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Bhargavanandha KS
Department of Food Engineering, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Kshirsagar RB
Department of Food Engineering, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Patil BM
Department of Food Engineering, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Bachate AH
Department of Food Engineering, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Corresponding Author:
Bhargavanandha KS
Department of Food Engineering, College of Food Technology, VNMKV, Parbhani, Maharashtra, India

Effect of addition of partially hydrolyzed guar gum on the quality attributes of tomato soup powder

Bhargavanandha KS, Kshirsagar RB, Patil BM and Bachate AH

Abstract
In the present research project, partially hydrolyzed guar gum (PHGG) was utilized in tomato soup powder and their effect in quality attributes of tomato soup powder was analyzed. Addition of PHGG decreases water absorption capacity, wettability time, swelling index, rehydration ratio, water absorption (hot water) and increases solubility, water solubility index and flowability of selected tomato soup powder. As increasing level of PHGG increases the TSS, pH and decreases viscosity of prepared soup samples. As increasing spindle speed decreases the viscosity of tomato soup samples. As increasing level of PHGG (5%, 10%, 15% and 20%) decreases the viscosity of prepared tomato soup samples. Addition of PHGG decreases the bioactive components of tomato soup powder such as lycopene, vitamin C and β-carotene (4.87±0.02, 82.54.87±1.63 and 25.074.87±0.26) mg/100g. Tomato soup powder can be stored for 90 days at ambient temperature (37ºC) and refrigerated condition (4ºC) without any microbial spoilage. Increasing storage period of tomato soup powder increases titratable acidity and decreases TSS, solubility, pH value and overall acceptability of tomato soup powder stored at ambient temperature (37ºC) and refrigerated condition (4ºC). HDPE laminated standing pouch can be used as packaging material for storage of tomato soup powder at ambient temperature (37ºC) for 90 days and it is not suitable for storage at refrigerated condition (4ºC) and poly propylene can be recommended for storage of tomato soup powder at refrigerated condition (4ºC) for 90 days. Solubility, titratable acidity, pH and TSS of tomato soup powder changes irrespective of packaging material and storage condition.

Keywords: PHGG, reconstitutional properties, microbial study and storage study

Introduction
Instant soups (soup powder) are one type of dried foods, it can be prepared by mixing spices, flavours, salts, corn starch and flavor enhancers and reconstituted in suitable amount of water. Instant soup mix obtains its own recognition among all dried foods as they are easy to prepare and accessible in various packet sizes and also satisfy amount of nutrients and energy needed by the human body, so it can be used as breakfast substitute (Gandhi *et al.*, 2018; Joshi *et al.*, 2020) [12, 16]. In the world market various forms of soups are exits such as canned soup, frozen soup, dried soup powder, chilled soup and recently ultra-high temperature with aseptic packaging of soups are available. Among these soups, dry soup mix are mostly preferred by consumer as they does not require more space for storage purpose and also can be stored for longer periods without any refrigeration or cold condition, easy to transport, longer shelf life, easy to prepare (Chavan *et al.*, 2015; Niththiya *et al.*, 2014) [7, 8, 21].
PHGG (partially hydrolyzed guar gum) as a source of highly soluble dietary fibre. Consuming 20-40g of PHGG per day well accepted and there was absence of abnormalities (Meier *et al.*, 1993) [23]. So, PHGG can be used for various food applications. Utilizing 2.23% PHGG improves textural and organoleptic attributes, increases cooking loss and decreases cooking yield and increases soluble dietary fibre content in noodles (Mudgil *et al.*, 2018) [31]. 1.59% of PHGG improves the textural attributes such as hardness decreases and specific volume increases and also used as a soluble dietary fibre fortification in bread (Mudgil, *et al.*, 2016b) [27]. PHGG improves texture quality in yoghurt based on parameters such as springiness (elasticity), adhesiveness and cohesiveness increases with increasing level of PHGG, hardness (firmness) and gumminess decreases with increasing level of (>2.5%) PHGG in yoghurt (Mudgil *et al.*, 2017a) [29]. Utilizing 4% of PHGG decreases phase separation, without negatively effecting on organoleptic and also there is no much changes in pH, acidity in buttermilk, viscosity of butter milk increases as increase level of PHGG as fibre (Mudgil & Barak, 2016a). Addition of 2.21% PHGG as a soluble dietary fibre enrichment in cookies and also improves texture quality by decreasing hardness (due to formation of gluten content in

dough is reduced) and spread ratio of cookies (Mudgil *et al.*, 2017c) [30].

In view of functional and physico-chemical properties of PHGG, an efforts have been under taken to utilize PHGG in tomato soup powder to improve the physical, chemical and reconstitutional properties of tomato soup powder.

Materials

The raw materials such as tomato powder, red onion powder, garlic powder, ginger powder was prepared by using cabinet tray dryer at 60°C temperature. Partially hydrolyzed guar gum prepared by using cellulase enzyme (Barak & Mudgil, 2020; Mudgil *et al.*, 2014) [3, 25]. Salt, chilli powder were purchased from the local market of parbhani district, Maharashtra. Guar gum, glass wares and chemicals required for research work was available in the Department of Food engineering and Department of Food chemistry and nutrition parbhani district of Maharashtra.

Methodology

Determination of physicochemical properties

Bulk density, true density, tapped density, angle of repose and static coefficient of friction of tomato powder, guar gum, PHGG and tomato soup powder was estimated as per method (Sarkar *et al.*, 2018) [38]. Water holding capacity and oil (soyabean oil) holding capacity of guar gum and PHGG was evaluated by method given in (Sarkar *et al.*, 2018) [38]. Hausner ratio defined to be ratio of tapped density to bulk density (Hayes 1987) [13]. All samples were analyzed for minerals contents to their respective standard methods as described in (AOAC, 2005) [1], pH was determined with help of digital pH meter which was firstly calibrated 4, 7 and 10 pH buffers, then by dissolving 10 g of powder in 100 ml of distilled for dry samples it was calibrated. Determination of TSS 10 g of tomato soup powder was reconstituted in 75 ml of water or prepared tomato soup. A drop of prepared or reconstituted sample was placed on the prism of Hand Refractometer (ERMA make) and total soluble solids (TSS) was recorded in percentage. Water absorption capacity was evaluated as per (Adebowale *et al.*, 2005) [2]. Water solubility index and wettability was estimated by method of (Kumar *et al.*, 2017) [19], water solubility index and water absorption index formula given by (Gandhi *et al.*, 2018) [12]. Rehydration ratio method given in (Farooq *et al.*, 2020) [11]. Solubility of tomato soup powder was determined by modified method given by (Chavan, 2015) [7, 8]. Water absorption was determined by following methods (Oluwaseun *et al.*, 2015) [33]. Swelling index was determined by using method given by (Ukpabi & Ndimele, 1990) [42] and its formula given by (Bharti *et al.*, 2020) [4]. Estimation of lycopene given by (Obadina *et al.*, 2018) [32], β-carotene given by (Farooq *et al.*, 2020) [11], ascorbic acid method given by (Kamal *et al.*, 2019) [17]. Viscosity was measured by using (Brookfeild viscometer, U.S.A). Spindle number (S64), (S1) and (S61) used for measuring viscosity of guar gum, partially hydrolyzed guar gum (PHGG) method given by (Barak & Mudgil, 2020) [3] and after preparation of reconstituted tomato soup viscosity was measured. Microbial analysis was as per method (Harrigan & Mc-Cance, 1966), storage study was carried out upto 3 months by using packaging materials, parameters was analyzed 30 days interval time.

Statistical analysis

The data obtained was analyzed statically by completely Randomized design (CRD) as per the procedure given by (Panse and Sukhatme, 1967) [35]. The analysis of variance revealed at significance of $P<0.05$ level, S.E, and CD. at 5% level is mentioned wherever required.

Formulation of tomato soup powder

The tomato soup powder was prepared with composition of ingredients such as (tomato, onion, garlic, chilli, ginger) powders, salt, partially hydrolyzed guar gum and guar gum. The formulation for the five samples of tomato soup powder was prepared, presented in Table 1.

Formulation of tomato soup powder

Table 1: Formulation of tomato soup powder with addition of PHGG

Ingredients (%)	Samples				
	T_0	T_1	T_2	T_3	T_4
Tomato powder	71.5	67.5	62.5	57.5	52.5
Onion powder	10	10	10	10	10
Garlic powder	5	5	5	5	5
Ginger powder	5	5	5	5	5
Chilli powder	2.5	2.5	2.5	2.5	2.5
Salt	5	5	5	5	5
PHGG	-	5	10	15	20
Guar gum	1	-	-	-	-

Reconstitution of formulated tomato soup powder

10 g of tomato soup powder was reconstituted in 75 ml of water and analysed for viscosity and TSS% of prepared tomato soup.

Results

Selection of formulated tomato soup powder

Based on organoleptic evaluation of reconstituted tomato soup with 15% PHGG in (T_3) sample was selected. Further analysis was evaluated between control (T_0) and (T_3) sample.

Physical properties of guar gum, PHGG and tomato powder: Physical properties required for packaging, mixing, conveying, hopper designing and storage of powders. 200 mesh size guar gum, 350 µm PHGG and 250 µm tomato powder was used to determine physical properties of powders. Determined values presented in Table 2.

Table 2: Physical properties of guar gum, PHGG and tomato powder

Parameters	Guar gum	PHGG	Tomato powder
Bulk density (g/ml)	0.55±0.02	0.25±0.01	0.45±0.01
Tapped density (g/ml)	0.67±0.02	0.28±0.01	0.58±0.02
Compressibility index (%)	25.27±0.12	10.71±0.04	22.78±0.02
Hausner ratio	1.21±0.03	1.10±0.04	1.28±0.01
Angle of repose (°)	31.45±0.14	27.47±0.1	34.058±1
Static coefficient of friction (µ)	0.84±0.015	0.46±0.03	1±0.05
True density (g/ml)	0.53±0.02	1±0.01	1.03±0.20

*Each value is an average of three determinations

Table 2 analyzed the guar gum, PHGG and tomato powder bulk density was found to be 0.55±0.02g/ml, 0.25±0.01g/ml and 0.45±0.01g/ml respectively, tapped density was 0.67±0.02 g/ml, 0.280.67±0.01g/ml and 0.58±0.02g/ml respectively. It was observed that PHGG showed lower compressibility (10.71±0.04%), than guar gum (25.27±0.12%) and tomato powder (22.78±0.02%). PHGG contain good flowability characteristics when compared to guar gum and tomato powder. (Carr, 1965) [6] reported that low (11-15%), high (16-20%), very high (>31%) of compressibility index indicates the good, fair and poor flowability characteristics of powders. Hausner ratio of guar gum, PHGG and tomato powder was found to be 1.21±0.03, 1.10±0.04 and 1.28±0.03 respectively. Based on hausner ratio PHGG classified as free- flowing (1.0-1.1), guar gum classified as medium flowing (1.1-1.25) and tomato powder classified as difficult flowing (>1.4), classification of flowability of powders given by (Hayes, 1987) [13]. It was revealed that angle of repose of PHGG (27.47±0.1°) was higher than guar gum (31.45±0.14°) and tomato powder (34.05±1°). PHGG has higher flowability when compare to guar gum and tomato powder due to lower value of angle of repose higher the flowability mentioned by (Chavan, 2015) [7, 8]. Static co-efficient of friction guar gum, PHGG and tomato powder was found to be 0.84±0.015, 0.46±0.03 and 1±0.05. True density of tomato powder and PHGG was higher than guar gum. Physical properties of guar gum agreement with near values reported by (Sarkar *et al.*, 2018) [38].

Functional properties of guar gum, PHGG and tomato powders

The data with respect to functional properties such as water holding capacity, oil holding capacity, solubility and viscosity was analyzed and it is presented in Table 3. Commercial value of gums depends on its viscosity and water holding capacity.

Table 3: Functional properties of guar gum and PHGG

Properties	Guar gum	PHGG	Tomato powder
Water holding capacity (g/100g)	760.3± 0.67	37.4±0.1	-
Oil holding capacity (g/100g)	123±0.70	261±0.65	-
Solubility (%)	66±0.70	88±0.66	-
Viscosity (cPs)	3600±15	17±2	-
Water absorption index (g/g)	-	-	2.81±0.01
Water solubility index (%)	-	-	45.36±0.05

*Each value is an average of three determinations

The results of functional properties are shown in Table 3. Water absorption and water solubility index of tomato powder was found to be 2.81±0.01 (g water/g of powder) and 45.36±0.05 percent. These results are higher than findings reported by (Kumar *et al.*, 2017) [19], it may be due to method of drying and variety of tomatoes. The water holding capacity was significantly lower in PHGG 37.4±0.1 (g water/100g PHGG) than guar gum 760.3± 0.67 (g water/100g guar gum). Which might be due to higher insoluble network in guar gum compared to PHGG. Insolubility network can be determined based on solubility of gum. However, solubility was significantly higher in PHGG (88±0.66%) than guar gum (66±0.70%), for this reason PHGG has lesser water holding capacity when compared to guar gum. Similarly, PHGG was highly soluble in water reported that (Yoon *et al.*, 2008) [46]. Water holding capacity depends on insoluble network of gums reported by (Sarkar *et al.*, 2018) [38]. Oil holding capacity of PHGG and guar gum was 261±0.65 g oil/100g of PHGG and 123±0.70 g oil/100g of guar gum respectively. Lower viscosity of PHGG was attributed to guar gum that under goes partially hydrolysis by enzymatic and acid method, guar gum consists of heteropolysaccharide that break down into oligosaccharide by an hydrolysis (Sun *et al.*, 2013) [41] and also (Yoon *et al.*, 2008) [46] reported that endo-β-D-mannanase breaks the mannan backbone-chain of galactomannan by an hydrolysis. Based on water holding capacity and high viscosity nature of guar gum has commercial value and it is used as thickener and stabilizer in various food products (Barak & Mudgil 2020) [3], as PHGG shows a low viscous nature than guar gum so it can be incorporated in higher amount in food products and also it solves the high viscous problems of guar gum in the food products (Yoon *et al.*, 2008) [46].

Mineral composition of guar gum, PHGG and tomato powder: The minerals like zinc, manganese, copper and iron were estimated and results are in Table 4.

Table 4: Mineral composition of guar gum, PHGG and tomato powder

Parameters	Values (mg/100g)		
	Guar gum	PHGG	Tomato powder
Zinc	1.328±0.001	3.486±0.002	3.66±0.014
Iron	0.435±0.001	0.304±0.001	1.752±0.002
Copper	0.148±0.001	0.024±0.004	0.382±0.003
Manganese	5.026±0.016	0.216±0.002	0.562±0.003

*Each value is an average of three determinations

Data revealed from Table 4, PHGG showed higher zinc content (3.486±0.002 mg/100g), than the guar gum (1.328±0.001 mg/100g). However, manganese content was higher in guar gum (5.026±0.016 mg/100g) than PHGG (0.216±0.002 mg/100g). Iron content in guar gum, PHGG and tomato powder was found to be (0.435±0.001, 0.304±0.001 and 1.752±0.002) mg/100g. Copper content in guar gum was 0.148±0.001 mg/100g, PHGG was 0.024±0.004 mg/100g and tomato powder was 0.382±0.003 mg/100g. Tomato powder contain (0.562±0.003 mg/100g) of manganese and also appreciable amount of zinc (3.66±0.014 mg/100g). The tomato powder results were close with (Srivastava and Kulshreshtha, 2013) [39] and guar gum results were similar to findings reported by (Eldirany *et al*., 2015) [9].

Effect of addition of partially hydrolyzed guar gum (PHGG) on the physical properties of tomato soup powder

The physical properties plays very important role in during operations like hopper design, storage, mixing, packaging and process designing of food powders (Sarkar *et al.*, 2018) [38] and also helps in deciding flowability characteristics of powders. Physical properties of tomato soup powder were represented in Table 5.

Table 5: Effect of addition of partially hydrolyzed guar gum (PHGG) on the physical properties of tomato soup powder

Physical properties	Control (T_0)	(T_3)
Bulk density (g/ml)	0.49±0.01	0.47±0.01
Tapped density (g/ml)	0.655±0.04	0.615±0.02
Compressibility index (%)	25.19±0.03	23.57±0.02
Hausner ratio	1.33±0.05	1.30±0.04
Angle of repose (°)	47.36±0.25	46.12±0.10
Static coefficient of friction (µ)	1±0.05	0.9±0.04
True density (g/ml)	0.78±0.01	0.72±0.02

*Each value is an average of three determinations

T_0 (control) - 1% guar gum and 71.5% of tomato powder, T_3 (selected sample) - 15% PHGG and 57.5% of tomato powder

The results for bulk density of control and T_3 tomato powder samples was 0.49±0.01 g/ml and 0.47±0.01 g/ml respectively. These results are similar to value reported by (Pandey, 2006; Yatnatti & Vijayalakshmi, 2018) [45]. T_0 sample showed higher true density (0.78±0.01 g/ml), than T_3 sample (0.72±0.02 g/ml). Tapped density of control and T_3 was 0.655±0.04 g/ml and 0.615±0.02 g/ml. However, compressibility index was lower in T_3 sample (23.57±0.02%) than the control sample (25.19±0.03%). Decrease in compressibility index increases the flowability of tomato soup powder, based on results of compressibility index tomato soup powders (control and T_3) can be categorized under high compressibility index and fair flowability characteristics (Carr, 1965) [6]. It was evident from Table 5, T_3 sample showed lower hausner ratio (1.30±0.04), than control sample (1.33±0.05). These tomato soup powders are classified as difficult flowability (Hayes, 1987) [13]. Angle of repose was lower in T_3 sample (46.12±0.10°) when compare to control sample (47.36±0.25°), as decreasing angle of repose increases the flowability of powder (Chavan, 2015) [7, 8]. Static coefficient friction values of T_3 and control was found to be 0.9±0.04 and 1±0.05 respectively. By observing results of angle of repose and compressibility index, it can be decided that utilizing 15 percent of PHGG improves flowability of (T_3) tomato soup powder. Decrease or increase for physical properties of tomato soup powders, it depends on physical properties of guar gum, PHGG and tomato powder which was given in Table 2.

Effect of addition of PHGG on TSS, pH and viscosity properties of prepared tomato soup

Tomato soup was prepared by reconstituting 10g of tomato soup powder in 75 ml of water with addition of PHGG. TSS (total soluble solids), pH and viscosity of tomato soup were evaluated and the results are represented in Table 6.

Table 6: Effect of addition of PHGG on TSS, pH and viscosity properties of prepared tomato soup

Samples	TSS (%)	pH	Viscosity (cPs) at 30 °C, spindle no. 61, speed in rpm		
			20 rpm	30 rpm	50 rpm
T_0	8.2	4.0	47.4	43	40.1
T_1	8.8	4.1	38	35	26
T_2	9.0	4.26	36	32	23
T_3	9.2	4.34	34	28	19
T_4	9.6	4.42	32	24	15
SE	0.0637	0.0493	0.3061	0.3079	0.3669
CD at 5%	0.1868	0.1447	0.8980	0.9031	0.9762

*Each value is an average of three determinations

T_0 (control) - 1% guar gum and 71.5% of tomato powder, T_1 - 5% PHGG and 67.5% of tomato powder, T_2 - 10% PHGG and 62.5% of tomato powder, T_3 (selected sample) - 15% PHGG and 57.5% of tomato powder and T_4 - 20% PHGG and 52.5% of tomato powder

Data presented in Table 6 showed the percent of total soluble solids (TSS %) increased from T_1 (8.8) to T_4 (9.6), these values are higher than the T_0 (8.2). Addition of PHGG increases TSS percent in prepared tomato soup samples compared to control (T_0), as increasing level of PHGG increases the TSS percent in incorporated soup samples. (FSSAI, 2011) specifications (based on dilution) mentioned that tomato soup contain at least 7 percent total soluble solids (TSS) (w/w), whereas other soup samples contain at least 5 percent TSS (m/m), TSS level of soup samples should not be less than given specifications by (FSSAI, 2011). pH value was increased from T_0 (4.0) to T_4 (4.42) due to decreasing the percent of tomato powder from T_0 to T_4. Viscosity of prepared tomato soup samples decreased from T_1 (38 cPs) to T_4 (32 cPs) at 20 rpm, T_1 (35 cPs) to T_4 (24 cPs) at 30 rpm and T_1 (26 cPs) to T_4 (15 cPs) at 50 rpm respectively. These values are lower than viscosity of T_0 (control sample). Addition of PHGG decreases the viscosity in tomato soup samples compared to control sample due to PHGG has low viscosity when compared to guar gum which is given in (Table 3). Increasing level of PHGG decreases the viscosity of tomato soup samples, similarly (Mudgil *et al.*, 2016c) [28] reported that increasing level of PHGG decreases the water holding capacity (WHC), when water holding capacity decreases in yoghurt, therefore viscosity also decreases in yoghurt. Increasing spindle speed decreases the viscosity of each and every sample from 20 rpm to 50 rpm. Similarly (Lavanya, 2011) [20] reported that increasing shear rate decreases the viscosity of tomato ketchup. The viscosity result of T_3 (selected tomato soup) sample are close with findings of (Ramana, 2004) [36]. It can be concluded that PHGG can be utilized higher percent in liquid foods and also solves the viscosity problem.

Effect of addition of PHGG on the reconstitutional properties of tomato soup powder

Reconstitutional properties of tomato soup powder was estimated and presented in Table 7.

Table 7: Effect of addition of PHGG on the reconstitutional properties of tomato soup powder

Parameters	Control (T_0)	(T_3)
Water absorption capacity (%)	339±1.13	297±1.33
Wettability (seconds)	55±0.01	48±0.02
Solubility (%)	26.4±0.80	30.52±0.93
Swelling Index (ml/g)	1.20±0.01	0.80±0.013
Rehydration ratio	3.65±0.06	3.18±0.04
Water solubility index (%)	44.12±0.14	45.5±0.23
Water absorption (hot water) (ml/100g)	360.28±1.16	299.15±1.01

*Each value is an average of three determinations

T_0 (control) - 1% guar gum and 71.5% of tomato powder, T_3 - 15% PHGG and 57.5% of tomato powder It was observed from Table 7, water absorption capacity of control and T_3 sample was 339±1.13 percent and 297±1.33 percent. Water absorption (hot water) was higher in control sample (360.28±1.16 ml/100g) than T_3 sample (299.15±1.01 ml/100g). Higher amount of water absorbed by control sample was due to guar gum can hold higher amount of water than the PHGG which was given in Table 3. Tomato soup powder absorbs higher amount of hot water. Wettability was defined that, separately 10 g of (T_3 and control) sample was added into 100 ml of water within 48±0.02 and 55±0.01 seconds and allowed to wett completely. These values are close agreement with values reported by (Verma & Mogra, 2017) [44]. It was observed that there was no lumps formation during wettability of tomato soup powder. T_3 tomato soup powder (normal water) showed significantly higher solubility (30.52±0.93%), than control sample (26.4±0.80%). Water solubility index (hot water) was higher in T_3 sample (45.5±0.23%) than control sample (44.12±0.14%). Tomato soup powder was highly soluble in hot water when compare to normal water. Swelling index was significantly lower in T_3 (0.80±0.013 ml/g) than control sample (1.20±0.01 ml/g). The result was similar findings with (Mamta, 2016) [22]. Rehydration ratio for control sample was 3.65±0.06 and T_3 sample was 3.18±0.04. Result of rehydration ratio was similar with (Sudharani, 2011) [40]. Addition of 15 percent PHGG decreases the water absorption, wettability time, swelling index and rehydration ratio and also increases the solubility and water solubility index in T_3, compared to control (T_0), it is due to PHGG highly soluble in water (Yoon, 2008) [46] when compared to guar gum and tomato powder, which was given.

Effect of addition of PHGG on mineral composition and bioactive components of tomato soup powder

Zinc, manganese, copper, iron and bioactive components was depicted in Table 8.

Table 8: Effect of addition of PHGG on mineral composition and bioactive components of tomato soup powder

Parameters	Values (mg/100g)	
	Control (T_0)	(T_3)
Zinc	1.7022±0.0011	1.522±0.0026
Manganese	0.9846±0.0040	0.586±0.0022
Copper	1.351±0.0036	0.988±0.0011
Iron	0.678±0.012	0.584±0.0034
Lycopene	6.41±0.01	4.87±0.02
β-carotene	28.08±0.63	25.07±0.26
Vitamin C	100±1.41	82.5±1.63

*Each value is an average of three determinations

T_0 (control) - 1% guar gum and 71.5% of tomato powder, T_3 (selected sample) - 15% PHGG and 57.5% of tomato powder

The mineral content in control and T_3 sample was found to be zinc (1.7022±0.0011 and 1.522±0.0026 mg/100g), manganese (0.9846±0.004 and 0.586±0.0022 mg/100g), copper (1.351±0.0036 and 0.988±0.0011 mg/100 g) and iron (0.678±0.012 and 0.584±0.0034 mg/100g). These values are similar with the results of (Buren *et al.*, 2019). Lycopene content in T_3 and control (T_0) sample was found to be 4.87±0.02 mg/100g and 6.41±0.01 mg/100g. These values of lycopene was higher than values reported by (Chavan *et al.*, 2015) [7, 8] and also similar to values reported by (Vashista *et al.*, 2003) [43]. β-carotene was 28.08±0.63 mg/100g in control and 25.07±0.26 mg/100g in T_3 sample. However, vitamin C content was higher in control sample (100±1.41 mg/100g) than T_3 sample (82.5±1.63 mg/100g). Addition of 15 percent PHGG decreases the minerals and bioactive components of tomato soup powder, it also due to decrease in percent of tomato powder in T_3.

Microbial analysis of standardized tomato soup powder

Microbial analysis is a perfect quality evaluation methodology used in food product. Selected tomato soup powder (T_3) after organoleptic evaluation stored at ambient temperature 37ºC and refrigerated temperature 4ºC for 3 months and TPC (total plate count), yeast and mold count and coliforms count was determined after interval of 30 days and presented in Table 9.

Table 9: Microbial analysis of standardized tomato soup powder

Days	Ambient temperature (37 ºC)			Refrigerated condition (4 °C)		
	TPC (cfu/g)	Yeast and mold (cfu/g)	Coliforms (cfu/g)	TPC (cfu/g)	Yeast and mold (cfu/g)	Colifoms (cfu/g)
30	3×10^3	ND	ND	ND	ND	ND
60	6×10^3	ND	ND	1×10^3	ND	ND
90	10×10^3	ND	ND	2×10^3	ND	ND

ND-Not detected

It was absorbed from Table 9, that coliforms, yeast and molds was absent upto 30, 60 and 90 days of storage of tomato soup powder at ambient temperature (37ºC) and refrigerated condition (4°C). The total plate count (TPC) was detected at 30th day 3×10^3 cfu/g and increased upto 6×10^3 cfu/g for 60 days and 10×10^3 cfu/g for 90 days of storage at ambient temperature (37ºC). While in case of refrigerated condition (4ºC) total plate count (TPC) was found to be 1×10^3 cfu/g for 60 days of storage and 2×10^3 cfu/g for 90 days of storage. Microbial population was decreased in refrigerated condition (4ºC) when compare to ambient temperature (37ºC). The microbial results of tomato soup powder agreement with results reported by (Jay, 1992; Megha, 2015) [15, 24].

Storage study of standardized tomato soup powder at ambient temperature (37 ºC): Selected tomato soup powder (T_3) was stored in HDPE (High Density Polyethylene) aluminum laminated standing pouch and poly propylene as a packaging material at ambient temperature (37ºC) and analysing the parameters such as TSS (total soluble solids), titratable acidity, solubility, moisture and overall acceptability for 3 months at 30 days interval of time.

Table 10: Storage study of standardized tomato soup powder at ambient temperature (37ºC) OAA= Overall acceptability

Days	HDPE aluminum laminated standing pouch					OAA
	TSS (%)	pH	Titratable acidity (%)	Solubility (%)	Moisture (%)	
0	9.2	4.34	2.74	30.52	4.89	8.2
30	9.0	4.26	2.92	30.1	4.92	8.1
60	8.8	4.09	3.15	29.6	4.93	8.0
90	8.6	3.90	3.32	28.3	4.95	7.9
Days	Polypropylene					OAA
	TSS (%)	pH	Titratable acidity (%)	Solubility (%)	Moisture (%)	
0	9.20	4.34	2.74	30.52	4.89	8.0
30	9.0	4.20	2.83	30.2	4.93	7.9
60	8.6	4.10	2.91	29.7	4.96	7.8
90	8.4	4.0	3.07	28.8	4.99	7.7

Table 10 revealed that at ambient temperature (37ºC) as increasing storage period from (0 to 90 days) decreases the TSS from (9.2 to 8.6%), pH (4.34 to 3.90), solubility (30.52 to 28.3%) and OAA from (8.2 to 7.9) and acidity increased from (2.74 to 3.32%), when tomato soup powder was stored in HDPE aluminum laminated standing pouch. Similarly as increasing storage period from (0 to 90 days) decreases the TSS from (9.2 to 8.4%), pH (4.34 to 4.0), solubility (30.52 to 28.8%) it is may be due to binding of particles and OAA from (8.2 to 7.7) and acidity was increased from (2.74 to 3.07%), when tomato soup powder stored in poly propylene. Both packaging material act as good moisture barrier. Similarly (Sarker, 2014) [37] reported that as increasing storage period of tomato powder, pH decreases and titratable acidity increases in tomato powder, it is due to decrease in ascorbic acid due to oxidation by an enzyme ascorbic oxidase reported by (Kumar *et al.*, 2016) [18]. Similarly as increasing storage period TSS (ºBrix) of tomato powder was decreases due to break down solids reported by (Farooq *et al.*, 2020) [11] and solubility of tomato soup powder was decreases reported by (Chavan, 2015) [7, 8]. By considering data from Table 10, TSS and OAA was decreased highly in poly propylene when compared to HDPE aluminum laminated standing pouch at 90 days of storage. It can be decided that HDPE aluminum laminated standing pouch better than when compare to polypropylene, but both packaging materials can be recommended upto 90 days of storage.

Storage study of standardized tomato soup powder at refrigerated condition (4ºC)

The parameters such as titratable acidity, solubility, TSS (total soluble solids), moisture and overall acceptability was analyzed. The results are presented in Table 11.

Table 11: Storage study of standardized tomato soup powder at refrigerated condition (4ºC)

Days	HDPE aluminum laminated standing pouch					OAA
	TSS (%)	pH	Titratable acidity (%)	Solubility (%)	Moisture (%)	
0	9.2	4.34	2.74	30.52	4.89	8.2
30	-	-	-	-	20	-
Days	Polypropylene					OAA
	TSS (%)	pH	Titratable acidity (%)	Solubility (%)	Moisture (%)	
0	9.20	4.34	2.74	30.52	4.89	8.2
30	9.1	4.20	2.79	30.1	4.95	8.1
60	9.0	4.15	2.84	29.7	5.0	8.0
90	8.9	4.1	2.90	28.8	5.1	7.9

OAA= Overall acceptability

Data presented in Table 11 revealed that, moisture was increased within 30 days of storage period due to improper sealing and entering of moisture or water into packaging material (HDPE aluminum laminated standing pouch), therefore it is not as a packaging material at refrigerated condition (4 ºC). As increasing storage period from (0 to 90 days) decreases the TSS from (9.2 to 8.9%), pH (4.34 to 4.1), solubility (30.52 to 28.8%) and OAA from (8.2 to 7.9) and increases acidity from (2.74 to 2.90%), moisture from (4.89 to 5.1%), when tomato soup powder was stored in poly propylene.

Conclusion

It can be concluded that utilization of 15 percent partially hydrolyzed guar gum in T_3 tomato soup powder decreased bulk density, improved the flowability, reconstitutional properties such as solubility, water solubility index and wettability and also improved the TSS and decreased the viscosity of prepared tomato soup. Selected tomato soup powder can be stored in HDPE aluminum laminated standing pouch and poly propylene at ambient temperature (37°C) and poly propylene can be recommended at refrigerated condition (4 °C) for 3 months without any microbial spoilage.

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