Intl. J. Food. Ferment. Technol. 4(2): 129-136, December, 2014

DOI Number: 10.5958/2321-7111.2014.00007.9

Research Paper

Effects of different packaging conditions and storage temperatures on the physico-chemical properties of barbecue sauce

Ravneet Singh[1], Sandeep Pal Kaur Brar[2]*, and S.S Thind[3]

[1,2]College of Dairy Science and Technology, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab-141004, India.
[3]Department of Food Science and Technology, Punjab Agricultural University, Ludhiana-141004, Punjab, India.

*Corresponding author: sonubrar2611@gmail.com

Paper No. 88 Received: 11 July, 2014 Accepted: 21 November, 2014 Published: 28 December, 2014

Abstract

Recipe and preparation procedure of Barbecue sauce incorporating traditional ingredients to suit the Indian palate was standardized. Barbecue sauce prepared was thermally processed, preserved and stored in glass bottles and retortable pouches at room temperature (15-30°C) and low temperature (5-7°C) respectively upto three months and evaluated for different physico-chemical properties after every 15 days. The average acidity of Barbecue sauce stored in glass bottles and retortable pouches decreased non-significantly ($p<0.05$) with the increase in the storage time. But the average pH value increased non-significantly ($p<0.05$) with the increase in the storage time. of Barbecue sauce stored in glass bottles and retortable pouches. The average total soluble solids (TSS) increased non-significantly ($p<0.05$) with the increase in the storage period. The average viscosity of Barbecue sauce stored in glass bottles and retortable pouches increased significantly ($p<0.05$) with the increase in the storage time. However , the average spreadibility of Barbecue sauce stored in glass bottles and retortable pouches decreased significantly ($p<0.05$) with the increase in the storage time. It was concluded that Barbecue sauce prepared incorporating traditional ingredients was found highly acceptable to the consumers. The product was found stable and highly acceptable at the end of storage period of three months, in glass bottles and retortable pouches.

Keywords: Barbecue sauce, spreadibility, viscosity, total soluble solids, proximate composition

The food processing sector in India with its vast potential has emerged as one of the major drivers of economic growth. The share of food in total retail market of consumer products in 2011 was 61 per cent (India Today, 2011). The poultry production is no longer a backyard activity and has taken the shape of high growth industry. Poultry production has been rising at the rate of around 8% per annum, with an annual turnover of US$ 7 500 million (Poultry Industry in India 2012).

According to market report "Vision for Indian Poultry Industry-Current Scenario and Future Prospects," the poultry production and consumption in the domestic market is slated to grow by 66 per cent (Bhatt, 2006). The production of broilers exceed 200 million per annum. Value added poultry meat products such as chicken ham, chicken sausages, chicken samosa, chicken patties etc are being produced by some processors and marketed under different brand names, have high consumer acceptance. Chicken

meat products are getting more popular in India as there are no social and religious restrictions imposed on their consumption. Poultry meat consumption is also considered to be more healthy compared to red meats.

Preparation and production of sauces have been a practice for centuries. During Roman times, sauces were used to hide flavour and taste of meat that was possibly not as fresh as it should have been. The base of sauce is some form of liquid. This liquid is then thickened with a thickening agent such as flour, fat, eggs, honey, cream or cornflour (Pourkomailian, 2000). The majority of sauces are of French origin and the word "sauce" is actually a French word that means a "relish" that makes food more attractive. Sauces come in many forms. There are sauces used to pour over certain foods to bring moisture and extra flavour to the meal Sauces form an integral part of many popular dishes. Cold sauces or dressings are used to liven up salads and cold meats (Pechak *et al*, 2003).

Barbecue sauce is a liquid flavoring sauce or condiment ranging from watery to quite thick. While it can be applied to any food, it usually tops meat after cooking or during barbecuing, grilling or baking. It is also used for dipping items like fries, as well as a replacement for tomato sauce in barbecue style Pizzas. The first commercially-Produced Barbecue sauce was made by 'Louis Maullco' in 1962. Different geographical regions have allegiances to their particular styles and variations for Barbecue sauce. For example, vinegar and mustard-based Barbecue sauces are popular in certain areas of the Southern United States, while in Asian countries, ketchup and corn syrup-based sauces are common (Nerurkar, *et al*, 1999).

Barbecue sauces can be. thick and thin and between those two categories there are tangy, hot, sweet and spicy sauces. In Barbecue sauce, tomato is the most widely used ingredient. It is used in form of tomato paste or tomato puree. Vinegar is another important ingredient, that penetrates inside the meat to develop acidic flavour.The trend of eating fast foods among the Indians is increasing with increase in incomes (Martínez, *et al*, 2006).Fast food products like chicken sausages, burgers, patties, pizzas etc are getting popular with Indian consumers. The Barbecue sauce was developed keeping in the view the continuous increase in the availability of variety of processed food products,which is fueld by fast expansion of organized retail networks. Since the composition of Barbecue sauce varies in the different regions of the world. The present study was planned with the objective of developing Barbecue sauce as per the requirements of Indian palate for chicken products and to study the effects of packaging conditions (glass bottles/retort pouches) and storage temperatures on its proximate composition and physico-chemical properties (Cullen, *et al.*, 2003).

Materials and Methods

Raw materials

Tomato puree ("Home Made" brand), honey ("Dabur" brand), crystal sugar, refined groundnut oil (Ginni), ginger paste ("Home Made" brand),garlic paste ("Home Made" brand), onions, Common salt ("TATA" brand), powdered white pepper, black pepper, red chilli, cardamom(MDH brand) and cloves ("CYLONS" brand) were procured from the local market and used in the preparation of Barbecue sauce. The sugar was powdered in a grinder ("TIFFANY" brand) before its incorporation in product preparation. Onion paste was prepared in the laboratory using mixer-grinder. Vinegar was prepared by using 3 per cent food grade glacial acetic acid with potable water. Xanthan gum powder was provided by M/S Cremica Food Industries Ltd., whereas M/s Potassium sorbate was purchased from S.D Fine Chemicals Limited, Mumbai.

Preparation of Barbecue sauce

The recipe of Barbecue sauce and its procedure of preparation was standardized by referring to recipes given in the literature which were modified by incorporating ingredients integral to Indian taste requirements. In the standardization process, the suggestions of sensory panel members were incorporated. The standardized recipe of Barbecue

sauce is given in Table 1. The required quantity of refined oil was taken in a non-stick pan. The ingredients were added in the following order: onion paste, salt, ginger and garlic paste. Dry ingredients in the powder form (white pepper, black pepper, chillies, cardamom, cloves and xanthan gum) were added in the pan. The material was stirred continuously at 100°C for 10-15 minutes while stirring, vinegar; tomato puree water was added slowly. The contents were cooked at 90-95°C for 10 minutes. The cooked material was removed from the flame, followed by addition of sugar and honey. The contents were uniformly mixed. The product was hot filled (80-85°C) in 200 ml glass bottles (200 ml capacity and purchased from local market) and 250 ml retort pouches (4 ply laminates with outside layer of polyester, a nylon second layer, an aluminum foil third layer and a polypropylene inside layer; procured from C.I.F.T, Kochi). The glass bottles and retort pouches were exhausted at 85°C for 15 minutes by placing them vertically in a hot water bath. The pouches were sealed using heat sealer and the glass bottles were sealed with crown corks. The sealed glass bottles were sterilized at 90°C for 30 minutes in a hot water bath. The sealed retort pouches were placed in specially designed rack and retorted at 121°C for 20 minutes. The product in bottles and retort pouches was cooled and stored at both room temperature (15-30°C) and low temperature (7-10°C).

Table 1: Recipe of Barbecue sauce

Ingredients	Quantity (g)/250 g
Tomato Puree (26°brix)	90
Honey	20
Powdered Sugar	15
Groundnut Oil	10ml
Ginger Paste	10
Garlic Paste	10
Onion Paste	20
White Pepper powder	1
Black Pepper powder	2
Salt	1
Cardamom powder	2
Cloves powder	2
Red Chilli powder	1
Vinegar	15ml
Xanthan gum	1
Water	50ml

Analysis

Proximate composition of barbecue was analysed for per cent moisture, protein, fat and ash as per standard AOAC (2000) procedures.

Macro-kjeldahl method was followed to determine protein content in Barbecue sauce (AOAC, 2000). The per cent nitrogen was converted into per cent protein by multiplying the o/s nitrogen by a factor 6.25. Crude fat in Barbecue sauce was determined using Soxhlet method (AOAC, 2000) by extracting fat extracted from dried sample (5g) of Barbecue sauce with petroleum ether (boiling point 60-80°C) as per standard procedure. The fat was expressed as per cent. The per cent moisture in the was determined by the standard method. (AOAC, 2000).

Total acidity (expressed in terms of per cent acetic acid) was determined by standard AOAC method (2000) by titration method. The pH was determined using digital pH meter.

Total soluble solids (TSS) were determined using hand refractrometer and the results were expressed in terms of Degree Brix. Apparent viscosity of Barbecue sauce was estimated using Brookfield viscometer using Spindle No. 4, 30 rpm at 15-30°C. The viscosity of sample was expressed in centipoises (cP).

The spreadibility of Barbecue sauce (cm^2) was determined by spread test. Spreadibility was estimated by measuring the area (cm^2) covered by the marked surface between two glass slides. The sample was pressed between the two glass slides by placing a weight of 100 g for two minutes. The spread area was measured using a planimeter.

Table 2: Proximate composition of Barbecue sauce

Components	Percent
Moisture	74.05
Protein	4.65
Fat	0.79
Ash	1.31

Statistical Analysis

The data were statistically analyzed and subjected to analysis of variance using completely randomized design (CRD) and factorial design in CRD (Singh. *et al*. 2001).

Results and Discussion

Proximate composition of Barbecue sauce

Results of the proximate composition of Barbecue sauce are presented in the Table 2. The average moisture content in the Barbecue sauce was 74.05 % while he mean protein content in the Barbecue sauce was 4.65 %. Average fat and ash contents were 0.79 and 1.31 % respectively.

Effects of packaging conditions and storage temperatures

The data for acidity (Table 3) showed that the samples stored in bottles decreased non-significantly ($p<0.05$) with the increase in the storage period because of lower water activity and higher salt content. In Barbecue sauce samples stored at room temperature, the mean acidity decreased from 0.70 per cent in fresh to 0.66 per cent at the end of storage period.While those stored at low temperature, it decreased from 0.70 per cent in fresh to 0.67 per cent after 90 days of storage period. The average acidity of both the samples of Barbecue sauce packed in retort pouches decreased non-significantly ($p<0.05$) with increase in storage period upto 90 days. Those samples stored at room temperature, the mean acidity decreased from 0.70 per cent in fresh to 0.67 per cent and in Barbecue sauce samples stored at low temperature, the average acidity decreased from 0.70 per cent in fresh to 0.68 per cent after 90 days storage period. The decrease in acidity of Barbecue sauce during storage might be due to lower water activity and higher salt content and the interaction of ingredients (Luh, 1995). The progressive decrease in the acidity with increase in storage period was probably due to the reaction of acids with basic minerals in the product (Steffe, 1996). Other reason for decrease for this phenomenon could be interaction of acid with tomato components with increase in time or loss of acids, mainly acetic acid during processing of Barbecue sauce (Becker *et al*, 1968). The decrease in the average acidity was higher in the samples of Barbecue sauce stored at room temperature as compared to that of samples stored at low temperature which might be attributed to the decrease of reaction rate with the decrease in temperature (Rao, 1999).

Table 3. Effect of storage on the acidity (% acetic acid) of Barbecue sauce in glass bottles and retort pouches

	Storage in glass bottles			Storage in retort pouches		
Storage days	Room temperature	Low temperature	Factor mean	Room temperature	Low temperature	Factor mean
0	0.70	0.70	0.70	0.70	0.70	0.70
15	0.69	0.70	0.69	0.69	0.69	0.69
30	0.69	0.69	0.69	0.68	0.69	0.68
45	0.68	0.69	0.68	0.68	0.69	0.68
60	0.68	0.68	0.68	0.68	0.69	0.68
75	0.67	0.68	0.67	0.67	0.68	0.67
90	0.66	0.67	0.66	0.67	0.68	0.67
Factor Mean	0.68	0.69		0.68	0.68	

CD (5%), Between storage =NS, Between Treatment=NS, Between Combination =NS

The average pH of Barbecue sauce samples stored in glass bottles and in retort pouches increased non-significantly ($p<0.05$) with the increase in storage period (Table 4). The average pH of Barbecue sauce samples stored at room temperature increased marginally from 4.04 in fresh to 4.07 after storage

period of 90 days while those stored in glass bottles at low temperature, the mean pH increase was 3 lower than room temperature.

Table 4. Effect of storage on pH of Barbecue sauce in glass bottles and retort pouches

	Storage in glass bottles			Storage in retort pouches		
Storage days	Room temperature	Low temperature	Factor mean	Room temperature	Low temperature	Factor mean
0	4.04	4.04	4.04	4.04	4.04	4.04
15	4.04	4.04	4.04	4.04	4.04	4.04
30	4.05	4.04	4.04	4.04	4.04	4.04
45	4.06	4.05	4.05	4.05	4.04	4.04
60	4.06	4.05	4.05	4.05	4.04	4.04
75	4.07	4.06	4.06	4.06	4.05	4.05
90	4.07	4.06	4.06	4.06	4.05	4.05
Factor Mean	4.05	4.04		4.05	4.04	

CD (5%), Between storage =NS, Between Treatment=NS, Between Combination =NS

Table 5: Effect of storage on the Total Soluble Solids (°Brix) of Barbecue sauce in glass bottles and retort pouches

	Storage in glass bottles			Storage in retort pouches		
Storage days	Room temperature	Low temperature	Factor mean	Room temperature	Low temperature	Factor mean
0	27.0	27.0	27.0	27.0	27.0	27.0
15	27.0	27.0	27.0	27.0	27.0	27.0
30	27.2	27.0	27.1	27.2	27.0	27.1
45	27.4	27.2	27.3	27.3	27.2	27.2
60	27.6	27.3	27.4	27.5	27.3	27.4
75	27.8	27.3	27.5	27.6	27.4	27.5
90	28.0	27.5	27.7	27.9	27.4	27.6
Factor Mean	27.5	27.1		27.3	27.1	

CD (5%), Between storage =NS, Between Treatment=NS, Between Combination =NS

The average pH of Barbecue sauce samples packed in retort pouches, stored at room temperature and low temperature increased in-significantly ($p<0.05$) with the increase in storage period (Fumio Noda *et al*, 1982). In the products stored at room temperature, similar was the trend for change in pH. The packed in retort pouches and stored at low temperature, showed similar results the end of the three months storage study period. The pH is inversely proportional to the acidity. If the acidity of the product decreases, the pH values increase.

The average TSS (degree Brix) of Barbecue sauce samples stored in bottles at room temperature and at low temperature increased non-significantly ($p<0.05$) with the increase in the storage period (Table 5). While those samples stored at room temperature, the mean TSS increase from 27°Brix in fresh to 28°Brix after 90 days storage period while those samples stored in the bottles at low temperature, the mean TSS increase was a little more (27°Brix to 27.5° Brix) at the end of the three months storage period.

The mean TSS of Barbecue sauce samples packed in retort pouches, stored at room temperature and at low temperature, increased in-significantly ($p<0.05$) with increase in storage period as reported earlier (Charles *et al.*, 2004). (Rani & Bhatia, 1995). The increase in TSS might be due to the slow solubility of some components in the ingredients of Barbecue sauce during storage.

The average viscosity of Barbecue sauce samples packed in bottles, stored at room temperature and low temperature increased significantly ($p<0.05$) with the increase in the storage period (Table 6). In Barbecue sauce samples stored at room temperature, the mean viscosity increased from 3428cP in fresh to 3688cP respectively after 90 days of storage. However, storate at low temperature, the increase was lower than that at room temperature. In Barbecue sauce samples stored in the glass bottles at low temperature, the mean viscosity increased from 3428cP in fresh to 3623cP at the end of the storage period. Similar trend was separated earlier. (Bousmina *et al*, 1999).

Table 6: Effect of storage on the viscosity (centipoise) of Barbecue sauce in glass bottles and retort pouches

	Storage in glass bottles			Storage in retort pouches		
Storage days	Room temperature	Low temperature	Factor mean	Room temperature	Low temperature	Factor mean
0	3428^{a*}	3428^{a}	3428	3428^{a*}	3428^{a}	3428
15	3499^{b}	3460^{b}	3479	3461^{b}	3452^{b}	3456
30	3527^{c}	3505^{c}	3516	3487^{c}	3475^{c}	3481
45	3585^{d}	3555^{d}	3570	3499^{c}	3497^{d}	3497
60	3612^{e}	3593^{e}	3602	3520^{d}	3505^{d}	3462
75	3663^{f}	3618^{f}	3640	3535^{d}	3528^{e}	3531
90	3688^{g}	3623^{f}	3652	3563^{e}	3535^{e}	3549
Factor Mean	3570	3540		3484	3488	

CD (5%), *Values with different superscripts vary significantly

Table 7. Effect of storage on the spreadibility (cm^2) of Barbecue sauce in glass bottles and retort pouches

	Storage in glass bottles			Storage in retort pouches		
Storage days	Room temperature	Low temperature	Factor mean	Room temperature	Low temperature	Factor mean
0	6.62^{a*}	6.62^{a}	6.62	6.62^{a*}	6.62^{a}	6.62
15	6.52^{ab}	6.59^{ab}	6.45	6.58^{ab}	6.55^{a}	6.56
30	6.43^{bc}	6.57^{ab}	6.50	6.55^{b}	6.50^{ab}	6.52
45	6.39^{cd}	6.53^{ab}	6.46	6.51^{bc}	6.48^{b}	6.49
60	6.26^{de}	6.50^{b}	6.38	6.49^{bc}	6.46^{b}	6.47
75	6.16^{ef}	6.49^{b}	6.32	6.46^{bc}	6.44^{b}	6.45
90	6.10^{f}	6.47^{b}	6.28	6.42^{c}	6.38^{b}	6.40
Factor Mean	6.35	6.53		6.51	6.49	

CD (5%), *Values with different superscripts vary significantly

The average viscosity of the samples of Barbecue sauce packed in retort pouches, stored at room temperature and low temperature, increased significantly ($p<0.05$) with increase in the storage period. In Barbecue sauce samples stored at room temperature, the mean viscosity increased from 3428 cP in fresh to 3563 cP after 90 days storage period and in the samples of Barbecue sauce stored at low temperature, the average viscosity increased from 3428 cP in fresh to 3535 cP at the end of the storage period. Claybon and Barringer (2002) also concluded that the viscosity of Non-Newtonian fluids such as tomato ketchup, tomato sauce, Barbecue sauce, tomato puree increased due to the water binding ability of the ingredients such as xanthan gum, guar-gum etc.

The average spreadibility of the samples of barbecue stored in glass bottles at room temperature and low temperature decreased significantly ($p<0.05$) with increased in the storage period in Table 7. In Barbecue sauce samples stored at room temperature, the mean spreadibility decreased from 6.62 cm^2 in fresh to 6.10 cm^2 respectively after 90 days storage period. In Barbecue sauce samples stored in glass bottles at low temperature, the average spreadibility decreased

from 6.62 cm^2 in fresh to 6.47 cm^2 respectively after completion of 90 days storage period. (Bayod *et al*, 2008) Similar results were documented earlier also.

The average spreadibility of samples of Barbecue sauce packed in retort pouches, stored at room temperature and low temperature, decreased significantly ($p<0.05$) with the increase in storage period. In the samples of Barbecue sauce stored at room temperature, the mean spreadibility decreased from 6.62 cm^2 in fresh to 6.42 cm^2 after 90 days storage period. In the samples of Barbecue sauce stored at low temperature, the average spreadibilitty decreased from 6.62 cm^2 in fresh to 6.38 cm^2 at the end of the storage period. Harrison and Cunningham (1985) studied the spreadibility of many semi-solid foods like liquid egg yolk, sauces, mayonnaise etc and observed that the spreadibility values ranged between 4.5 cm^2 to 10.5 cm^2. The spreadibility values of Barbecue sauce prepared ranged between above mentioned limits (Valencia *et al*, 2002).

Conclusions

It concluded that Barbecue sauce prepared by incorporating traditional ingredients was found highly acceptable by the consumers. The product packed and thermally processed in glass bottles and retortable pouches was found stable and acceptable up to three months of storage.

References

A O A C 2000. Official methods of analysis 16thedn. Association of Official Analytical Chemists, Washington, USA.

Bayod, E.; Willers, E P and Tornberg, E. 2008. Rheological and structural characterization of tomato paste and its influence on the quality of ketchup. *Journal of LWT - Food Science and Technology*, **41**(7): 1289–1300.

Becker R, Wagner J R, Miers J C, Sanshuck D W 1968. Consistency of tomato products III. Effect of pH adjustment during tomato puree preparation of pectin content and characteristics. *FdTechnol* **22**: 503.

Bhatia, R. 1995. Observations recorded for increase and decrease of TSS in tomato ketchup/puree. *J Fd Sci Technol* **167**(6): 179-92.

Bhatt, P. 2006. Business out of the nest. *Ind Poult Indsu* **36**(5): 58-59.

Bousmina, M.; Ait-Kadi, A. and Faisant B. 1999. Determination of shear rate and viscosity from batch mixer data. *Journal of Rheology*, **43**(2): 415–433.

Chao P.C; Hsu C. and Yin, M. 2009. Analysis of glycative products in sauces and sauce-treated foods. *Journal of Food Chemistry*. **113**(1): 262–266.

Charles, J.B.; Fernando, C.; Antje, B.; Sarah, O.; Steven A. H.; Paul W.Q.; Alisdair R.F and Lee J.S. (2004). Fruit Carbohydrate Metabolism in an Introgression Line of Tomato with Increased Fruit Soluble Solids. *Journal of Plant and Cell Physiology*. **46**(3): 425-437.

Claybon, K.T and Barringer, S.A. 2002. Consumer acceptability of viscosity in processed tomato products by African-American, Latino, and prototypical consumer groups. . *FdSciTechnol*, **67**(6): 2380-2384.

Cullen, P.J.; O' Donnel C.P., Houska M. 2003. Rotational rheometry using complex geometries—A review Journal of Texture Studies, **34**(3): 1–20.

Daubert, C.R.; Tkachuk, J.A and Truong V.D. 1998. Quantitative Measurement of Food Spreadability Using the Vane Method. *Journal of Texture Studies.* **29**(4): 427–435.

Desai, A.; 2004. An overview of the Indian poultry and future scenario. All India Poultry Year Book, Special Millennium Issue. Delhi.

Goodman, C.L.; Fawcett, S and Barringe,r S.A. 2002. Flavor, Viscosity, and Color Analyses of Hot and Cold Break Tomato Juices. *Journal of Food Science*. **6**(1): 404–408.

Harrison, L. J and Cunningham, F. E 1985. Factor influencing the quality of semi-solid foods. *J Fd Quality* **8**: 1-20.

India Today 2011. Smart Money – Spending on Living and Eating **27**(4): 57.

Luh, B.S 1995. Industrial production of soy sauce. Journal of industrial microbiology. Dept. of Food Science & Technology, University of California, Davis., **14**: 467-471.

Martínez, L.P. and Rivera-Vargas, C. 2006. Flow behavior of Mexican sauces using a vane-in-a-large cup rheometer. *Journal of Food Engineering*, **72**(2): 189–196.

Mehta, R and Nambiar, R.G. 2012. The Poultry Industry in India.

MOSP 2014. Ministry of Statistics and Programme Implementation (Trading Economics 2014).

Nerurkar, P. V; Marchand, L. L; and Cooney, R.V. 1999. Effects of Marinating With Asian Marinades or Western Barbecue Sauce on PhIP and MeIQx Formation in Barbecued Beef, Nutrition and Cancer, **34**(2): 147-152.

Noda, F.; Hayashi, K and Mizunuma, T. 1982. Influence of pH on Inhibitory Activity of Acetic Acid on Osmophilic Yeasts Used in Brine Fermentation of Soy Sauce. *Journal of Appl. Environ. Microbiol.* **43**(1): 245-246

Pechak, D.; Schwimmer,B.; Borwankar, R. P., and Ford, L.D. 2003. Food Emulsions, Chapter 13-Dressing and Sauces, pp. 683-714.

Pourkomailian, B. 2000. The Stability and Shelf-Life of Food. Chp-13 Sauces and dressings. A volume in Woodhead Publishing Series in Food Science, Technology and Nutrition:pp 311–331.

Rao, M.A. 1999. Rheology of fluid and semisolid foods. Principles and applications. pp. 61–73 Aspen Publishers Inc, Maryland (1999).

Sherkat, F.and Luh, B.S. 1976. Quality factors of tomato pastes made at several break temperatures. *J. Agric. Food Chem.*, **24**(6): 1155–1158.

Singh S, Bansal M L, Singh T P and Kumar R 2001. Statistical Methods for Research Workers, Kalyani Publishers, New Delhi.

Steffe, J.F. 1996. Rheological methods in food process engineering. pp. 158–168 (2nd edn.) Freeman Press, East Lansing, Michigan.

Valencia, C.; Sánchez, M.; Ciruelos, A.; Latorre,A.; Franco, J and Gallegos C. 2002. Linear viscoelasticity of tomato sauce products: influence of previous tomato paste processing. *European Food Research and Technology*, **214**(5) : 394-399.