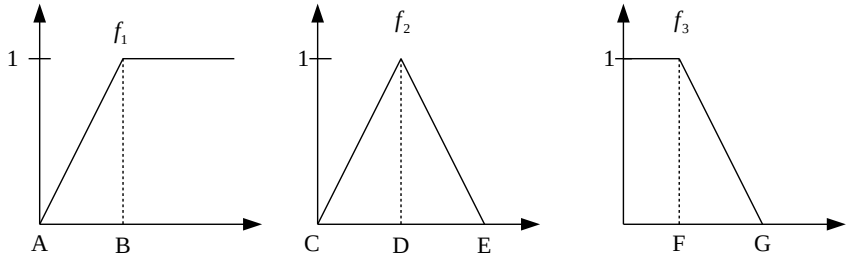

Fig. 6 Whiteness weighting function (high, medium, and low)

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3.2 Basic Mathematic Model

1.Identify $a_1, a_2, a_3, \ldots, a_m$ are the statistical objects, $b_1, b_2, b_3, \ldots, b_n$ are the statistical index, and, $f_1, f_2, f_3, \ldots, f_l$ are the whitening weight function.

where: $m, n, l \in N$, and the real number d_{ij} is the sample value of the *i*-th statistical object for the *j*-th statistical index. Means under d_{ij}, $1 \le i \le m,\ 1 \le j \le n$, it can get the *D* matrix with d_{ij} as its element

$$D = \begin{bmatrix} d_{11} & d_{12} & \ldots & d_{1n} \\ d_{21} & d_{22} & \ldots & d_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ d_{m1} & d_{m2} & \ldots & d_{mn} \end{bmatrix} \tag{1}$$

2 F is a mapping, and $F: op[f_k(d_{ij})] \to \sigma_{jk} \in [0,1]$, for $k \in N$, $1 \le i \le m,\ 1 \le j \le n$, then we can get

$$\sigma_j = (\sigma_{j1}, \sigma_{j2}, \sigma_{j3}, \ldots, \sigma_{jl}),\ 1 \le j \le n \tag{2}$$

where the σ_j is called weighting vector sequence, and F is called grey statistics.

3.3Calculation Steps

1.Subjectively give the values of the whitening weight function $f_1, f_2, f_3, \cdots, f_l$.

2.Calculate the corresponding value of statistical index j for all given whiteness weighting functions $f_k(d_{ij})$.

$$\begin{aligned} \sum_{i=1}^{m} f_1 &= f_1(d_{1j}) + f_1(d_{2j}) + f_1(d_{3j}) + \ldots + f_1(d_{mj}) \\ \sum_{i=1}^{m} f_2 &= f_2(d_{1j}) + f_2(d_{2j}) + f_2(d_{3j}) + \ldots + f_2(d_{mj}) \\ &\cdots\cdots \\ \sum_{i=1}^{m} f_l &= f_l(d_{1j}) + f_l(d_{2j}) + f_l(d_{3j}) + \ldots + f_l(d_{mj}) \end{aligned} \tag{3}$$

3.Calculate the sum of the corresponding values for all given whiteness weighting functions.

$$\sum f = \sum_{i=1}^{m} f_1 + \sum_{i=1}^{m} f_2 + \sum_{i=1}^{m} f_3 + \ldots + \sum_{i=1}^{m} f_l \tag{4}$$

4.Calculate and normalize the weighting σ_j for each statistical index *j*.

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$$\sigma_{j1}=\frac{\sum_{i=1}^{m} f_1}{\sum f},\sigma_{j2}=\frac{\sum_{i=1}^{m} f_2}{\sum f},\cdots,\quad \sigma_{jl}=\frac{\sum_{i=1}^{m} f_l}{\sum f} \tag{5}$$

5.The maximum value of the weighting in the vector is the statistical grey class relative to the statistical object.

$$\max.(\sigma_j)=\max.(\sigma_{j1},\sigma_{j2},\sigma_{j3},...,\sigma_{jl}) \tag{6}$$

6.Repeat steps (1) to (5) to determine the statistical grey class of other statistical objects.

7.From the results of the statistical grey class, the percentage of each grey class in the whole system can be found.

4.Calculation and Analysis

4.1 Analysis Objects and Factors

Because Taiwanese sticky rice with duck and takikomigohan are not very common in traditional dish, and zongzi must be removed from the bamboo leaves before eating, which is not very convenient. Therefore, the paper takes four commoner's dishes as the analysis objects: Taiwanese sticky rice(x_1), salty rice cake(x_2), tube rice cake(x_3) and braised pork rice(x_4). Degree of color, aroma, degree of *Q*, softness and price are the analysis factors. The numerical values of the expert evaluation are presented as shown in Table 1 [14].

The meaning of four signifivant factors are explanation in the below.

1.Degree of color: The color of the rice grains.

2.Aroma: The aroma emitted by the entire grain of rice.

3.Degree of *Q*: The flexable of rice grains when eating.

4.Softness: The springy of rice grains when eating.

Table 1 The evaluation scores of significant factor assessed by experts (from 1 to 10 points)

Type/factor	Degree of color	Aroma	Degree of Q	Softness	Price(180g)
x_1	7.85	8.75	8.7	8.9	45
x_2	8.25	8.0	8.4	8.2	45
x_3	8.0	7.5	8.0	8.25	50
x_4	8.5	7.7	7.8	9.0	40

4.2 Analysis Steps

1 Since the pricesm of four object are quite similar, the price factor is removed,

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and the statistical objects are degree of color, aroma, degree of Q and softness.

2.The statistical index are Taiwanese sticky rice (x_1), salty rice cake(x_2), tube rice cake(x_3) and braised pork rice(x_4)

3. f_1, f_2 and f_3 are the whiteness weighting functions, and is given by the experts.

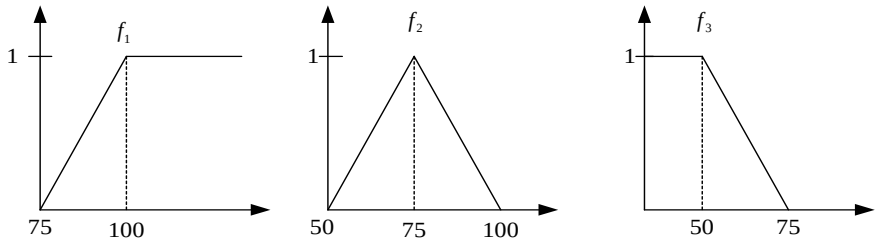

Fig. 7 Whiteness weighting function from experts (high, medium, and low)

According to the values from Table 1, $D = \begin{bmatrix} 7.85 & 8.75 & 8.7 & 8.9 \\ 8.25 & 8.0 & 8.4 & 8.2 \\ 8.0 & 7.5 & 8.0 & 8.25 \\ 8.5 & 7.7 & 7.8 & 9.0 \end{bmatrix}$,

4.3 Actual Calculation

4.3.1 Degree color

1.Calculate the corresponding value of statistical index *j* for all given whiteness weighting functions.

$$\sum_{i=1}^{4} f_1 = f_1(7.85) + f_1(8.25) + f_1(8) + f_1(8.5)$$

$$=0.2833+0.4167+0.3333+0.5000 =1.5333$$

$$\sum_{i=1}^{4} f_2 = f_2(7.85) + f_2(8.25) + f_2(8) + f_2(8.5)$$

$$=0.9250+0.8750+1.0000+0.7500 =3.5500$$

$$\sum_{i=1}^{4} f_3 = f_3(7.85) + f_3(8.25) + f_3(8) + f_3(8.5)$$

$$=0.0000+0.0000+0.0000+0.0000=0.00000$$

2.Calculate the sum of the corresponding values for all given whiteness weighting functions.

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$$\sum f = \sum_{i=1}^{4} f_1 + \sum_{i=1}^{4} f_2 + \sum_{i=1}^{4} f_3 = 1.5333 + 3.5500 + 0.0000 = 5.0833$$

3.Calculate and normalize the weighting for each statistical index *j*.

$$\sigma_1 = \frac{1.5333}{5.0833} = 0.3016, \quad \sigma_2 = \frac{3.5500}{5.0833} = 0.6984, \quad \sigma_3 = \frac{0.000}{3.600} = 0.0000$$

4.The maximum value of the weighting in the vector is the statistical grey class relative to the statistical object.

max. (0.3016, 0.6984, 0.0000)=0.6984= σ_{12}

4.3.2 Aroma

1.Calculate the corresponding value of statistical index *j* for all given whiteness weighting functions.

$$\sum_{i=1}^{4} f_1 = f_1(8.75) + f_1(8.0) + f_1(7.5) + f_1(7.7)$$

$$= 0.5833 + 0.3333 + 0.1667 + 0.2333 = 1.3167$$

$$\sum_{i=1}^{4} f_2 = f_2(8.750 + f_2(8.0) + f_2(7.5) + f_2(7.7)$$

$$= 0.6250 + 1.0000 + 0.7500 + 0.8500 = 3.2250$$

$$\sum_{i=1}^{4} f_3 = f_3(8.75) + f_3(8.0) + f_3(7.5) + f_3(7.7)$$

$$= 0.0000 + 0.0000 + 0.0000 + 0.0000 = 0.0000$$

2.Calculate the sum of the corresponding values for all given whiteness weighting functions.

$$\sum f = \sum_{i=1}^{4} f_1 + \sum_{i=1}^{4} f_2 + \sum_{i=1}^{4} f_3 = 1.3167 + 3.2250 + 0.0000 = 4.5417$$

3.Calculate and normalize the weighting for each statistical index *j*.

$$\sigma_1 = \frac{1.3167}{4.5417} = 0.2899, \quad \sigma_2 = \frac{3.2250}{4.5417} = 0.7101, \quad \sigma_3 = \frac{0.0000}{4.5417} = 0.00000$$

4.The maximum value of the weighting in the vector is the statistical grey class relative to the statistical object.

max.(0.2899 , 0.7101 , 0.0000)= 0.7101= σ_{22}

4.3.3 Degree of Q

1.Calculate the corresponding value of statistical index *j* for all given whiteness weighting functions.

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$$\sum_{i=1}^{4} f_1 = f_1(8.7) + f_1(8.4) + f_1(8.0) + f_1(7.8)$$

$$=0.5667+0.4667+0.3333+0.2667 =1.6333$$

$$\sum_{i=1}^{4} f_2 = f_2(8.7) + f_2(8.4) + f_2(8.0) + f_2(7.8)$$

$$=0.6500+0.8000+1.0000 +0.9000 =3.3500$$

$$\sum_{i=1}^{4} f_3 = f_3(8.7) + f_3(8.4) + f_3(8.0) + f_3(7.8)$$

$$=0.0000+0.0000+0.0000+0.0000=0.0000$$

2.Calculate the sum of the corresponding values for all given whiteness weighting functions.

$$\sum f = \sum_{i=1}^{4} f_1 + \sum_{i=1}^{4} f_2 + \sum_{i=1}^{4} f_3 =1.6333+3.3500+0.0000=4.9833$$

3.Calculate and normalize the weighting for each statistical index *j*.

$$\sigma_1 = \frac{1.6333}{4.9833} =0.3278, \quad \sigma_2 = \frac{3.3500}{4.9833} =0.6722, \quad \sigma_3 = \frac{0.0000}{4.9833} =0.0000$$

4.The maximum value of the weighting in the vector is the statistical grey class relative to the statistical object.

max. (0.3278 , 0.6722 , 0.0000)= 0.6722= σ_{32}

4.3.4 Softness

1.Calculate the corresponding value of statistical index *j* for all given whiteness weighting functions.

$$\sum_{i=1}^{4} f_1 = f_1(8.0) + f_1(8.2) + f_1(8.25) + f_1(9)$$

$$=0.6333+0.4000+0.4167+0.6667=2.1167$$

$$\sum_{i=1}^{4} f_2 = f_2(8.0) + f_2(8.2) + f_2(8.25) + f_2(9)$$

$$=0.5500+0.9000+0.8750+0.5000 =2.8250$$

$$\sum_{i=1}^{4} f_3 = f_3(8.0) + f_3(8.2) + f_3(8.25) + f_3(9)$$

$$=0.0000+0.0000+0.0000+0.0000=0.0000$$

2.Calculate the sum of the corresponding values for all given whiteness weighting functions.

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$$\sum f = \sum_{i=1}^{4} f_1 + \sum_{i=1}^{4} f_2 + \sum_{i=1}^{4} f_3 = 2.1167+2.8250+0.0000 = 4.9417$$

3.Calculate and normalize the weighting for each statistical index *j*.

$$\sigma_1 = \frac{2.1167}{4.9417} = 0.4283, \quad \sigma_2 = \frac{2.8250}{4.9417} = 0.5717, \quad \sigma_3 = \frac{0.0000}{4.9417} = 0.0000$$

4.The maximum value of the weighting in the vector is the statistical grey class relative to the statistical object.

max. (0.4283 , 0.5717 , 0.0000)= 0.5717= σ_{42}

Based on the values are calculated, the final results are shown in Table 2, and also to draw the percentage chart for each indexs, as shown in Fig. 8.

Table 2 The results of clustering analysis(%)

Factor/clustering	High	Medium	Low
Degree of color	30.16	69.84	0.00
Aroma	28.99	71.01	0.00
Degree of Q	32.78	67.22	0.00
Softness	42.83	57.17	0.00

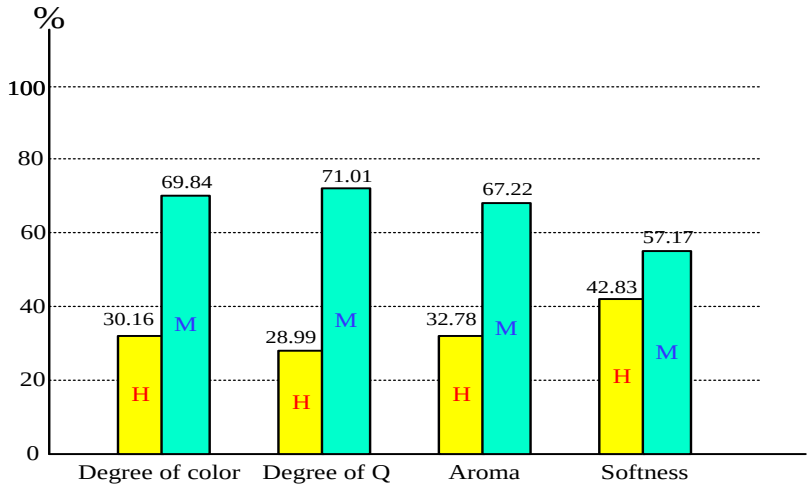

Fig. 8 Percentage distribution of each significant factors

5.Conclusion

The rice dishes presented in this paper-Taiwanese sticky rice, tube rice cake and braised pork rice -have been staples of the common people for thousands of years due to their affordable price. While quite common, their

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evolution into today's food scene presents challenges in matching them with relevant influencing factors. Therefore, the paper proposes a grey clustering method by using objective weight analysis to improve the past shortcomings of traditional analytical methods. Four influencing factors are proposed: degree of color, aroma, degree of Q and softness. Through integration of expert opinions and computational analysis, the relationship between each influencing factor is under cardinal stste. Table 2 shows that all four factors are within the acceptable range, and all areclosed into moddle level, which aligns well with actual conditions.

Overall, the paper integration of grey clustering into the cardinal study of common people's diets is anew approaching in this field. It allows for a better understanding of the combination of relevant content and mathematics. If other relevant mathematical methods are combined, and the high, medium, and low scaling values in the clustering are adjusted based on expert opinions for some verifications, the results may be even more convincing.

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Information for Authors

Types of Contributions

Upon acceptance of a paper, authors will be requested to supply their biographies (100 to 200 words) and the final version of their manuscript on a computer diskette along with the hard copy. The manuscripts should be typed by Microsoft Word 7.0 (or upgrade version) and submitted to Chief Editor or Executive Editor. Electronic submission (in doc, or zip compressed postscript) of manuscripts is required.

Manuscripts

Submitted manuscripts must be typewritten in English. All submitted manuscripts should be as concise as possible, and the regular papers are normally limited to 30 typed pages.

Style for Manuscript

Papers should be arranged in the following order of presentation:

1. First page must contain: Title of paper (without Symbols); Author(s); Abstract, 4 to 6 suggested keywords; Completed affiliation(s), email address and mailing address of correspondence author.
2. The text(insert the Tables and Figures)
3. Acknowledgements of financial or other support (if any).
4. References

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5. Appendix(if necessary)

Style for Illustrations

1. Original drawings should be in black ink on white background. Maximum size is not large than 15 by 22.7 cm.
2. All lettering should be large enough to permit legible reduction of the Figure to column width, sometimes as small as one quarter of the original size.

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