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An Interactive Computerized Method for Rank Analysis

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Abstract. **An interactive computer program, written in Fortran as implemented on a microcomputer, was designed to do rank analysis. The program minimizes the time involvement in the determination of rank analyses and thus facilitates the study of rank responses. Although the system still included manual typing of the raw ranks into the microcomputer, the calculations of rank totals and subsequent rank analysis to determine significant differences among the ranks was performed much faster than an analogous manual handling of the same data.**

Experimentalists often are confronted with the task of evaluating similarly processed products made with raw material from different cultivars. The job of analyzing the results in a meaningful manner can be overwhelming and burdensome when evaluating a large number of breeding lines. A good place to start is rank analysis, a recognized statistical technique (1, 2, 3, 4, 5, 6, 7, 8) in which significant differences among samples are determined based upon rank scores.

In rank analysis, judges are requested to rank, in order of preference, the samples of interest. The totals of all rank scores then are calculated for each sample. The totals are compared to upper and lower limits defining a range of statistically nonsignificant differences. Rank sums would have to fall above and/or below this significance range in order to be determined as having a significantly better or worse rank.

Although the technique of rank analysis is straightforward, many would-be users shy away from its use due to the time involvement of manual methods. These include: 1 — collecting the rank scores, 2 — calculation of the rank sums, 3 — checking a table of significant rank totals and 4 — reranking if necessary. The entire process can be very cumbersome to manage, and highly time consuming. These negative aspects tend to reduce its use where it could be of most benefit.

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The use of microcomputers in sensory analysis has been proposed as a valuable tool, both as a time-saving device and a means by which versatility may be developed (9, 10). Our objective was to develop a computer program for rank analysis. The program would calculate rank sums after raw data input, calculate binomial coefficients, and derive limits for significant rank totals. Additionally, the software would separate and display the significantly different rank totals.

The equipment used was an 8-bit, Z80A microprocessor-based, S-100 bus microcomputer system (TecMar Inc., Cleveland, Ohio) with 64K of memory. The results were printed on an IDS Prism Printer (Integral Data Systems, Milford, NH.) when hardcopy was needed. The complete system was mounted on a rolling rack for portable use. Program and data storage was accomplished using 8-inch soft-sectored disk drives.

The software was written in Fortran-80 (Microsoft Inc., Bellevue, Wash.) as implemented on a CP/M operating system (Digital Research Inc.). This program and its related data storage requirements accounted for about 20K of memory. The software was designed to emulate as close as possible the methodology employed by Kramer et al. (8) in their approach to this type of analysis. Although the software was written in Fortran, its design is highly compatible with BASIC or Pascal, 2 languages commonly found on microcomputers and could be translated easily. Copies of the Fortran program are available from the senior author.

The interactive program starts by requesting from the sensory analyst the product, source, date, and time. Specific information also is requested concerning the number of samples, number of judges, and the desired significance level for testing purposes. In the design of the software it was assumed that the analyst is interested in any observed rank total exceeding the upper limit or being exceeded by the lower limit. At this point, appropriate binominal coefficients are calculated using an abbreviated Pascal's Triangle Method (11). Calculations are made to determine the upper and lower range of rank totals, outside of which fall any significant totals. The lowest possible rank total for any given treatment would be equal to "r" and the largest would be equal to "tr". These 2 possibilities would occur only once, the remaining would be symmetrically distributed among the other possible rank totals. The probability (P) that the sum of the ranks (S) is less than or equal to a test number (n) is calculated based on equation 1 as derived by Doornbos and Prins (2, 3). The equation is:

$$P[s = n] = \left[\binom{n}{r} - \binom{r}{1}\binom{n-t}{r} + \binom{r}{2}\binom{n-2t}{r} \cdots\right] t^{-r}. \quad [1]$$

The proper test number (n) is reached by testing possibilities in sequential order starting with one. Once the specific test number (n) is known for a required probability level, i.e., 95%, it constitutes the lower limit. The upper limit (UL) of the range is easily determined using equation 2.

$$UL = (t \times r) - n + r \quad [2]$$

Finally, the program requests the remainder of the information from the sensory analysts including sample names, judges' initials, and scores. The rank totals then are calculated and displayed in relation to the upper and lower limits.

The computerized rank analysis was incorporated into the evaluation portion of our apple breeding program. In a sample session, 10 processed applesauce samples were evaluated. The 5 expert judges determined their evaluations on a varietal evaluation form. The form included sample code and 3 rating columns of unacceptable, acceptable, and superior. One of the 3 columns was to be checked for each sample. Additionally, a small amount of room for comments and a column to determine the rank of each sample was included for each sample. Immediately after evaluation of all of the samples, the information was typed into the microcomputer where a printout of the analysis was obtained (Fig. 1). In the sample session described here one sample, NY-415, was noted as being significantly worse than the others. On the reranking that followed, no statistically significant differences were found among the remaining samples.

This software system greatly reduces the time and effort required for: 1) the calculation of rank totals; 2) derivation and comparison to an appropriate range, and 3) determination of what samples to withdraw or include in a follow-up reranking.

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                    RANK ANALYSIS PROGRAM
                DEPT. FOOD SCIENCE & TECHNOLOGY

PRODUCT: 81SAUCE      SOURCE: R.WAY
DATE   : 4/6/83       TIME  : 9:30AM

                  RAW RANK SCORES FOR EACH SAMPLE
JUDGE                          SAMPLE NO.
NAME      1    2    3    4    5    6    7    8    9    10
-------------------------------------------------------------------------
MRM       2    1    3    4    9    6    5    8    7    10
RWK       6    4    5    8    9    7    2    3    1    10
RW        1    4    6    7    5    8    9    2    3    10
KL        7    4    8    3    9    10   1    5    2    6
LRL       2    3    5    6    4    9    1    7    8    10
-------------------------------------------------------------------------
RANK      18   16   27   28   36   40   18   25   21   46
TOTALS
=========================================================================

        SAMPLE SPREAD - SECTIONS SIGNIFICANTLY DIFFERENT @ 5% LEVEL

********** LOWER LIMIT =    12  ********************************

SAMPLE#   1    PROD-CODE =    NITTANY          RANK TOTAL =   18
SAMPLE#   2    PROD-CODE =    NY-409           RANK TOTAL =   16
SAMPLE#   3    PROD-CODE =    NY-269           RANK TOTAL =   27
SAMPLE#   4    PROD-CODE =    NY44408-11       RANK TOTAL =   28
SAMPLE#   5    PROD-CODE =    NY-266           RANK TOTAL =   36
SAMPLE#   6    PROD-CODE =    NY-418           RANK TOTAL =   40
SAMPLE#   7    PROD-CODE =    NY-422           RANK TOTAL =   18
SAMPLE#   8    PROD-CODE =    NY-316           RANK TOTAL =   25
SAMPLE#   9    PROD-CODE =    SPIJON           RANK TOTAL =   21

********** UPPER LIMIT =       43 **************************

SAMPLE#   10   PROD-CODE =    NY-415           RANK TOTAL =   46

=========================================================================

                  ****  ORDERED RANK TOTALS  ****

SAMPLE:   2    SAMPLE NAME:   NY-409           RANK TOTAL     =   16
SAMPLE:   1    SAMPLE NAME:   NITTANY          RANK TOTAL     =   18
SAMPLE:   7    SAMPLE NAME:   NY-422           RANK TOTAL     =   18
SAMPLE:   9    SAMPLE NAME:   SPIJON           RANK TOTAL     =   21
SAMPLE:   8    SAMPLE NAME:   NY-316           RANK TOTAL     =   25
SAMPLE:   3    SAMPLE NAME:   NY-269           RANK TOTAL     =   27
SAMPLE:   4    SAMPLE NAME:   NY44408-11       RANK TOTAL     =   28
SAMPLE:   5    SAMPLE NAME:   NY-266           RANK TOTAL     =   36
SAMPLE:   6    SAMPLE NAME:   NY-418           RANK TOTAL     =   40
SAMPLE:   10   SAMPLE NAME:   NY-415           RANK TOTAL     =   46
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Fig. 1. Example output from rank analysis program used for quality evaluation of applesauce made from 10 apple breeding lines.

We have found the rank analysis with the use of the computer to be a strong asset. It permitted a statistically appropriate approach to a setting (cultivar cutting or new recipe cutting) which is often left to a few "experts" trying to decide, through discussion, which is best. Although discussion is needed during cuttings, individuals are too often swayed by the more vocal or more prestigious members of the judging panel.

A number of enhancements to the computer program were seen as desirable for future versions. Some form or file storage may be useful if further analysis on the data is desired. This also would open up the possibility of maintaining comparative records of how panelists evaluated samples from one time to another. To enhance the time savings, data entry might be shifted to mark-sense cards. This would allow rankings to be read immediately from penciled cards thus reducing further the amount of time devoted to data input and analysis rather than actual evaluation.

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