The Pharma Innovation Journal 2018; 7(11): 405-408

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(11): 405-408

www.thepharmajournal.com
Received: 25-09-2018
Accepted: 27-10-2018

Sumeet Saurav
Ph.D. Scholar, ICAR-Indian Agricultural Statistics Research Institute, PUSA, New Delhi, India

Cini Varghese
Principal Scientist, ICAR-Indian Agricultural Statistics Research Institute, PUSA, New Delhi, India

Eldho Varghese
Scientist, ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India

Seema Jaggi
Principal Scientist, ICAR-Indian Agricultural Statistics Research Institute, PUSA, New Delhi, India

Correspondence
Cini Varghese
Principal Scientist, ICAR-Indian Agricultural Statistics Research Institute, PUSA, New Delhi, India

Designs for sensory trials involving foods of animal origin

Sumeet Saurav, Cini Varghese, Eldho Varghese and Seema Jaggi

Abstract
Sensory quality is a basic factor that influences consumers while purchasing processed food of animal origin. Experimental designs will prove an effective tool in establishing a sensory fact in trials involving animal produce. To draw valid conclusion from a study, it is important to eliminate or minimize all sources of error and control all factors that may influence the inference. Hence, in addition to the potential sources associated with the preparation of the test products, variability due to measurement or assessment process, order effects, carryover effects and assessor fatigue are to be considered. When there are a large number of products, two operational constraints limit the choice of experimental designs *viz*., assessor constraint that sets a maximum number of products that an assessor can evaluate within a session before onset of sensory fatigue and preparation constraint that limits the number of products that can be prepared for a given session without loss of experimental control. Hence, it is many times necessary to split sensory evaluation into two sessions. Here, a general method to construct designs for sensory trials in two sessions, which are balanced for carry over effects within session, is proposed. The design is resolvable in the sense that panelist would get an opportunity to evaluate every product exactly once at the end of both the sessions.

Keywords: Carry over effects, efficiency factor, sensory trials, two-session trials, variance balance

Introduction

Sensory trial is an inevitable part of experiments with foods of animal origin *viz*., processed meat and poultry, fish and seafood products and dairy products. When a consumer wants to choose a particular type of food, it has to appeal his/her senses. The sensory facts like how a carton of milk smells and the colour of a packet of meat are equally critically examined by consumers as that of the official facts consisting of date of packing or the seal. All the senses must conspire to agree that taste, smell, colour and texture are appealing. Here comes the importance of sensory trials.

While conducting a sensory trial, in addition to the potential sources associated with the preparation of the products, there may be variability due to measurement or assessment process, order effects, carryover effects and assessor fatigue. There should be balancing in the order of presentation of the products to the assessors, but the sequences may be randomly assigned to assessors.

Amerine *et al*. (1965) [1] discussed some basic principles to be followed and analytical procedures for data obtained from sensory trials. Muir and Hunter (1991/1992) [8] evaluated order of tasting and residual effects of Cheddar cheese during a sensory study. They concluded that the influence of order of tasting and residual effects can be minimized and their magnitudes were calculated by application of well-proven principles of experimental design.

Schlich (1993) [14] illustrated the design and analysis of sensory trials taking into account the effects of serving order and previously assessed treatments. Crossover designs balanced for both presentation order and carry-over effects were used. The appropriate analysis of variance allowed the testing of these effects and the estimation of treatment means adjusted for carry over effects.

Wakeling and Macfie (1995) [17] discussed the problem of balancing out carry over effects of preceding samples in consumer trials when each consumer only receives *k* out of possible *t* products. For large trials, an 'all possible combinations approach' gave balance for all higher order effects. Kunert (1998) [7] emphasized the importance to use a design which is balanced for carry over effects and not to randomize the order in which the products are tasted. In most sensory studies the products are evaluated one after another and there is concern that the perception of panelists might be influenced by carry over effects.

Nonyane and Theobald (2007) [10] described the importance of using treatment sequences which were balanced for first order carry over effects when investigating the phenomenon experimentally with several types or levels of stimulus.
Avery and Masters (1999) [2] considered sensory evaluation experiments (*eg*. taste panels) using data from cooked pork. Judges could assess about six samples at each session before their ability to discriminate declines considerably. Thus allowance was made for effects due to judge, session and order of tasting as well as treatment. They advised on the use of design for sensory evaluation.
Jones and Wang (2000) [6] described methods of analyzing repeated measures in sensory studies from the perspective of a medical statistician. Husson and Pages (2003) [5] compared the sensory profiles of six dark chocolates done by two types of juries: trained jury and an untrained jury. Analysis of variance showed that the two types of juries gave similar sensory profiles and that the few differences were mainly due to different ways of using the scale. Naes *et al*. (2010) [9] described the most basic statistical methods for analysis of data from trained sensory panels and consumer panels with a focus on applications of the methods. Application of designs like factorial, fractional factorial, split-plot designs, nested designs, randomized complete block designs and incomplete block designs were discussed.
Recently, a lot of research is being conducted on sensory evaluation aspects of processed products from animal origin in India. Yadav *et al.* (2013) [19] conducted a sensory trial to determine effect on sensory attributes of soy protein (soy crumbles) extended chevon meat patties. Sharma *et al*. (2014) [16] studied sensory properties of probiotic dahi packed in oxo biodegradable and areca nut sheath cups. Patil *et al*. (2015) [11] evaluated the quality of burfi enriched with dried date through sensory analysis. Further, Salunkhe *et al*. (2015) [12] examined sensory characteristics of kheer fortified with carrot shreds.
When a large number of products are to be compared, mainly two operational constraints exist. On one hand, the panelist constraint sets a maximum number of products that can be assessed by a panelist in a session, before getting fatigue. *i.e*., after tasting many samples judges can no longer distinguish between good or bad. It is generally agreed that judges can taste 6-8 products before their discrimination declines badly. On the other hand, the preparation constraint restricts the number of products that can be prepared in a session of cooking. It is usually the panelist constraint which is the more limiting. Therefore, it is many times necessary to split sensory evaluations into two sessions. Most of the sensory trials are designed using incomplete blocks, in which all panelists evaluate a subset of samples (mostly half) in each of the two session. If resolvable designs are used for the trial, the same judge will not have to taste the same product twice during two different sessions and at the same time, each panelist would get an opportunity to evaluate every product exactly once at end of both the sessions.
Deppe *et al.* (2001) [3] developed a multi-step procedure to obtain nested incomplete block designs for judging some contrasts with higher precision than others taking into account of both assessor constraint and preparation constraint. It was identified that assessor fatigue was unrelated to kitchen constraint, but was more serious in nature. Nested incomplete block designs provided an opportunity to take proper care of both the constraints, and gave more precise product comparisons. The new multi-stage procedure yielded such designs and criteria for assessing their quality was described. This was extended for situations in which the products were of factorial structure and illustrated how some contrasts were judged with more importance than others.
More recently, Saurav *et al*. (2017) [13] developed a method based on initial sequences to construct designs resolvable multi-session sensory trials balanced for carry over effects. However, as these methods are based on initial sequences, there is a limitation on the number of products for which the designs can be developed.
Here, a general method of constructing designs for sensory trials in two sessions has been developed. The method of construction is based on Williams' Latin squares given by Williams (1949) [18]. These Latin squares are commonly used as single session changeover designs where treatments are balanced for first order carry over effects. These squares are used for making designs for sensory trials in two sessions for even as well as odd number of products. The contrasts pertaining to direct as well as carry over effects of various products are estimated with a constant variance indicating that these designs are variance balanced.

2. Materials and Methods

The following additive linear fixed effects model is considered:

$$y_{j(i)klm} = \mu + \eta_i + \pi_{j(i)} + \psi_k + \tau_l + \rho_m + \varepsilon_{j(i)klm} \qquad (1)$$

$i = 1,2,\ldots,s;\ j = 1,2,\ldots,p;\ k = 1,2,\ldots,n;\ l, m = 1,2,\ldots,v;$

where μ is the general mean, η_i is the effect of i^{th} session, $\pi_{j(i)}$ is the effect of j^{th} period nested within the i^{th} session, ψ_k is the effect of k^{th} panelist, τ_l is the direct effect of l^{th} food product and ρ_m is the first order carry over effect of m^{th} food product given in the $(j - 1)^{th}$ period in session i to k^{th} panelist. $\varepsilon_{j(i)klm}$ is random error ~ $N(0,\sigma^2)$.
A SAS program has been written in PROC IML to calculate average variance of estimates of contrasts pertaining to direct effects $V(\widehat{\tau_i - \tau_j})\sigma^{-2}$ and the average variance of estimates of contrasts pertaining to carry over effects $V(\widehat{\rho_i - \rho_j})\sigma^{-2}$ of different products for all the designs belonging to the proposed class.
The canonical efficiency factor of the proposed designs in terms of direct effects of products relative to an orthogonal design with the same number of products has been computed by working out the harmonic mean of (1/*r*) times the non-zero eigen values of the information matrix [Dey, 2008] [4] where, *r* represents the number of replications of direct effects in the proposed design.

Williams squares

Williams (1949) [18] constructed a set of Latin squares having certain properties, subsequently called Williams squares. These Latin square(s) are balanced for first order carry over effects and are most popularly being used in crossover trials since then. Sharma (1975) [15] gave an easy method of constructing Williams squares. The various steps involved are as described:

- Let there be *v* products.
- Obtain a $v \times v$ Latin square for even *v* and two Latin squares for odd *v*.
- In these squares, number the rows from 1 to *v* in natural order, from top to bottom.
- Assign the product symbols 1, 2,…, *v* to the *v* cells in the first column, from top to bottom, in odd-numbered cells

in the first and even numbered cells in the second Latin square. Then reverse the direction, filling in even numbered cells in the first and odd numbered cells in the second Latin square.

- Develop the remaining columns of both the squares by adding 1 to each element of the previous column and reducing the elements, by mod *v*.

It is to be noted that in each of the constructed squares every numeral occurs in each row and in each column precisely once. Moreover, when *v* is even, each numeral is preceded exactly once by every other in either of the two squares. Thus, in this case either of the two squares may be used. This situation occurs in neither of the two squares if *v* is odd. However, when both the squares are considered together, one after another horizontally, each symbol is preceded by every other symbol two times. Hence, both the Latin squares must be used in odd case.

3. Methods of Construction of Designs

Designs for two-session sensory trials for even and odd number of products, considering pre-periods wherever necessary, balanced for first order carry over effects, are obtained using Williams Latin square(s). While designs for even number of products are obtained in equal number of periods per session whereas those for odd number of products are obtained in unequal number of periods per session.

Case I. Odd number of products

For any odd number of products ($v \geq 5$), first construct two Williams Latin squares and juxtapose these Latin squares horizontally one after another. Then partition the rows into two unequal parts so that the first part consists of (v -1)/2 rows and second part contains (v +1)/2 rows. Treating rows as periods (p) and columns as panelists (n), there are two sessions with unequal number of periods where the first session contains (v -1)/2 periods and second session containing (v +1)/2, periods and 2v panelists. Add a pre-period, consisting of last period products of the second session, before the first session. Observations are not recorded from the pre-period, but first period observations contain carry over effects of products given to this period.

Example: Let v = 5. A design for two-session sensory trials having parameters s = 2, p = 5 and n = 10 can be obtained using Williams squares as follows:

		Periods	**Panelists**									
			I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**
Sessions	I	0	3	4	5	1	2	3	4	5	1	2
		i	1	2	3	4	5	5	1	2	3	4
		ii	5	1	2	3	4	1	2	3	4	5
	II	iii	2	3	4	5	1	4	5	1	2	3
		iv	4	5	1	2	3	2	3	4	5	1
		v	3	4	5	1	2	3	4	5	1	2

The information matrix for the estimation of product effects is:

$$C = 7.46I_5 - 1.89J_5$$

Case II. Even number of treatments

Let there be an even number of products ($v \geq 4$) to be tested in a sensory trial. Construct a Williams Latin square for v and then partition it horizontally into two equal parts (sessions) such that both parts contain v/2 rows and v columns. Representing rows as periods (p) and columns as panelists (n), a series of designs for sensory trials for even number of products in two sessions each having v/2 periods and v panelists is obtained.

Example: For v = 6, a design for two-session sensory trials can be obtained using William square with parameters s = 2, p = 6 and n = 6 as follows:

		Panelists						
		Periods	**I**	**II**	**III**	**IV**	**V**	**VI**
Sessions	I	0	4	5	6	1	2	3
		i	1	2	3	4	5	6
		ii	6	1	2	3	4	5
		iii	2	3	4	5	6	1
	II	iv	5	6	1	2	3	4
		v	3	4	5	6	1	2
		vi	4	5	6	1	2	3

The information matrix for the estimation of product effects is:

$$C = 5.78I_6 - 0.96J_6$$

The variances, efficiency factors and other parameters v, s, p, n (for all ≤ 20) are listed in Table1. The designs obtained are variance balanced as all elementary contrasts pertaining to direct effects of various products are estimated with a constant variance and those pertaining to carry over effects of various products are estimated with another constant variance.

Table 1: Efficiency factors

S. No.	*v*	*p*	*n*	$V(\hat{\tau_i - \tau_j})\sigma^{-2}$	$V(\hat{\rho_i - \rho_j})\sigma^{-2}$	Efficiency Factor
1	4	4	4	0.550	0.800	0.909
2	5	5	10	0.211	0.277	0.947
4	6	6	6	0.345	0.428	0.965
5	7	7	14	0.146	0.175	0.975
7	8	8	8	0.254	0.296	0.981
8	9	9	18	0.112	0.128	0.985
9	10	10	10	0.202	0.227	0.988

4. Results and Discussion

The proposed method is based on Williams' Latin square(s) and yields designs for even as well as odd number of products. Both the cases require two sessions and takes into account of carry over effects within sessions. First case is for testing odd number of products and number of periods within each session is not the same. It gives designs that require $2v$ panelists. The second case is for even number of products and for equal number of periods per session. It requires only v panelists. Both cases give rise to variance balanced designs. Canonical efficiency factor for each design was worked out by writing SAS code in PROC IML and all the designs are found to be highly efficient.

5. Acknowledgements

The financial assistance received by the first author in the form of JRF from ICAR is acknowledged. The authors are thankful to the Director of IARI, New Delhi for providing the necessary facilities for the execution of this study.

6. References

1. Amerine MA, Pang born RM, Roessler EB. Principles of Sensory Evaluation of Food. Academic Press, New York, 1965.
2. Avery PJ, Masters GA. Advice on the design and analysis of sensory evaluation experiments using a case-study with cooked pork. The Statistician. 1999; 48(3):349-359.
3. Deppe C, Carpenter R, Jones B. Nested incomplete block designs in sensory testing: construction strategies. Food Quality and Preference. 2001; 12:281-290.
4. Dey A. Canonical efficiency factors and related issues revisited. Journal of Indian Society of Agricultural Statistics. 2008; 62(2):169-173.
5. Husson F, Pages J. Comparison of sensory profiles done by trained and untrained juries: methodology and results. Journal of Sensory Studies. 2003; 18(6):453-464.
6. Jones B, Wang J. The analysis of repeated measurements in sensory and consumer studies. Food Quality and Preference. 2000; 11:35-41.
7. Kunert J. Sensory experiments as crossover studies. Food Quality and Preference. 1998; 9:243-253.
8. Muir DD, Hunter EA. Sensory evaluation of cheddar cheese: order of tasting and carryover effects. Food Quality and Preference. 1991-1992; 1(3):141-145.
9. Naes T, Brockhoff P, Tomic O. Statistics for Sensory and Consumer Science. John Wiley and Sons Ltd, Norway, 2010.
10. Nonyane BAS, Theobald CM. Design sequences for sensory studies: Achieving balance for carry-over and position effects. British Journal of Mathematical and Statistical Psychology. 2007; 60:339-349.
11. Patil RV, Sawant P, Sawant D, Todkar SR. Physicochemical analysis and sensory evaluation of burfi enriched with dried date. Journal of Animal Research. 2015; 5:131-134.
12. Salunkhe MR, Sawant, PJ, Sawant DJ, Rai D. Physicochemical analysis and sensory evaluation kheer fortified with carrot shreds. Journal of Animal Research. 2015; 5:849-853.
13. Saurav S, Varghese C, Varghese E, Jaggi S. Resolvable multi-session sensory designs balanced for carryover effects. Journal of Indian Society of Agricultural Statistics. 2017; 71(2):121-126.
14. Schlich P. Uses of change-over designs and repeated measurements in sensory and consumer studies. Food Quality and Preference. 1993; 4:223-235.
15. Sharma VK. An easy method of constructing Latin square designs balanced for the immediate residual and other order effects. Canadian Journal of Statistics. 1975; 2(1):119-124.
16. Sharma B, Kumar S, Yadav S, Sharma J. Physicochemical and sensory analysis of probiotic dahi packed in oxo biodegradable and areca nut sheath cups. Journal of Animal Research. 2014; 4:59-64.
17. Wakeling IN, MacFie JH. Designing consumer trials balanced for first and higher orders of carry-over effects. Food Quality and Preference. 1995; 6:299-308.
18. Williams EJ. Experimental designs balanced for the estimation of residual effects of treatments. Australian Journal of Scientific Research. 1949; A2(3):149-168.
19. Yadav S, Tanwar VK, Sharma JK, Yadav S. Sensory attributes of chevon patties extended with soy protein. Journal of Animal Research. 2013; 3:85-90.