https://doi.org/10.29321/MAJ.10.000560 (online first)

RESEARCH ARTICLE

Conjoint Analysis for Optimizing the Level of Ingredients in Millet and Pulse based Ready-To-Eat (RTE) Extruded Product

Selvaprakash N[1*], Geetha P[2], Ayyavoo Preamnath Manoharan[3], Sudha K[4], Serma Saravana Pandian A[5]

[1]College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University, Koduveli, Chennai - 600 052.

[2]Department of Food Processing Technology, College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University, Koduveli, Chennai - 600 052.

[3]Department of Food Process Engineering, College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University,Koduveli, Chennai - 600 052.

[4]Department of Food Safety and Quality Assurance, College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University, Koduveli, Chennai - 600 052.

[5]Department of Animal Husbandry Economics, Madras Veterinary College, Tamil Nadu Veterinary and Animal Sciences University, Chennai - 600 007.

Corresponding author mail id: nselvaprakash1998@gmail.com

ABSTRACT

The present study was performed using conjoint analysis for optimizing the ingredients level in the development of millet and pulse-based Ready-To-Eat (RTE) extruded products. Conjoint analysis is a multivariate technique used to understand the preference of the product by the consumer, and it is helpful to formulate the prediction about the different ingredient levels in the product. Also, it is called "Trade-off analysis". The experimental design of treatments with several card ID lists about 9 numbers with different levels of ingredients used for developing the extruded product. The primary level of raw material was barnyard millet (*Echinochloa esculenta*) (40 %, 50 %, 60 %), chickpea (*Cicer arietinum*) (10 %, 20%, 30%) and Maize *Zea mays* (40 %, 50%, 60%). These principle levels of ingredients give more combinations so sensory panel members may give irresponsible and inappropriate results. The statistical tool conjoint analysis will reduce the number of treatments for optimizing the product. The selection of ingredients level in the development of millet and pulse based RTE extruded products was based on relative importance and utility estimate of quality attributes, which was given by conjoint analysis software program through panelist rank for sensory attributes using of 9 point hedonic scale. Hence, the ingredients combinations were found to be barnyard millet (60%), chickpea (20 %), and Maize (40 %). These combinations were optimized based on their higher level of relative importance and utility estimate.

Keywords: *Conjoint analysis; Millet and Pulse based extruded product; Ready-To- Eat; Barnyard millet; Utility estimate; Relative importance*

INTRODUCTION

The conjoint analysis method is based on the multi-attribute product concepts, i.e. on the premise that consumers assess the value or utility of a product by combining the separate amounts of utility provided by each ingredients level. The power of the method is to provide an explanatory model of consumers' liking, which can then be used to define the product concepts constituting the optimum combination of the attribute levels. The most crucial decision in the conjoint analysis is selecting the attributes to characterize the millet and pulse-based extruded snacks. When a vast number of combinations (3 × 3 × 3 = 27) are presented to the sensory panel, the non-response rate (due to fatigue, monotony) becomes very high. Fortunately, the number of cards can be reduced by generating an orthogonal array method using SPSS statistical software.

The food patterns and preferences of consumers is undergoing considerable changes worldwide due to rapid globalization, increasing urbanization, and fast-paced lifestyles. Children and adolescence age group mostly like snack foods. Due to increasing demand, the manufacturing of healthy snack foods is a big challenge for the snack manufacturing industry. Consumption of ready to eat snacks with high sugar, carbohydrate, and fat increases the risk of obesity, diabetes, and other lifestyle diseases. For that reason, people are more interested in healthy snacks. To overcome these harmful effects of these snacks, incorporating barnyard millet and chickpea in the ready-to-eat foods is encouraged gives nutritionally enriched snack to the people. Barnyard millet is the fourth most produced millet, which provides food security to many poor people across the world. India is the top most producer of barnyard millet in terms of area (0.146 m ha^{-1}), production (0.147 m t), with average productivity of 1034 kg ha^{-1} during the last 3 years (IIMR, 2018). Barnyard millet is a rich source of protein that is highly digestible and is also an excellent source of dietary fiber content; hence it is a more suitable crop for the bio-fortification of micronutrients such as iron and zinc [Reganathan *et al*. (2020)]. Barnyard millet is the effective hypoglycemic and hypolipidemic agent compared to rice, wheat, and other minor millets [Krishnakumari and Thayumanavan, (1997)]. It has low amount of slowly digestible carbohydrates [Veena *et al*. (2005)], which helps the people with sedentary lifestyle. However, the barnyard millet lacks some essential amino acids, namely tryptophan and lysine, which lowers the protein quality (Indira and Naik, 1971). The protein quality of barnyard millet-based product can be improved by blending it with chickpea as it is an excellent source of quality protein. Optimal incorporation of chickpea flour (21.87 % protein and 5.40 % fat) in snacks could increase the protein quality [Altaf *et al*., 2021)].

Extrusion processing is an advanced technology used in many food processing industries to develop ready to eat cereal snacks, baby foods, pasta, and pet food manufacturing where, starchy and protein-rich raw materials are being utilized [Hongyuan and Alan, (2010)]. Extrusion cooking is a thermo-mechanical process that exhibits many advantages, the key advantage being that the feeding ingredients undergo several physiochemical and biochemical unit operations like mixing, kneading, shearing, shaping, cooking, forming, drying [Hongyuan and Alan, (2010)] and another distinct advantage is that the gelatinization of starch, destruction of microorganism, inactivation of anti-nutrients, tannins [Nibedita and Sukumar, (2003)] and increase in the fiber digestibility in a single energy efficient and rapid process.

MATERIAL AND METHODS

Raw Materials

The raw materials shown in Figure 1. were used to prepare millet and pulse-based extruded snacks. Barnyard millet, chickpea, and maize grains were purchased from the local market of Poochiathipedu, Thiruvallur, Tamil Nadu, India.

Figure 1. Raw Materials used for development of millet pulse based extruded product

Barnyard Millet

Chickpea

Maize

Equipment

Twin-screw extruder

Twin-screw extruder of capacity, 15 kg / h (Basic Technology Pvt. Ltd., Kolkata) was used for the manufacture of extruded snacks (Figure 2). It consist of main drive provided with a 2.5 kW motor (380 - 440 V / 3 phase/ 50 Hz). The extruder barrel received the feed from co-rotating, variable speed feeder fitted with screw augers. The knob of the feeder controller controlled the rated capacity of the feeder. The 4 mm circular die was used to extrudates the materials.

Figure 2. Twin Screw Extruder

EXPERIMENTAL DESIGNS

Table 1 showed that the three levels of all ingredients used for development of millet and pulse-based extruded snacks through conjoint analysis.

Table 1. Levels of ingredients used in development of RTE snacks

S.No	Barnyard millet (%)	Chickpea (%)	Maize (%)
1.	40	10	40
2.	50	20	50
3.	60	30	60

The number of cards created is 9 as shown in Table 2. This card is the combination of ingredient levels of snacks. The created card list was given to the sensory panel to rank each card from 1 to 9 (1 – highly preferred to 9 – least preferred). With this preference data, conjoint analysis was performed.

Table 2. Card ID list of treatments for preparation of RTE snacks

Card Id List	Barnyard Millet (%)	Chickpea (%)	Maize (%)
1.	60	10	60
2.	50	30	40
3.	40	30	60
4.	60	20	40
5.	60	30	50
6.	50	20	60
7.	50	10	50
8.	40	20	50
9.	40	10	40

The process flow chart is shown in Figure 3. Barnyard millet, chickpea, and maize grains were cleaned by winnowing to remove foreign matters. Chickpea was roasted at 90 ^{o}C for 10 minutes and milled in a pulverizer. Barnyard millet and Maize were milled in a hammer mill. The measured quantities of barnyard millet flour, chickpea flour, and maize flour were mixed in a stainless steel vessel along with 20 % water and 3 % salt. Mixing should be done intermittently for 15 minutes. After thorough mixing, the mixture was passed through the 2 mm size sieve, for breaking the flour lumps and to obtain the uniform size mixture. The maize outer shells retained over the sieve were discarded as they were unsuitable for extrusion processing. The sieved flour mixture was once again softly blended for 10 minutes. The flour mix was transferred to stainless steel vessel covered with a lid for 90 minutes for pre-conditioning which would help the uniform distribution of moisture content throughout the flour mix.

The twin-screw extruder was turned on, and the first and second heating sections were set at 65 °C and 110 °C, respectively. After attaining the required temperature, the pre-conditioned flour mixture was fed into a feed hopper equipped with screw augers to load materials into the barrel at a uniform rate (10 kg/h). The feeder screw and extruder screw speeds were constant at 40 and 370 rpm. The twin screws then conveyed the material to the cooking section, which was heated by heat and friction of the food materials up to 65 °C. Then, it passes to the second heating section which was maintained at 110 °C. The starch present in the raw material was gelatinized due to the extrusion temperature and reduced space between screw and barrel in the heating section, which compressed the plasticized mass. The plasticized mass was then passed through a 4 mm die and exposed to the atmosphere, which led to the expansion of the extruded product because of the evaporation of water from the plasticized mass owing to a sudden drop in pressure. After the extrusion, extruded material was cut into pieces of the preferred length by a rotating-blade cutter. The extrudates were dried in an electric oven for 10 minutes at 140 °C to equilibrate the product moisture to 5-6 %. Dried extrudates were packed in metal laminated aluminium pouches and stored at room temperature.

Figure 3. Preparation of Millet and Pulse based extruded snacks

Barnyard millet | Chick pea | Maize

Roasting 90 °C for 10 minutes

Milling

Blending of flours as per the formulation

Addition of salt (3 %) and moisture (20 %)

Conditioning (90 minutes)

Extrusion processing

(Temperature - 65 and 110 °C; Screw speed - 370 rpm)

Drying (140 °C for 10 minutes)

Packaging

After the development of the product, sensory evaluation (9 - point hedonic scale) was done by 30 numbers of semi-trained sensory panelists and the scores were recorded for each number of treatments and was ranked based on the score of each treatment from higher level of preference to lower level of preference. The data was analyzed using conjoint analysis software.

RESULTS AND DISCUSSION

The conjoint analysis result showed the part-worth utility values and standard error for attribute levels. Utility refers to a number that represents the value that consumers place on an attribute (the relative worth of the attribute) i.e. higher utility values indicate a greater preference. Utilities can be added together to arrive at the total utility of any combination.

The range of the utility values for each attribute provides a measure of how important the attribute was to the overall preference. Attributes with greater utility ranges play a major role than those with smaller ranges. Finally, the measure of the relative importance of each attribute known as an importance score or value is calculated.

$$\text{Relative importance} = \frac{\text{Utility range for each attitude}}{\text{Sum of utility ranges for all attributes}}$$

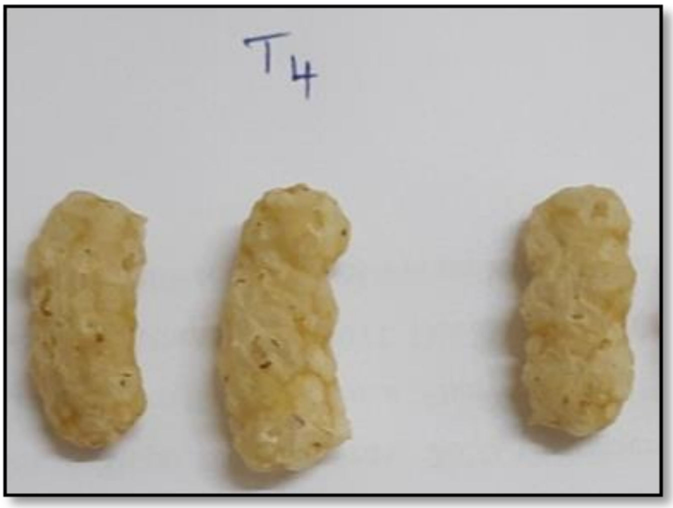
The values thus represent percentages and have the property that they sum to 100. Thus, the conjoint analysis identified the attribute combinations that confer the highest utility to the consumers. The result of conjoint analysis for ingredient levels of extruded products is presented in Table 3.

Table 3. Relative importance of conjoint analysis for quality attributes of millet and pulse based extruded product

Attributes	Levels	Utility Estimate	Relative importance (%)
Barnyard Millet	40	-0.529	37.53
	50	-0.789	
	60	1.318	
Chick Pea	10	-0.518	35.46
	20	1.245	
	30	-0.727	
Maize	40	0.948	27.01
	50	-0.317	
	60	-0.631	
	(Constant)	9.142	
Pearson's R value = 0.687**; Kendall's tau value = 0.583**			
n = 30			

Pearson's R and Kendall's tau values are 0.687 and 0.583, respectively, indicating a better fit to the data. The positive values of the utility estimate indicate the best combination of ingredients for optimization. The conjoint analysis for selecting the best ingredient levels of the extruded product found that it should have the combination of the following attributes: Barnyard Millet - 60, Chickpea - 20 and Maize - 40. The optimized final product is shown in Figure 4.

Figure 4. Optimized millet and pulse-based extruded product through conjoint analysis



A similar study was conducted by Navarasam *et al*. (2021) for optimizing the carrot, mushroom, moringa, dates, and seaweed into the fortified dairy-based beverage. Optimization was done using utility estimates and relative importance. Assessing the quality attributes of cheese was done using a conjoint analysis study conducted by Shilpa shree *et al*. (2016).

CONCLUSION

Results from this research indicate that using conjoint analysis to standardize the ingredient levels of product quality attributes were relatively easier to handle the product characterization and their sensory properties. More treatments can be handled through this statistical method, which gives precision and reproduces solutions. The conjoint analysis gives the best combination for millet and pulse-based extruded product following were barnyard millet 60, chickpea 20, and maize 40. The above-mentioned ratio of ingredients was converted to 100 per cent and then the product was optimized accordingly.

Funding and Acknowledgment

The research work was supported in part by a grant from the College of Food and Dairy Technology, Tamil Nadu Veterinary and Animal Sciences University, Koduveli, Chennai, Tamil Nadu, India. Authors also wish to place on record their heartfelt thanks to each and everyone who had their part in this research.

Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Author contributions

Research grant-TANUVAS,

Idea conceptualization-SN,

Experiments- SN, SSPA,

Guidance -GP, APM, SK, SSPA,

Writing original draft - SN

Writing- reviewing &editing - SN, GP, APM, SK, SSPA

REFERENCES

Altaf, U., Hussain, S. Z., Qadri, T., Iftikhar, F., Naseer, B., and Rather, A. H. 2021. Investigation on mild extrusion cooking for development of snacks using rice and chickpea flour blends. *J. Food Sci. Technol.*, **58** (3), 1143-1155.

Cheng, H., and Friis, A. 2010. Modelling extrudate expansion in a twin-screw food extrusion cooking process through dimensional analysis methodology. *Food. Bioprod. Process.*, **88** (2-3), 188-194.

Indira, R., and Naik, M. S. 1971. Nutrient composition and protein quality of some minor millets. *Indian J. Agric. Sci.*, ***41***(10), 795-797.

Indian Institute of Millets Research. 2018. Annual Report

Krishnaveni, G. V., Hill, J. C., Leary, S. D., Veena, S. R., Saperia, J., Saroja, A., and Fall, C. H. 2005. Anthropometry, glucose tolerance, and insulin concentrations in Indian children: relationships to maternal glucose and insulin concentrations during pregnancy. *Diabetes care*., ***28*** (12): 2919-2925.

Kumari, S. K., and Thayumanavan, B. 1997. Comparative study of resistant starch from minor millets on intestinal responses, blood glucose, serum cholesterol and triglycerides in rats. *J. Sci. Food Agric.*, ***75***(3) :296-302.

Navarasam, R., Ayyavoo Preamnath Manoharan, V. Appa Rao, T. R. Pugazhenthi and Serma Saravana Pandian, A. 2021. Conjoint Analysis for Selecting the Ingredients Levels of Fortified Beverage. *Int. J. Curr. Microbiol. App. Sci.*, **10** (09).

Nibedita, M., and Sukumar, B. 2003. Extrusion cooking technology employed to reduce the anti nutritional factor tannin in sesame meal. *J. Food. Eng.*, **56**: 201-202.

Renganathan, V. G., Vanniarajan, C., Karthikeyan, A., & Ramalingam, J. 2020. Barnyard millet for food and nutritional security: current status and future research direction. *Front. genet.*, **11**:500.

Shilpa Shree, J., Pandian, A. S. S., and Kumaravelu, N.2016. Assessing the demand for quality attributes of cheese-an application of conjoint analysis.