



## DEVELOPMENT AND QUALITY ASSESSMENT OF NEWLY DEVELOPED ONION SAUCE

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### ABSTRACT

A sauce can be defined as a flavorful liquid, usually thickened, used to season, liquid, usually thickened, used to season, flavor and enhance other foods. Onion is widely cultivated, second only to tomato, and is a vegetable bulb crop known to most cultures and consumed worldwide. Even yet, long-term storage of onions in bulk can result in significant losses of up to 25%-30%. The present study aimed to develop and standardize the Onion sauce, assess its sensory, nutrition, texture, physicochemical and microbial analysis for a period of 60 days. Two types of Onion sauce were prepared with the variations in the ingredients. The sample A had the highest overall acceptability score (8.10) in sensory attributes. The moisture value of newly developed onion sauce was found to be 80.28g. The onion sauce contains low amount of fat 0.14g. The product contains very less content of sodium content (245.04g). The viscosity of onion sauce was identified to be a type of non-newtonian fluid with pseudoplastic behaviour. Physicochemical analysis indicated that the TSS and the titratable acidity values (21.90 °Brix and 1.20%) of newly developed onion sauce (21.90 °Brix) was found to be acceptable and was within the FSSAI limits for sauce. The color of onion sauce was good and brighter in color. The microbial results shows that the product had very low microbial colonies, no pathogenic organisms and no yeast and mold count on the 0<sup>th</sup> day, 30<sup>th</sup> day and 60<sup>th</sup> day of storage.

### 1.Introduction

Sauces, dressings and mayonnaises are commonly used in the everyday life of many consumers. They are usually packed in easy to use, small, disposable containers of different shapes, made of light materials and thus could be regarded as convenience foods. Sauces improve the taste of food (Sikora *et al.*, 2008). A sauce can be defined as a flavorful liquid, usually thickened, used to season, flavor and enhance other foods (The Culinary Institute of America, 2006). Sauces are savoury concoctions and mostly are liquid, fluid enough or thick. Sauce is a beloved complementary food and is one of the flavoring ingredients

often used in various foods. The main functions of a sauce are to enrich food, improve its flavor and aroma, as well as the taste. Besides, adding moisture, texture and improving visual appeal of the food (Krystyan *et al.*, 2012).

Onion (*Allium cepa* L.) has been valued as a food and a medicinal plant since ancient times. It is widely cultivated, second only to tomato, and is a vegetable bulb crop known to most cultures and consumed worldwide (FAO, 2012). It is commonly known as “Queen of the kitchen” due to its highly valued flavor, aroma, and unique taste. It has medicinal properties of its flavour compounds (Selvaraj, 1976; Griffiths *et al.*, 2002). Onion is an extensively

grown biennial bulb crop, with world production of 74,250,809 tonnes from an area of 4,364,000 hectares. China and India are the primary onion growing countries, followed by the USA, Egypt, Iran, Turkey, Pakistan, Brazil, the Russian Federation, and the Republic of Korea (FAO, 2012). Even yet, long-term storage of onions in bulk can result in significant losses of up to 25%-30%. As a result, onion processing maintains product stability while preserving its unique sensory character. Other products such as dehydrated goods, such as flakes, rings, granules, powder, and processed onions, such as frozen or canned onions, or onions in vinegar and brine, are becoming increasingly popular on the international market (Lawande, 2012). Onion is used throughout the year, for example in curries, in the form of spices, in salads, as a condiment, or cooked with other vegetables, such as boiled or baked. It is also used in different forms of processed food, e.g. pickles, powder, paste, and flakes, and it is known for its medicinal values (Pareek *et al.*, 2017). Despite its primary usage as a food source, this plant has been shown to provide a wide range of health benefits.

Onion and its bioactive components have been shown to have antioxidant, antibacterial, anti-inflammatory, anticancer, cardiovascular protective, neuroprotective, and immunomodulatory activities in several studies (Ranjith and Kumar, 2022). Onions are considered a rich source of more than 25 different flavonols with quercetin and its derivatives being the most significant ones, primarily in the form of flavonols glucosides (Petropoulos *et al.*, 2016). Therefore, this study focuses on developing a new product, onion sauce that ensures extended product shelf life and also provides a high level of convenience in preparation and use for the consumers.

## 2. Materials and methods

### 2.1. Materials

Major ingredients used in this preparation of Onion sauce were fully matured dry onions (*Allium. cepa L.*) and gooseberry (*Emblica officinalis Gaertn.*), whereas the minor

ingredients were ginger (*Zingiber officinale*) and garlic (*Allium sativum L.*), dry red chili, clove, peppercorn, salt, sugar, apple cider vinegar and arrowroot powder. These ingredients were purchased from local market in Chennai.

### 2.2. Standardization and pre-preparation of ingredients

Two types of Onion sauce were prepared with the variations in the ingredients. Sample A was developed without tomatoes and sample B was developed with addition of small quantity of tomatoes (Table 1). Fresh onion bulbs were selected and the outer dry layers were peeled off manually by using a sterile knife. They were washed with plenty of chilled running potable water to remove surface contamination. Cleaned and fresh mature bulbs of onion were cut by a stainless-steel knife into rough pieces and light sautéed in pan and soaked in apple cider vinegar for 5 hours and kept in well covered container until use. Gooseberry, ginger and garlic were cleaned, washed, deskinning, weighed using weighing balance and chopped into fine pieces. The stems of the red chillies were removed and was soaked in hot water for 15 minutes. Spices such as clove and peppercorns were ground into fine powder. All the ingredients were then kept ready until processing.

**Table 1.** Standardization of Onion Sauce

Ingredients	Sample A	Sample B
Onion	100g	100g
Tomato	-	20g
Gooseberry	20g	20g
Dry red chilli	1.5g	1.5g
Ginger	2.5g	2.5g
Garlic	2.5g	2.5g
Grounded spices	5g	5g
Apple cider vinegar	20ml	20ml
Lemon juice	5ml	5ml
Arrowroot powder	10g	10g

#### 2.2.1. Preparation of Onion Sauce

The sautéed, Onion, chopped gooseberry, ginger and garlic and, soaked red chillies were placed in a stainless-steel vessel with grounded spices such as clove and peppercorns were ground into fine powder and dry sautéed for 20 minutes without adding oil. The sautéed ingredients were cooled and placed in a food processor and crushed thoroughly to get a fine texture. The mixture was boiled for about 10 minutes and stirred frequently. Apple cider vinegar and lemon juice were added and mixed thoroughly. After the raw flavor disappeared arrowroot starch was added as a thickener, boiled for 5 minutes and mixed thoroughly to obtain sauce consistency. Sample A onion sauce was packed and sent to the laboratory for further analysis. In sample B, sautéed, onion, and chopped gooseberry, ginger, garlic and soaked red chillies and 20 g of blanched tomatoes along with grounded spices (clove and peppercorns) were dry sautéed. The mixture was grinded into fine texture in a food processor. After the sauce gets thoroughly cooked arrowroot starch was added, boiled for 5 minutes to obtain the final product. The finished products sample A and B was cooled and poured carefully into previously sterilized Aluminum laminated pouch and sealed using electronic sealing machine and stored in refrigerated (6°C). The shelf-life of onion sauce was analyzed at different time intervals (1<sup>st</sup>, 30<sup>th</sup>, 60<sup>th</sup>) days of storage.

### 2.3. Sensory Analysis of Onion Sauce

The sensory quality of the newly developed onion sauce was assessed by 50 panel of judges between the age group of 18-24 years. The panel members were invited to evaluate the overall quality of the two samples. They were briefed on the purpose of the study and they were instructed on the method of scoring. The sauce was evaluated using a nine-point score card. About 1 tablespoon of sauce was served and for palate cleanse, a cup of water was given. Same panelists were asked to evaluate sample A and B on 9-point scale (1 = Dislike extremely to 9 = Like extremely). Descriptive qualities were attributed to each score as a guide for panel members. The onion sauce was

evaluated for attributes like color, appearance, taste, aroma, flavor, texture, mouthfeel and overall acceptability.

### 2.4. Proximate analysis of Onion Sauce

The standardized sample A of Onion sauce was analyzed for proximate composition. Moisture content was estimated using standard method (AOAC, 2019). Energy value of onion sauce was calculated by the method given by FSSAI (2016). The macronutrients such as carbohydrate, protein and fat were estimated using standard methods given by (FSSAI, 2016; AOAC, 2012). The total ash content was analyzed using the method given by AOAC. (1995). The sodium value was determined by using the standard method (AOAC, 2012).

### 2.5. Texture analysis

The texture parameters such as firmness, viscosity and consistency of the onion sauce was measured (Paula and Conti-Silva, 2014).

### 2.6. Physicochemical analysis

The physicochemical tests, such as pH, total soluble solids (TSS), % acidity, water activity and color for the onion sauce were analyzed.

#### 2.6.1. pH

The pH of onion sauce was measured by a pH-meter, using standard method given by IS:3025 (Part11):1983.

#### 2.6.2. Total soluble solid (TSS)

Total soluble solids is a measure of the density of all soluble solids. The TSS content was determined using a refractometer. The amount of soluble solids is the total of all dissolved solids. The total soluble solids was analyzed using standard method of IS 13815: 1993 / ISO 2173: 1978 Fruit and Vegetable Products. Determination of Soluble solid content – Refractometer method.

#### 2.6.3. Titratable acidity

The percentage of acidity was estimated according to the method given by AOAC (2019). The total titratable acidity (TTA) was expressed as percentage.

#### 2.6.4. Water activity

The water activity was analyzed and estimated using the method described by Pardo *et al.* (2004).

#### 2.6.5. Color

The color was measured according to Krishnan and Prabhasankar (2010) where, the values of surface color of sauce in terms of lightness ( $L^*$ ) and color (+a: red; -a: green; +b: yellow; -b: blue) were measured using Hunter Lab color measuring system (Color measuring Labscan XE system, USA). The test was done in triplicates and the average value was reported.

#### 2.7. Shelf life

The microbiological tests performed were for enumeration of organisms, yeast and molds and pathogenic organisms such as *Escherichia coli*, following the methods described by Indian Standard (IS 5402 (Part 1):2012; IS 5403:1999 reaffirmed 2018). Microbial assay was carried out using pour plating method and Bacterial colonies were counted using a Plate count agar (PCA) colony counter. The Yeast and mold count was obtained by using standard method (IS 5403:1999 reaffirmed 2018). The viable count was enumerated by using Yeast-Extract-Dextrose Chloramphenicol-Agar medium. The

microbial analysis was conducted for 1<sup>st</sup>, 30<sup>th</sup> and 60<sup>th</sup> day of storage.

#### 2.8. Packaging

The newly developed onion sauce was aseptically packed in double layered Aluminium laminated pouch immediately after the preparation of the sauce is done. The sauce was directly poured into the pouch and sealed using electronic sealing machine to reduce the contamination. The product was stored in low temperature at refrigerated storage at different intervals of time (1<sup>st</sup>, 30<sup>th</sup>, 60<sup>th</sup>).

### 3. Results and discussions

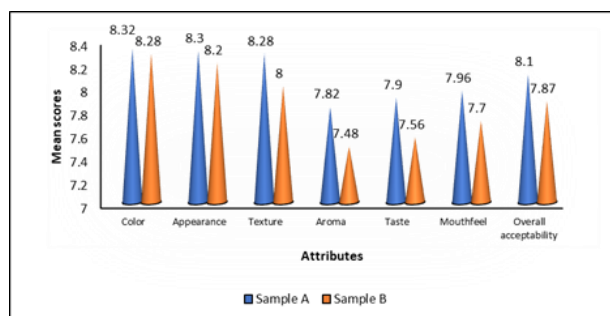
#### 3.1. Sensory analysis

Table 2 and figure 1, presents the mean scores for the sensory attributes color, appearance, texture, aroma, taste and mouthfeel of onion sauce samples A and B. The mean scores of the sensory attributes color, appearance, texture, aroma, taste and mouthfeel of Sample A were found to be 8.32, 8.3, 8.28, 7.82, 7.9 and 7.96 respectively. The mean scores of the sensory attributes in sample B was found to be 8.28, 8.2, 8, 7.48, 7.56 and 7.7 respectively. The mean scores for all the attributes were higher in sample A when compared to sample B.

**Table 2.** Sensory Attributes of Onion Sauce

Attributes	Sample A (M. $\pm$ S.D)	Sample B (M. $\pm$ S.D)
Color	8.32 $\pm$ 0.843704	8.28 $\pm$ 0.70102
Appearance	8.3 $\pm$ 0.839096	8.2 $\pm$ 0.699854
Texture	8.28 $\pm$ 0.881557	8 $\pm$ 0.968904
Aroma	7.82 $\pm$ 0.98333	7.48 $\pm$ 0.952762
Taste	7.9 $\pm$ 1.073807	7.56 $\pm$ 1.033322
Mouthfeel	7.96 $\pm$ 0.85619	7.7 $\pm$ 1.035098
Overall acceptability	8.32 $\pm$ 0.843704	8.28 $\pm$ 0.70102

M. = mean, S.D. = standard deviations



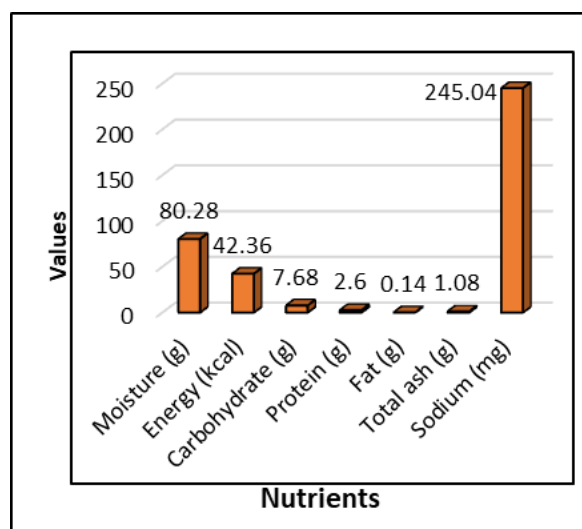
**Figure 1.** Mean sensory scores of Onion Sauce

However, statistical analysis showed no significant differences in the mean scores of sample A and B for all the attributes. The overall acceptability scores revealed that the sample A was more liked and preferred by the panelist as compared to the sample B. The higher overall acceptability could be due to the reason that tomatoes were not added in sample A, whereas in sample B tomatoes were added which masked the intense onion flavor in sauce.

The color of the sample A was brighter due to the addition of Kashmiri red chillies. Dried chilli is used primarily as a source of color, texture, and pungency, particularly in the production of crushed red pepper flakes, chilli powder, and chilli sauces. According to Fernandez *et al.* (2022), it was reported that the addition of cricket flour in barbeque sauces pointed to a more intense color when compared with sauce without cricket flour. While D'Heureux-Calix and Badrie (2004) showed that the color of sorrel (Hibiscus) sauces changed significantly ( $P < 0.05$ ) as they became less dark and red during storage days. Similar results were also reported in another study conducted by Arefin *et al.* (2019). He identified that the color of Ready-to-use onion paste with preservatives (sodium benzoate, potassium metabisulphite and citric acid) changed to a slightly brown colour on 180 day of storage at ambient (AT) condition. The storage days did not show any effect on the color of the onion sauce after 60 days of storage. This may be due to the absence of chemical preservatives and addition of natural preservative such as apple cider vinegar and lemon juice which deepens the color of onion sauce.

The appearance of onion sauce was found to be good. The score of sample A was higher than sample B. There was a marginal increase in the score of sample A than the sample B. The most important attribute of any food is its color. The fine ground texture and the presence of bright red color of red chilli enhanced the appearance of onion sauce.

The highest mean score for taste was observed in sample A. The panelists liked the intense flavor of onions with the spiciness of red chilli. This suggests that the spiciness was more tolerable to consumers. Dried chilli is also valued for its contribution to flavour in chilli sauces and chilli powders. The flavouring principle is associated with volatile aromatic compounds and color (Peter, 2001). The red chilli peppers are rich in antioxidant plant compounds that have been linked to various health benefits. According to Balaswamy *et al.* (2005), it was observed that the onion chilly chutney scored good in flavor and taste. It is recorded that the flavor of ready to use onion paste at fresh condition was ranked as good, which degraded to slightly off flavor from 5th and 20th days of storage at ambient and refrigerated condition respectively (Arefin *et al.*, 2019).



**Figure 2.** Nutrient Composition of Onion Sauce

Consequently, the panelist rating for overall acceptability of sample A was higher than sample B. This was also in accordance with

Arefin *et al.* (2019). When the onion was incorporated in hog plum sauce scored highest overall acceptability and was identified as best sample.

Durojaiye *et al.* (2003) and Gaffa *et al.* (2004) reported that storage at  $4\pm 10^{\circ}\text{C}$  refrigerated temperature ensured maximum retention of chemical and sensory properties in comparison to storage at higher temperature. Similarly, the onion sauce was also preserved in refrigerated temperature  $6^{\circ}\text{C}$  which resulted in higher retention of chemical and sensory characteristics.

### 3.2. Proximate analysis

From the above table 3 and figure 2, it can be seen that the nutrient composition of newly developed onion sauce has an 80.28g of moisture. The energy value was found to be 42.36kcal. The Carbohydrate, protein and fat content was found to be 7.68g, 2.60g and 0.14. The total ash content was found to be 1.08g. The sodium content in 100g of onion sauce was 245.05mg.

**Table 3.** Nutrient composition of Onion sauce

Nutrients	Sample A
Moisture (g)	80.28
Energy (kcal)	42.36
Carbohydrate (g)	7.68
Protein (g)	2.60
Fat (g)	0.14
Total ash (g)	1.08
Sodium (mg)	245.04

Moisture or water content is a measurement of the total water contained in a food product, usually expressed as a percentage by wet basis. Moisture is an important factor in food quality, preservation and resistance to deterioration. With regards to the moisture content, it was shown that 100g of onion sauce contains 80.28g moisture. The presence of onions and

gooseberry in the product which contains 85% of moisture, contributed to the moisture content in sauce. The prominent water content and low calorie content of onion sauce makes it a healthy accompaniment.

According to Valladão *et al.* (2022) the moisture content of the red wine sauce and white wine sauce was found to be 83.72% and 85.36% respectively. Whereas, the moisture content of onion sauce was 80.28% and is found to be lower. The low moisture content in onion sauce resulted in prolonged shelf life and minimum microbial growth even at the 60<sup>th</sup> day of storage. Product having high moisture content has minimum shelf stability (Ayub *et al.*, 2005).

The product had an energy value of 42.36 kcal/100 g. The energy content is very low in onion sauce. Low calorie content in onion sauce is due to the addition of vegetables such as onion, gooseberry and also spices that are added in sauce. Fruits and vegetables are indeed very low in calories, supplying only 9%. Most fruits and vegetables are very important in dietary planning because they provide the double benefit of being key components in the diet with a minimum level of calories.

According to Costa *et al.* (2017) the energy value of tucupi cream paste was found to be 153kcal, the energy values of commercial mustard pastes ranged between 44.66 to 66.7 kcal/100g and the commercial ketchups ranged from 112 to 138 kcal/100g. In another study Khedkar *et al.* (2019) reported energy amount of 441kcal in curry leaf chutney. In the present study, onion sauce contains significantly lower energy due to the use of only vegetable such as onion and gooseberry which are low in calories.

Macronutrients are the body's source of calories or energy to fuel life processes. With regards to the macronutrients in onion sauce, carbohydrate was found to be 7.68g, protein was found to be 2.60g and fat was found to be 0.14g. The carbohydrate value of newly developed onion sauce was identified to be low in content. According to Longvah *et al.* (2017) the carbohydrate values of onion and gooseberry was revealed to be 9.56g and 4.39g

respectively. The low carbohydrate values of onion and gooseberry resulted in low carbohydrate level. The addition of arrowroot and a negligible amount of sugar in sauce, explained the low carbohydrate level in sauce. With regards to the protein content, the addition of arrowroot starch significantly increases the amount of protein in onion sauce 2.60g. Apostol *et al.* (2020) reported that the addition of purslane leaves significantly increases the amount of protein in tomato sauce from 0.12 (%) to 1.83 (%). Whereas, in another study by Avinash and Madhav (2014), the protein content of tomato sauce enriched with bael was 0.13%. While comparing with these studies, the onion sauce contains significantly higher amount of protein which is (2.60%)/100g.

Sauce is generally considered as low fat product. However, onion sauce has very negligible amount of fat compared to tomato sauce which contains  $0.62 \pm 0.01$ g of fat (Akhtar *et al.*, 2009). This could be due to the presence of onion and gooseberry in sauce which contains very low amounts of fat (0.08%) and (0.1%) respectively. Fruits contain less fat so their incorporation leads to decrease in fat content. However, the fat content of onion sauce is considered as low fat product which is less than 1.5g/100ml according to the FSSAI (2018) regulations.

The total ash content is the mineral content that are present in food product. Minerals play an important role in maintaining proper function and good health in the human body. The newly developed onion sauce contains 1.08g of ash content. The ash content of onion sauce was due to onions and gooseberry, which are rich in vitamins and minerals. The sodium content of onion sauce was 245.04mg.

The product has low calorie, low carbohydrate, and low fat. Hence, it could be a healthier choice for using onion sauce as an accompaniment or as bases in daily cooking and also it is made up of spices and condiments which are rich in antioxidants.

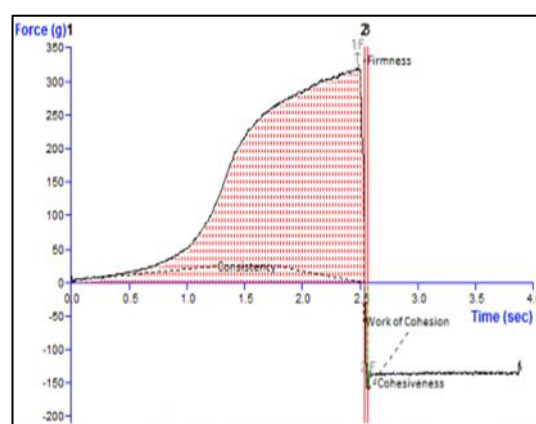
### 3.3. Texture analysis

The textural properties of the onion sauce are presented in Table 4 and figure 3. From the

table 4 it is shown that firmness was found to be 321.10g, cohesiveness was found to be -167.17g and consistency of the sauce was found to be 374.63 g.sec respectively.

**Table 4.** Textural properties of Onion Sauce

Properties	Value
Firmness	321.10g
Cohesiveness	-167.17 g
Consistency	374.63 g.sec



**Figure 3.** Texture analysis

#### 3.3.1. Firmness

With regards to the firmness of onion sauce, the addition of arrowroot enhanced the texture and did not affect the firmness of sauce. The incorporation of gooseberry particles in protein matrix would have strengthened the binding during cooking. Fernandez *et al.* (2022) identified that, the increase in the addition of cricket flour concentration in the Barbecue sauce led to a higher firmness and adhesiveness due to the increased protein content of cricket flour.

#### 3.3.2. Consistency

With regards to the consistency, the newly developed onion sauce had a good consistency and there was no change in consistency even after storage days. This could be due to the factor that arrowroot starch will gel when cooled and it is less likely that the cornstarch will break down when heated for long time. Arrowroot starch is popular for its high digestibility and medicinal properties. It

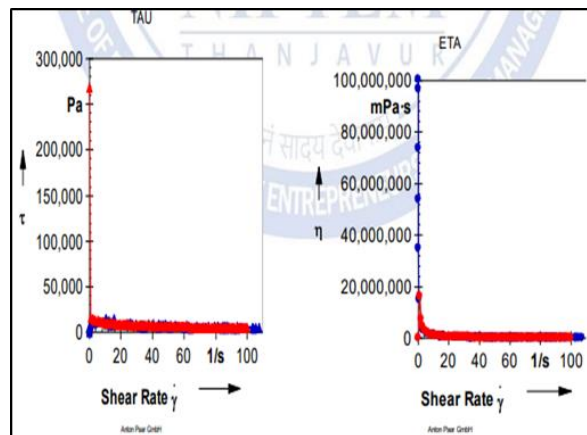
possesses demulcent properties that soothes and protects irritated or inflamed internal tissues of the body and hence is given in bowel complaints (Jyothi *et al.*, 2009).

### 3.3.3. Viscosity

From the given figure 4, it can be seen that the viscosity of the onion sauce was found to be a type of non-Newtonian fluid with pseudoplastic characteristic due to the decrease in viscosity over shear rate time. The viscosity was thick and it was due to onion puree, sugar, gooseberry paste and also arrow root being used as thickener. It has been found that viscosity decreased with increase in shear force and rate. This revealed that onion sauce possesses a type of non-Newtonian liquid called pseudoplastic fluid where viscosity decreases as the shear rate increases. A non-Newtonian fluid is one whose properties are different from Newtonian fluids i.e., apparent viscosity changes with applied stress or forces (Barman *et al.*, 2016). Similar results were reported by Costa *et al.* (2017) who detected the decrease in the steepness of the flow curves as the shear rate increases suggests the product behaved as a non-Newtonian fluid with pseudoplastic characteristic at the temperature range studied. This behavior is confirmed by the reduction in product viscosity as the shear rate increases (Schramm, 1994). In a study by Apostle *et al.* (2020) the same results were observed. The viscosity of purslane-rich sauces presents a type of non-newtonian liquid, which changes its viscosity under the action of shear force increase. It can be considered that the addition of purslane leaves leads to sauces with uniform and stable viscosity with specific appearance. According to Bortnowska *et al.* (2021), the steady rheological measurements showed that meat-based sauces behaved as non-Newtonian fluids and demonstrated pseudoplastic behavior. It was also explained that with increasing storage time the viscous nature of meat-based sauces was decreased, due to raise of fluidity. In the development of Kembayau fruit sauce the viscosity of the sauce decreased in long, but in small value.

This is due to low usage of xanthan gum in

sauce. Syneresis that occurs in sauce will affect to the final viscosity of the sauce product (Khadijah and Hamdzah, 1987).



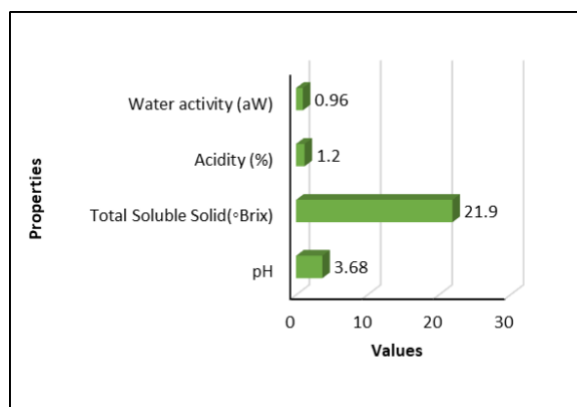
**Figure 4.** Viscosity (Results from NIFTEM, Thanjavur)

### 3.4. Physicochemical analysis

From table 5 and figure 5, it is shown that the newly developed onion sauce had a pH value of 3.68. The total soluble solid value of onion sauce was found to be 21.90°Brix, acidity was found to be 1.20% and water activity was found to be 0.96(aW) respectively.

**Table 5.** Physicochemical properties of Onion Sauce

Properties	Sample A
pH	3.68
Total Soluble Solid(°Brix)	21.90
Acidity (%)	1.20
Water activity (aW)	0.96



**Figure 5.** Physicochemical properties

### 3.4.1. pH

Among the physicochemical properties analyzed, pH is very important because acidity influences the thermal processing conditions required for producing safe products. The pH value of onion sauce was found to be 3.68 and it is acidified foods.

According to FDA (2021) the acidified foods should have water activity greater than 0.85 and have a pH of 4.6 or below and these parameters must be maintained in all finished foods. Acidified foods are less likely to develop a quick microorganism growth, which means they might take longer to deteriorate. Although the sample was high in moisture content, which was reported in table 3 it also contained sugar, salt and acid. This reduces the water activity (aw) and inhibits the growth of disease causing microorganisms in the selected sample. To suit consumer acceptance, the pH was increased with the addition of apple cider vinegar which is natural preservative that works by raising the acidity of the food, which disables enzymes and kills bacteria that may cause spoilage. The obtained values were in accordance with a study conducted by (Rani and Banins. 1987), who found that the pH value for tomato ketchup ranged between 3.55 to 3.87. Whereas in another study, it was identified that the fresh onion paste pH value was 5.29 which was higher when compared to onion sauce developed in the present study.

### 3.4.2. Total soluble solids (TSS)

Results from table 5 showed that, the TSS content of newly developed onion sauce (21.90) was found to be acceptable and was within the

FSSAI limits, where it stated that sauces/culinary pastes should not contain less than 15.0 percent of TSS. In comparison with jackfruit sauce which contains 34.5 to 41.8 °Brix (Ritthiruangdej *et al.*, 2011), the TSS was found to be lower in onion sauce. While in another study it shows that the total soluble solid (TSS) of Kembayau fruit sauce was increased for 1°Brix during storage days. In general, total soluble solid of freshly prepared sauce will increase from 35 to 37°Brix. According to Aramouni *et al.* (2013) the absence of sugar in the sugar free barbeque sauce resulted in a 65% reduction in solid content and also it is well known that the higher of the total solids the better will be the quality of the end product.

### 3.4.3. Titratable acidity

With regards to the titratable acidity, according to FSSAI standards for the sauces/culinary pastes should not have less than 1.2% of acidity and the onion sauce value was within the given limit (1.20%). According to Thakur *et al.* (2018), the titratable acidity of pomegranate chutney ranged from 1.11 to 1.98% which is more or less similar with the onion sauce acidity value. In comparison with acidity value of tomato sauce  $1.54 \pm 0.03$ , onion sauce contains lower acidity value 1.20%. Scientific report stated that acidity value is influenced by sodium benzoate, vinegar, and citric acid (Rahman and Thajudin. 2015, Hussain *et al.*, 2008)

### 3.4.4. Water activity

Water activity is usually controlled by the use of salt or sugar. The presence of salt and sugar concentration in the onion sauce may be sufficient to document control of water activity and commercial sterility. The water activity of onion sauce was found to be 0.96. According to FDA (1984) regulations, most foods have a water activity above 0.95 and that will provide sufficient moisture to support the growth of bacteria, yeasts, and mold. Depending on various product characteristics this minimum level can be as high as 0.96 and the standard levels were maintained in onion sauce.

### 3.4.5. Color

From table 6, it can be seen that the color of onion sauce was found to be good and brighter in color. The  $L^*a^*b^*$  values of onion sauce are 31.48, 20.21 and 33.09 respectively. The color of the onion sauce was observed to be intense red color. The addition of kashmiri red chillies in preparation of sauce lends a bright red color to sauce. Dried chillies contain capsaicin that has anti-inflammatory properties. Similarly in a study conducted by D'Heureux-Calix and Badrie. (2004), the color of the sorrel sauce changed slightly from less dark to red due to the addition of sorrel(hibiscus) which is an excellent source of red color of food products (Esselen and Sammy, 1973). When apple cider vinegar and lemon juice was added, it deepens the color of the product.

**Table 6.** Color of the Onion Sauce

Sample	L*	a*	b*
Onion sauce	31.48	20.21	33.09

### 3.5. Shelf life

From table 7, we can see that the total plate count on first day was <1 cfu/g and on the 30<sup>th</sup> day it was found to be 6 cfu/g and after 60 days of storage it was found to be 12 cfu/g. There was marginal but insignificant increase in the number of colonies from 1<sup>st</sup> day to the 60<sup>th</sup> day of storage. There was no coliforms and pathogenic organisms found on the 1<sup>st</sup>, 30<sup>th</sup> and 60<sup>th</sup> day of storage. *E. coli* and pathogenic organisms were absent in the sample at the different days of storage. The yeast and mold count on the 1<sup>st</sup>, 30<sup>th</sup> and 60<sup>th</sup> day was <10 cfu/g. The table 7 indicates that there are very low microbial colonies, no *E. coli* and pathogenic organisms and also no yeast and mold. This shows that product had very low microbial colonies, no pathogenic organisms and no yeast and mold count on the 0<sup>th</sup> day, 30<sup>th</sup> day and 60<sup>th</sup> day of storage.

Microbiological contamination is a very important factor in determining the quality of food products. Microbiological tests were conducted for TPC (Total plate count), *E. coli* and yeast and mold count. These microorganisms are responsible for many food

borne diseases. As per the FSSAI (2011) standards for thermally processed fruits and vegetables, the product should comply with TPC count of  $1 \times 10^2$  and yeast and mould count of 50/g. There is no standard prescribed by the FSSAI for onion sauce. The quality of onion sauce was maintained due to the proper handling of product, storage condition and use of natural preservatives. The apple cider vinegar was added to increase the acidity and it is one of the best natural preservative. This inhibits the growth of spoilage and food microorganisms. Other ingredients such as salt and sugar could have also contributed to the preservative effect. According to FDA, change in the pH could transform a food into one which could support the growth of pathogens.

Onions were washed thoroughly using chilled water to reduce the risk of microbiological load. Park *et al.* (1998) reported that repeated washing of trimmed and cut pieces of onions by using chilled water resulted in a reduction of total microorganisms count. The product was processed and cooked in heat treatment namely boiling which kills or inactivates any bacteria active at the time, including *E. coli* and salmonella. The product was packed into double layered Aluminium laminated pouch in aseptic condition and kept in tight sterile air tight container at refrigerated temperature (6°C) during the study for extended shelf life.

This resulted in prolonged shelf-life and minimum microbial load in the product. Chilled foods stored at temperatures near 0 to 6°C have been reported to have longer shelf-life because of slower growth of psychrotrophs leading to delayed onset of spoilage (King and Cheetham, 2012). In fresh fruits and vegetables, low temperature does not necessarily stop enzymatic and non-enzymatic chemical reactions but instead slows their rates thereby leading to increased shelf-life in products (Kitinoja and Kader, 2002). Similar results were observed in a study conducted by Nkhata and Ayua (2018), the shelf-life of homemade tomato sauce was increased at low temperatures especially at 6°C. while in another study, Aramouni *et al.* (2012) identified that the

TPC of all the treatments was below detectable levels (<10 CFU) in storage periods. This was due to the effect of pasteurization treatment. In onion sauce the yeast and mold count remained below the detectable levels during the storage days due to the storage of product in refrigerated temperature. It was also identified that sauces were preserved for longer period at refrigerated temperature than room temperature.

**Table 7.** Microbiological data of Onion Sauce during storage

Storage period	TPC (cfu/g)	Yeast and mold/g	Coliforms/g
0	<1	<10	ND
30	6	<10	ND
60	12	<10	ND

Preservatives are commonly used in almost all the processed food items in order to enhance the shelf life and maintain the product's quality. The shelf life of onion sauce was found to be shelf-stable due to the addition of natural preservative apple cider vinegar and dietary antioxidant lemon juice (ascorbic acid). It was found that the natural antioxidant ascorbic acid tends to delay, control, or inhibit oxidation and deterioration of food quality. The spices added in sauce (cinnamon and pepper) also could be a reason for prolonged shelf-life. According to Shahidi (2015), states that the natural antioxidant components of spices and herbs are great sources of antioxidants for food preservation.

The usage of apple cider vinegar as preservative on onion sauce shows effectiveness in terms of bacteria, yeast, and mold retardation. The apple cider vinegar was used due to its more conventional uses as a flavouring agent and as a food preservative to enhance the product shelf life. These results were in accordance with study conducted by Arefin *et al.* (2019), where it has been observed that, the bacterial load was lowest for onion paste treated with citric acid and potassium metabisulfite (KMS) stored at refrigerated temperature. In another study Balaswamy *et al.*

(2005) reported that the total plate count (TPC) and yeast and mold count were within the permitted levels. It is also showed that there is a decreasing trend in the TPC and yeast and mold count during storage period due to low pH and presence of salt in onion-chilly chutney.

#### 4. Conclusions

In the present century, people are living in a fast-paced environment. They are looking for quick, easy and convenient foods on-the-go, which can please their palate at the same time healthier. Onion is an important vegetable crop grown in India and forms a part of daily diet in almost all household facilities throughout the year. Due to over production in some seasons it leads to lot of wastage. This study has paved the way for commercial production of onion sauce by using appropriate processing and storage method to ensure longer shelf life and making it available in an easily accessible way for all the consumers. The production of newly developed onion sauce lends to retain the intense onion flavor and texture with a potential prolonged shelf life. The newly developed onion sauce may find its extensive use in the home as well as in catering industries and other establishments. It can be used as an accompaniment and dipping sauce, paste or base for preparation of curries and gravies, thickening agent for soups, gravies and also it enhances the nutritional value of the dish. The newly developed onion sauce, for its anticipated widespread use, may help to fill the needs of consumer's choice of convenient food product.

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