Research Article

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Enhancing the shelf life of tomato ketchup: An organoleptic analysis of natural and synthetic preservatives

Renu Godara*, Kanak Lata, Shakti Khajuria and J.K. Jadav

Krishi Vigyan Kendra-Panchmahal, (ICAR-CIAH), Gujarat

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ABSTRACT

Tomato ketchup, a widely consumed condiment, requires effective preservation to maintain its shelf-life, taste, and quality. This study, conducted in 2025 at ICAR-KVK Panchmahal, Gujarat, compared the sensory attributes of tomato ketchup prepared with natural preservatives (NP) (vinegar and lemon juice) and synthetic preservatives (SP) (sodium metabisulphite). Sensory evaluation was conducted using a 5 point Hedonic scale among 40 farmers and 10 staff members of ICAR-KVK Panchmahal, Gujarat. The organoleptic assessment revealed that colour was slightly more preferred in SP ketchup, with 76% of respondents strongly liking it, compared to 74% for NP ketchup. Flavour and smell were rated higher for NP ketchup, with 72% and 84% of respondents strongly liked its flavour and aroma, respectively, while SP ketchup scored 68% and 80% on these parameters. Texture preference was comparable, with 52% of respondents strongly liking NP ketchup and 50% preferring SP ketchup, though the Weighted Mean Score (WMS) was higher for SP ketchup (4.26) than NP ketchup (4.12). General acceptability was higher for SP ketchup (WMS: 4.68) compared to NP ketchup (4.52), primarily due to its extended shelf-life (40 days at room temperature, 90 days refrigerated vs. 7 and 15 days for NP). NP ketchup was favoured for its natural taste. Production costs were lower for SP ketchup (₹92/kg) than NP (₹130/kg), though NP appeals to health-conscious consumers. While SP ketchup offers superior shelf stability and cost-effectiveness, NP ketchup is preferred for its flavour and natural ingredients, highlighting a trade-off between shelf-life, cost and sensory appeal.

Introduction

Tomatoes (*Solanum lycopersicum* L.) is widely consumed as vegetable and play an important role in nutrition because of well-established health benefits (Salehi *et al.,* 2019). It is used in various processed food products such as sauces, salads, soups, and pastes. Common nutrients reported in tomatoes are vitamins, minerals, fibre, protein, essential amino acids, monounsaturated fatty acids (MUFA), carotenoids and phytosterols (Lenucci *et al.,* 2006). Many types of antioxidant compounds i.e., alpha/beta/gamma/delta tocopherols, carotenoids, ascorbic acid, lycopene, and flavonoids are found in tomatoes. Generally, antioxidant compounds play important roles in the prevention of several human degenerative diseases, including CVD (cardio vascular diseases), diabetes, cancer, neurological diseases,

*Corresponding author.
E-mail address: messigodara@gmail.com (Renu Godara)

and aging by minimizing oxidative stress. Oxidative stress (resulting from redox homeostasis imbalance between prooxidative and antioxidant systems) is a major player in the pathogenesis of many inflammatory, metabolic, cardiovascular, degenerative, and neoplastic diseases (Halliwell, 2015).

Tomato helps in improving vision, boosting immunity, and normalizing blood glucose level and cholesterol levels (Bhowmik *et al.,* 2012). The highest tomato producing states in India are Madhya Pradesh, Andhra Pradesh, Karnataka, Gujarat and Tamil Nadu. These states account for about 90% of total tomato production in the country. Tomato is highly perishable commodity as it has moisture content more than 90 percent (Dereje *et al.,* 2019). Shelf life of tomatoes is few days (less than 3 days) due to its high moisture content in tropical regions. So, post-harvest losses of tomatoes are great challenge in the developing countries where cold storage facilities are inadequate (Arah *et al.*, 2015). It is therefore, extremely important to process the tomatoes into value added products like paste, puree, juice and ketchup etc. to utilize for further consumption.

The processing of tomato helps to protect these losses that occur in between the harvest to final consumption stage. Thus, food preservation is a sound approach to utilize the tomato during off season by storing them in form of some product for off season use. There is also a great scope in the food processing sector through value addition of tomatoes in the form of puree, paste, juice and ketchup to generate income of farmers in developing countries. Hence, food preservation is useful technique for enhancing shelf life of the tomato. So, this study was conducted to analyse the sensory taste of tomato ketchups prepared with natural and synthetic preservatives.

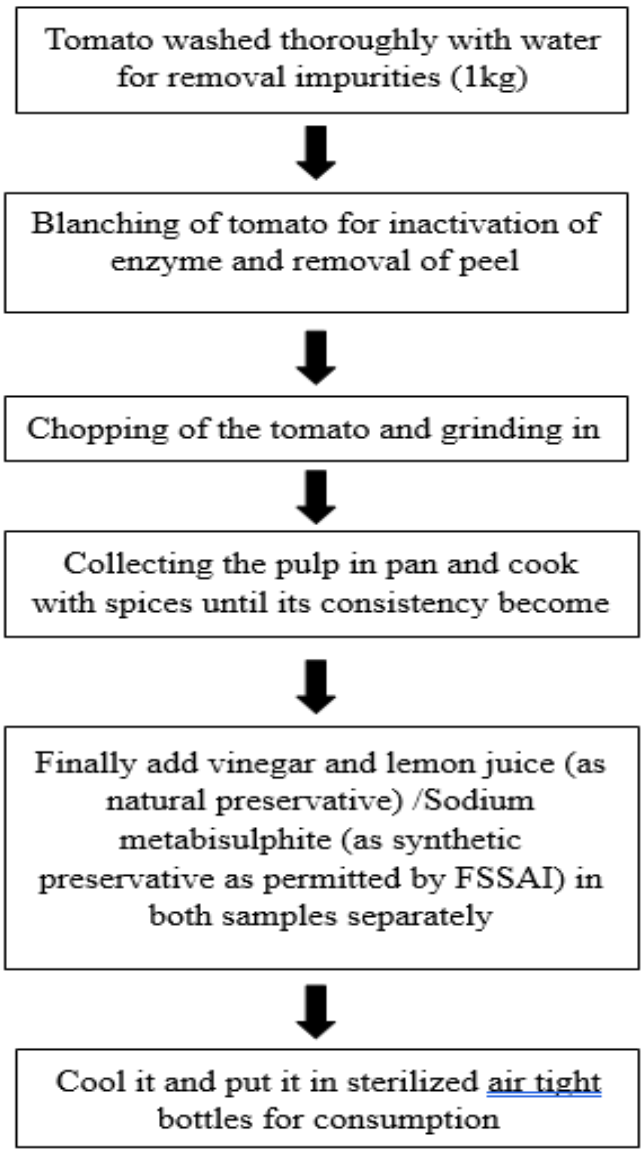
Material And Methods

The present study was conducted in year 2025 at ICAR-CIAH-Krishi Vigyan Kendra Panchmahal, Gujarat. Fresh tomatoes were purchased from the local market in Godhra, thoroughly washed with lukewarm water and salt to remove dirt and pesticide residues. Blanching was performed by boiling for less than one minute and immediately immersing the tomatoes in cold water. The tomatoes were then peeled, sliced, deseeded, and blended into a pulp. The pulp was cooked on low flame with water, spices (black pepper, cardamom), and salt until it thickened (half of initial concentration). Two formulations were prepared:

1. Natural Preservatives (NP): Vinegar (50 ml of 2% acetic acid concentration), lemon juice (20 ml) and salt (1%) were added.
2. Synthetic Preservatives (SP): Sodium metabisulphite (0.001%) was added as per FSSAI recommendations.

Both samples were cooled and stored in sterilized glass jars for sensory evaluation.

Flow chart for preparation of tomato ketchup



The effect of natural and synthetic preservatives was studied using a 5 point Hedonic scale of sensory evaluation (Birol *et al*., 2015). The organoleptic quality scoring system is presented in Table 1.

Table 1. Hedonic scale (5 point) for sensory evaluation

Score	General/overall acceptability	Colour	Smell	Flavour	Texture
1	Strongly dislike	Very pale	Strongly dislike	Very poor	Strongly dislike
2	Dislike	Pale	Dislike	Poor	Dislike
3	Neutral	Moderate red	Neutral	Fair	Neutral
4	Like	Red	Like	Good	Like
5	Strongly like	Dark red	Strongly like	Very good	Strongly like

Sample size: The effect of natural and synthetic preservatives was analysed using a 5 point Hedonic scale of sensory evaluation. Data were collected from 50 untrained (40 farmers and 10 staff members of KVK Panchmahal, Gujarat) persons.

Statistical tools: Frequency, percentage, and weighted mean score (WMS) were used to evaluate the sensory responses. According to Agarwal (2006), weighted mean score was computed during the analysis of the data to calculate the likeliness of tomato ketchups with natural and synthetic preservatives. The weighted mean score was calculated by using following formula:

$$\bar{x} = \frac{w_1x_1+w_2x_2+\cdots w_kx_k}{w_1+w_2+\cdots w_k}$$

Where:-

w_1, w_2, ……. w_k are the frequencies of responses for each score.

x_1, x_2, ……x_k are the corresponding scores (1, 2, 3, 4, 5) on the 5-point Hedonic scale.

Results and Discussion

The organoleptic evaluation of tomato ketchup samples prepared with natural preservatives (NP) and synthetic preservatives (SP) was conducted using a 5 point Hedonic scale, with responses recorded from 40 farmers and 10 staff members of ICAR (CIAH) KVK Panchmahal. The results, as shown in Table 2, highlight variations in consumer preferences for colour, flavour, smell, texture, and general acceptability of both formulations. For colour, 74% of respondents strongly liked the NP formulation, whereas 76% strongly liked the SP formulation, as depicted in Fig. 1a. The like responses were 8% for NP and 4% for SP, while 10% and 14% of respondents remained neutral for NP and SP, respectively. Dislike levels were 8% for NP and 6% for SP, with no strong dislikes for either formulation. As shown in Fig. 1b for flavour, 72% of respondents strongly liked the NP formulation, compared to 68% for the SP. The "like" category had 14% for NP and 10% for SP, whereas neutral responses were 8% for NP and 16% for SP. Additionally, 6% of respondents disliked the NP formulation, while 4% disliked SP, and 2% strongly disliked the SP formulation. For smell, NP was strongly liked by 84% of respondents, compared to 80% for SP, as illustrated in Fig. 1c. Neutral responses were 4% for NP and 10% for SP, while both formulations had 4% dislikes and 2% strong dislikes. In terms of texture, 52% strongly liked NP, while 50% strongly liked SP. The like responses were 20% for NP and 26% for SP, while neutral responses were 20% for NP and 24% for SP. Notably, 4% of respondents disliked NP, while none disliked SP (Fig. 1d). The overall acceptability was higher for SP, with 84% strongly liked it, compared to 76% for NP as exhibited in Fig. 1e. Few respondents (2%) disliked or strongly disliked both formulations, mainly due to differences in shelf-life. Overall, the SP formulation was more preferred for its longer shelf-life, while NP was rated higher for its natural flavour and aroma. There was no significant ($p>0.05$) difference was found on organoleptic parameters of both ketchup formulations.

Table 2. Percent of respondents on organoleptic test scale for tomato ketchup samples

Sensory parameter	Dark red	Slightly red	Moderate	Pale	Very pale
Colour (NP)	74	8	10	8	0
Colour (SP)	76	4	14	6	0
Sensory parameter	Very good	Good	Fair	Poor	Very poor
Flavour (NP)	72	14	8	6	0
Flavour (SP)	68	10	16	4	2
Sensory parameter	Strongly like	Like	Neutral	Dislike	Strongly dislike
Smell (NP)	84	6	4	4	2
Smell (SP)	80	4	10	4	2
Texture (NP)	52	20	20	4	4
Texture (SP)	50	26	24	0	0
General acceptability (NP)	76	6	14	2	2
General acceptability (SP)	84	6	6	2	2

Shelf life of tomato ketchups with different preservatives

Table 3 presents the shelf life of tomato ketchups prepared using natural and synthetic preservatives under two storage conditions: room temperature and refrigeration. Ketchups made with natural preservatives such as vinegar, lemon juice showed a shelf life of 7 days at room temperature and 15 days under refrigerated conditions. On the other hand, those made with synthetic preservatives sodium metabisulphite lasted significantly longer 40 days at room temperature and 90 days when refrigerated. This clearly demonstrates that synthetic preservatives are more effective in extending the shelf life of tomato ketchup. However, natural preservatives are often preferred for being safer and more environmentally friendly, despite their shorter duration. Additionally, refrigeration helped improve the shelf life of both types of ketchups. These results are con-

sistent with the findings of Thakur *et al.* (2018), who also reported superior shelf life with synthetic preservatives.

Table 3. Shelf life (days) of tomato ketchups

Tomato ketchup	At room temperature	At refrigerator temperature
Natural preservatives	07	15
Synthetic preservative	40	90

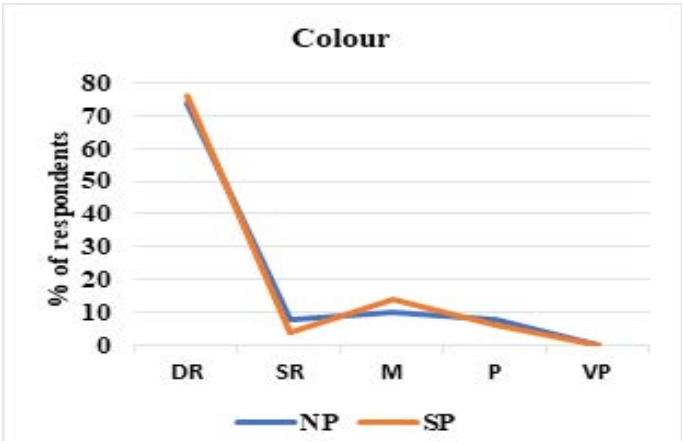


Fig.1a. Colour preference of both formulations of tomato ketchup

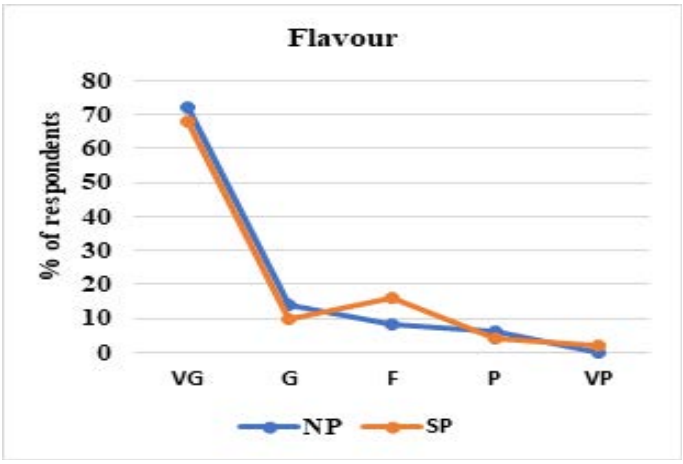


Fig.1b. Flavour preference of both formulations of tomato ketchup

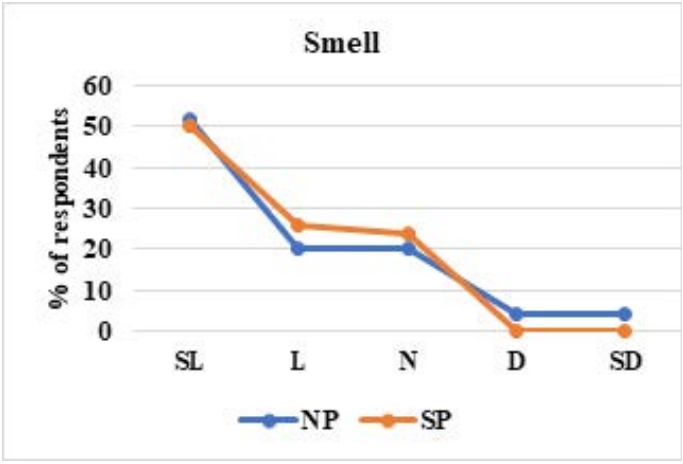


Fig.1c. Smell preference of both formulations of tomato ketchup

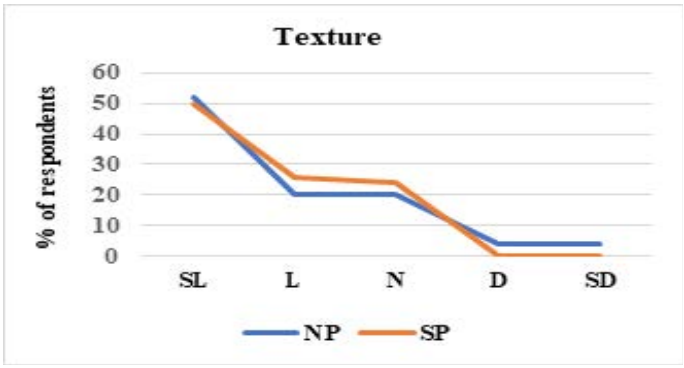


Fig.1d. Texture preference of both formulations of tomato ketchup

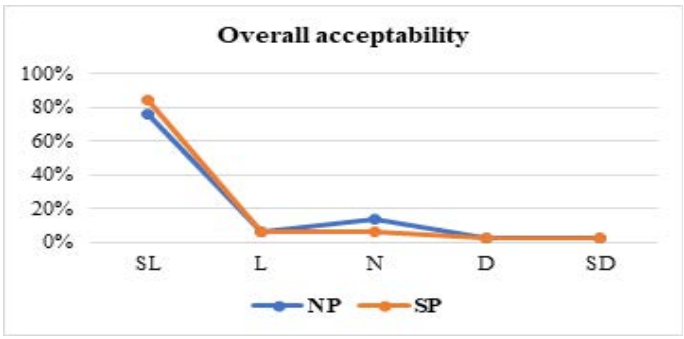


Fig.1e General acceptability of both formulations of tomato ketchup

Sensory evaluation of tomato ketchup based on weighted mean score

The weighted mean scores (WMS) for different sensory parameters of tomato ketchup formulations prepared with natural preservatives (NP) and synthetic preservatives (SP) were analyzed. The results, as presented in Table 4 & Figure 2 indicate variations in consumer preferences based on colour, flavour, smell, texture, and general acceptability. For colour, the WMS for NP ketchup was 4.48, while SP ketchup scored slightly higher at 4.50, showing a marginal preference for the synthetic formulation. In terms of flavour, NP ketchup received a higher score of 4.52, compared to 4.38 for SP ketchup, suggesting that consumers preferred the natural formulation due to its enhanced taste from ingredients like vinegar and lemon juice. For smell, both formulations scored high, with NP at 4.54 and SP at 4.56, indicating that consumers appreciated the aroma of both variants almost equally. Regarding texture, SP ketchup scored 4.26, which was slightly higher than 4.12 for NP ketchup, showing that the synthetic formulation provided a smoother consistency. These results show similarities with study of Tauferova, *et al.* (2015) that texture was the second most preferred parameter in consumer's choice. General acceptability of SP ketchup was rated highest, with a WMS of 4.68, while NP ketchup scored 4.52.

This suggests that although consumers liked the taste of the natural formulation, the synthetic variant was overall more preferred, likely due to its longer shelf life and smoother texture. Overall, while the natural preservative formulation was favoured for its flavour, the synthetic preservative formulation was preferred for its texture, colour and overall acceptability.

Table 4. Weighted mean score of respondents on sensory parameters

Sensory parameters	NP ketchup	SP ketchup
Colour	4.48	4.50
Flavour	4.52	4.38
Smell	4.54	4.56
Texture	4.12	4.26
General acceptability	4.52	4.68

NP: Natural preservatives and SP: Synthetic preservatives

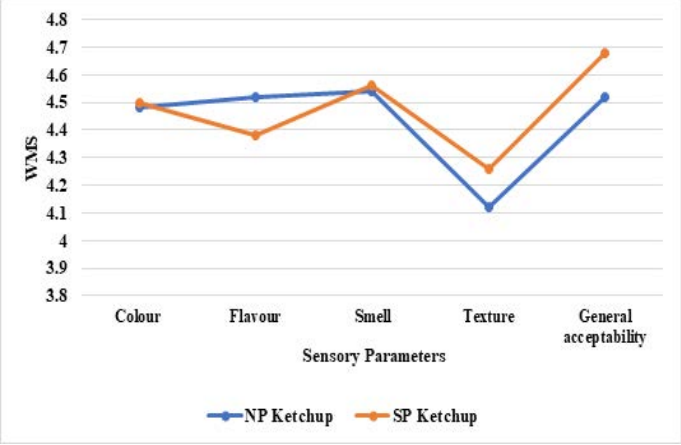


Fig. 2. Comparative analysis of tomato ketchup on sensory parameters using WMS

Comparative economics for tomato ketchup preparation using different preservatives

The production cost of tomato ketchup using natural and synthetic preservatives is compared. In both cases, the cost of tomatoes remains the same at ₹ 50 per kg. For natural preservatives, a combination of vinegar (₹ 20), lemon juice (₹ 20), and salt is used, making the preservative cost relatively higher. For synthetic preservatives, sodium metabisulphite is used, costing just ₹ 2 per gram, which is much more economical. The packaging cost, using a glass bottle, is constant at ₹ 40 for both types. When all factors are considered, the total production cost for ketchup with natural preservatives is ₹ 130 per kg, while that with synthetic preservatives is only ₹ 92 per kg. This shows that using synthetic preservatives significantly reduces the cost of production. However, natural preservatives may appeal more to health-conscious consumers. Thus, producers must balance between cost effectiveness and consumer preference when selecting preservatives for ketchup manufacturing, as shown in Table 5.

Table 5. Comparative economics for tomato ketchup preparation

Factor	Natural preservative	Synthetic preservative
Tomato	₹ 50/- kg	₹ 50/- kg
Preservative	Vinegar (₹ 20), Lemon (₹ 20), Salt	Sodium metabisulphite (₹ 2 per gram)
Glass bottle	₹ 40	₹ 40
Total production cost	₹ 130/- kg	₹ 92/- kg

Conclusion

The study revealed that synthetic preservative (SP) ketchup was preferred for its longer shelf life and had a higher general acceptability score (4.68) compared to natural preservative (NP) ketchup (4.52). However, NP ketchup was rated higher in flavour (4.52 vs. 4.38 for SP) and smell (4.54 vs. 4.56 for SP), likely due to the use of vinegar and lemon juice. Colour (4.48 for NP, 4.50 for SP) and texture (4.12 for NP, 4.26 for SP) showed marginal differences. Overall, SP ketchup was more acceptable (84% strongly liked it vs. 76% for NP), exhibited a longer shelf-life (40 days at room temperature and 90 days refrigerated), and had a lower production cost (₹92/kg). In contrast, NP ketchup had a shorter shelf-life (7 and 15 days) and a higher cost (₹130/kg), but was preferred for its natural flavour (72%) and aroma (84%), appealing to health-conscious consumers. No significant differences ($p > 0.05$) were observed in organoleptic parameters. These findings suggest consumer preferences vary based on priorities; natural quality versus shelf stability and cost.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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