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Comparative assessment of different processing methods used for minimization of bitterness in Bitter gourd.

Comparative assessment of different processing methods used for minimization of bitterness in Bitter gourd

Manish Kumar* and Anjali Bidlan

Department of Food Technology, Guru Jambheshwar University of Science and Technology, Hisar – 125 001 (Haryana), India

*(e-mail: gjumanish@gmail.com; Mobile: 9896164879)

ABSTRACT

The present study was carried out to evaluate the comparative effect of different processing methods used for minimization of bitterness in Bitter gourd. For each treatment 1 kg raw fruit was taken, prior to processing samples were washed thoroughly; followed by peel removal, seed removal and slicing into equal pieces (4 cm). Sample thus obtained were subjected five treatments viz; (i) Soaking in salt water followed by heat treatment, (ii) Microwave heating, (iii) Shallow-frying, (iv) Soaking in buttermilk and (v) Roasting. Bitter gourd (4 cm) slices (500g) were dipped in 1000 mL brine solution (35% wt. by volume) for 60 min at room temperature using a stainless-steel bowl. In second stage these samples were heat treated by transferring in boiled distilled water 1000 mL for 5 min up to 96 °C. Microwave heating of slices (460g) was carried out at grill mode of Microwave oven at 110 °C for 10 min. Shallow frying of slices (482g) was done using 4-5 mL mustard oil at 100-110 °C for 10-12 min. For Buttermilk treatment the slices (437g) were dipped in 1000 mL buttermilk for 1 hr at room temperature. Roasting treatment for Bitter gourd slices (446g) was given by using a stainless-steel pan 70-90 °C for 15-16 min, till attainment of golden-brown colour from dark green. After processing sensory analysis and colour analysis (colourimeter) was done and remaining samples of each treatment was converted into powder by preparing the paste in kitchen grinders and later on its drying. The stored powders of processed samples were used for estimation of different phytochemicals responsible for bitterness in Bitter gourd. Saponin content (mg DE/g), Cucurbitacins (mg GAE/mL), Total phenolic content (mg GAE/g), alkaloid content (g/100g) and flavonoids content (mg QE/mL) were estimated. Both Saponins and cucurbitacins were found decreased, in all treated samples. Samples treated with salt solutions followed by heat treatment had shown minimum level of saponin and cucurbitacins that is (0.18mg DE/g and 206 µg Cu/mL), respectively. The Total phenolic content of all treated samples was found increased (180-249 mg GAE/g) in comparison to fresh Bitter gourd (62 mf GAE/g). Alkaloid and flavonoids content of processed Bitter gourd samples were found both decreasing and increasing in different treatments. Colour degradation of Bitter gourd was recorded in term of L, a and b values. The negative values of a ranging from -2 to -485 with a positive score of b value 20 to 35.9 indicated the transformation of green colour into greenish-yellow colour. Soaking in salt water followed by heat treatment

was considered appropriate processing treatment for minimizations of bitterness and retainment of organoleptic characteristics.

Keywords: Bitter gourd, bitterness, cucurbitacin, alkaloids, triterpene

RESUMEN

The present study was carried out to evaluate the comparative effect of different processing methods used for minimization of bitterness in Bitter gourd. For each treatment 1 kg raw fruit was taken, prior to processing samples were washed thoroughly; followed by peel removal, seed removal and slicing into equal pieces (4 cm). Sample thus obtained were subjected five treatments viz; (i) Soaking in salt water followed by heat treatment, (ii) Microwave heating, (iii) Shallow-frying, (iv) Soaking in buttermilk and (v) Roasting. Bitter gourd (4 cm) slices (500g) were dipped in 1000 mL brine solution (35% wt. by volume) for 60 min at room temperature using a stainless-steel bowl. In second stage these samples were heat treated by transferring in boiled distilled water 1000 mL for 5 min up to 96 °C. Microwave heating of slices (460g) was carried out at grill mode of Microwave oven at 110 °C for 10 min. Shallow frying of slices (482g) was done using 4-5 mL mustard oil at 100-110 °C for 10-12 min. For Buttermilk treatment the slices (437g) were dipped in 1000 mL buttermilk for 1 hr at room temperature. Roasting treatment for Bitter gourd slices (446g) was given by using a stainless-steel pan 70-90 °C for 15-16 min, till attainment of golden-brown colour from dark green. After processing sensory analysis and colour analysis (colourimeter) was done and remaining samples of each treatment was converted into powder by preparing the paste in kitchen grinders and later on its drying. The stored powders of processed samples were used for estimation of different phytochemicals responsible for bitterness in Bitter gourd. Saponin content (mg DE/g), Cucurbitacins (mg GAE/mL), Total phenolic content (mg GAE/g), alkaloid content (g/100g) and flavonoids content (mg QE/mL) were estimated. Both Saponins and cucurbitacins were found decreased, in all treated samples. Samples treated with salt solutions followed by heat treatment had shown minimum level of saponin and cucurbitacins that is (0.18mg DE/g and 206 µg Cu/mL), respectively. The Total phenolic content of all treated samples was found increased (180-249 mg GAE/g) in comparison to fresh Bitter gourd (62 mf GAE/g). Alkaloid and flavonoids content of processed Bitter gourd samples were found both decreasing and increasing in different treatments. Colour degradation of Bitter gourd was recorded in term of L, a and b values. The negative values of a ranging from -2 to -485 with a positive score of b value 20 to 35.9 indicated the transformation of green colour into greenish-yellow colour. Soaking in salt water followed by heat treatment was considered appropriate processing treatment for minimizations of bitterness and retainment of organoleptic characteristics.

Keywords: Bitter gourd, bitterness, cucurbitacin, alkaloids, triterpene

INTRODUCTION

Bitter gourd (Momordica charantia Linn.), a tendril bearing vine is tropical and subtropical climber commonly grown in Malaysia, Thailand, India, China and Africa, as well as the Middle East. Due to the its bitter

flavour, which becomes more intensified as it ripens, this has been named as bitter gourd or melon. Its scientific name is Momordica charantia (M. charantia) and it belongs to family cucurbitaceae and momordica genus. Bitter melon, Karela, Balsam pear, Goya, Karavelli, Karli, Karelo, Baramasiya, Karali, Kaypa, Pakar, Kakara are some other common names used for Bitter gourd in India and abroad. It was originated in India and later carried to China during the 14th century (Aboa *et al*., 2008). It is a herbaceous plant filled with pulp and large flat seeds, surrounded with a comparatively thin layer of flesh. Its average height is around 5 m and it bears simple/alternate leaves of 4–12 cm with 3–7 deeply separate lobes (Oyelere *et al.*, 2022; Aboa *et al*., 2008; Saeed *et al.,*2018). It is rich source of carbohydrate, protein, minerals and vitamins and dietary fibres, (Kubola and Siriamarnpun, 2008). It contains 91.8-93.5 % water, 0.20% fat, 4.2% carbohydrates, and 1.4% fiber and 8.4 - 9.8% protein contents. It is also a good source of health-inducing components, such as vitamin A (471 IU/100 g), potassium (296 mg/100 g), vitamin C (84 mg/100 g), phosphorus (31 mg/100 g) and iron (0.43 mg/100 g) (Paul and Raychaudhuri, 2010). The oil recovery from bitter melon seeds is around 35% to 40% comprising 3.33% of MUFA (monounsaturated fatty acid) and 36.71% SFA (saturated fatty acids). PUFA (polyunsaturated fatty acids) are found to be present in bitter melon. (Saeed, 2018; Rashima *et al.*, 2016). A diversity of bioactive compounds are present in Bitter melon, which comprises two classes of saponins recognized as oleanane and cucurbitane-type triterpenoids. It is a good source of phenolic compounds, ascorbic acid, flavonoid, and chlorophyll, glycosides, saponins, charantin, steroidal saponin, alkaloids, reducing sugars, resins. Gallic acid in bitter melon is as main phenolic acid, many other phenolic components are also found to be present in bitter melon extract such as epicatechin, chlorogenic acid, catechin, and gentisic acid (Saeed et al., 2018; Thakur and Sharma, 2016). Polyphenolic compounds such as flavonoids, coumarins, anthroquinones, anthocyanin, carotenoid, gentisic acid, gallic acid, catechin and caffeic acid are also present in Bitter gourd (Kubola and Siriamornpun ,2008; Horax *et al*., 2010; Nagarani *et al*.,2014). Drewnowski and Gomez-Carneros (2000) reported that phenols, flavonoids, isoflavones, terpenes, anthroquinones, and glucosinolates contributes to both bitterness and medicinal value of bitter melon. Bitter gourd has been used for the treatment of diabetes, gout, jaundice, rheumatism and pneumonia (Joseph and Jini 2013), and possesses other medicinal properties, such as anti-tumor and anti-mutagenic activities (Anilakumar et al., 2015). Bioactive substances such as vicine, charantin, glycosides, karavilosides, polypeptide-p, and plant insulin contributes to anti-diabetic activity of M. charantia in both type 1 and 2 diabetes mellitus. These bioactive compounds are basically triterpene, protein, steroids, alkaloids, inorganic, lipid, and phenolic compounds. (Oyelere *et al.*, 2022).

In Asian countries, bitter gourds are usually cooked by steaming, microwave, or boiling etc. Philippines, Panama and Nepal also use this bitter vegetable for culinary purposes in addition to India. The immature fruits of bitter gourd can be fried, deep-fried, boiled, pickled, juiced, and dried to drink as tea (Myojin *et al.*., 2008). A large number of value-added products can be prepared from bitter gourd like bitter gourd juice, pickle, dried rings, chips, dehydrated, pickled or canned (Thakur and Sharma, 2016; Rashima *et al.*, 2016, Taleb *et al*., 2018). It is used as a vegetable in many countries but since time immemorial but due to its bitterness most people avoid consuming it because of its bitter taste, of being aware about its health benefits (Paul and Raychaudhuri 2010). Despite having high nutritional properties, bitter gourd is not very popular outside Asia, due to its perceived

bitterness. Standard constituents of bitter melon are charantin, momordicine, and p-insulin which are steroidal saponin, alkaloid and polypeptides in nature, respectively (saeed *et al.,*2018). Removal of active bitter components, through a variety of debittering processes as well as selective breeding can result in loss of possible health benefits. Traditionally many households used to soak bitter gourd in butter milk and salt water (Rajasthan and Haryana) to reduce its bitterness. Rashima *et al*., 2017 processed Bitter gourd in NaCl solution is a method used to preserve and reduce bitterness. Commonly, sodium chloride is used for debittering of Bitter gourd (Yadav and Singh, 2014; Din *et al*., 2011).

As the saponin are not stable at high temperature so it is also heated by conventional and modern methods (Taleb *et al*., 2018). Microwave heating is a voluminous type heating, it occurs from inside to outside. Frying has also been reported to reduce the bitterness of Bitter gourd in some of local articles published in newspaper. Present work was designed to assess the efficacy different methods used for processing of Bitter gourd to reduce its bitterness.

MATERIALS AND METHODS

The research work was carried out in the Department of Food Technology, GJUS&T, HISAR, HARYANA

Bitter gourd: Bitter gourd used in this study were procured from local market Hisar. Proper care was taken to select healthy and clean sample free from dirt and dust.

Tender and green samples were selected while mature and over-ripe sample were not selected for this study.

Processing equipment and ingredients: Knife, stainless pan, ladder, gas stove, mixer grinder used in study were taken from Food Technology lab GJUS&T, Hisar Buttermilk: Buttermilk used in this study was purchased from a Vita booth located in in Hisar.

Salt: Tata Lite was used in this study.

Oil: Edible oil Aggarwal brand manufactured in Hisar was used in this study.

Chemicals

All chemicals were of analytical grade, supplied by CDH, Qualigens and sigma Aldrich etc.

Sample Preparation: Before processing to Bitter gourd, sample preparation was done. In each case for sample preparation, 1 kg Bitter gourd were used. Bitter gourds were then gently washed to remove adherent dirt and dust followed by peel removal (manually with knife). Samples thus obtained were trimmed on both side and remaining portion was cut in to equal pieces (in general it was 4 cm). These slices were further processed by different methods. Weight of peeled Bitter gourd after seed removal was different for different treatments.

Processing of Bitter gourd: Five types of treatments were selected on basis of past experience and review of literature. Treatments were as follows: (i) Soaking in salt water followed by heat treatment, (ii) Microwave heating, (iii) Shallow-frying, (iv) Soaking in buttermilk, (v) Roasting

Soaking in salt water followed by heat treatment: Salt solution was prepared by dissolving 35 g salt in 1000 mL distilled water. For this treatment 500 g slices (peel and seed removed) of Bitter gourd were immersed in 1 litre salt solution for one hr. After one hr salt water was drained off and pieces were roughly washed under running tap water. Further these pieces were heat treated by dipping them in boiling water for (4-5 min). Heat treated sample were subjected to sensory analysis to assess the impact of treatment on minimization of bitterness, sensory analysis of samples was carried out on hedonic scale. At the end of processing these slices were turned into powder. For powder preparation slices were fed in cup of grinder (Sujata Dynamix Mixer Grinder, 900 Watts, Power supply: 230 to 240 Volts, AC 50-60 Hz). Grinding was carried out at maximum speed for 2-3 min to convert these pieces into paste. Paste was spread over in a stainless-steel pan. It was allowed to dry in open at room temperature in month of June-July. Paste was dried in 02 to 03 days and turned into flakes and finally these flakes were grounded by using Sujata grinder to obtain powder. Powder was kept in glass bottle with screw cap and stored for further analysis, as shown in Fig. 1.

Microwave heating: Microwave heating Bitter gourd slices (462 g) was carried out using microwave oven (Sharp, R 9538A type Grill and Convection oven) for 10 min. The frequency and output power of the Panasonic microwave oven were 2450 MHz and 900 W (ICE 705), respectively. The outside dimensions of the oven were 627 m (W) x 381 mm (H) x 410 nm (D). The total cooking capacity of the oven was 41 liters. The cooking uniformity was attained with a turntable (390 mm diameter tray system). After sensory analysis the remain steps were same as it was done in soaking in salt solution.

Shallow – frying: For shallow frying, slices (289 g) were fried in 2-3 mL edible mustard oil by using a stainless-steel pan. Process was carried on gas stove. Flame modulation was done as per requirement. Samples were continuously stirred to avoid burning and overheating with help of wooden ladder. It took around 10-12 min to turn samples into light green to brown from dark green colour. Process was stopped and slices were allowed to cool in open air in room (4-5 min). After sensory analysis the remain steps were same as it was done in soaking in salt solution.

Soaking in Buttermilk: For this treatment (430 g) slices were taken in a stainless-steel bowl followed by transferring buttermilk (1 litres) to ensure the proper immersion. After draining off the buttermilk slices were washed again to remove the adherent buttermilk residue and clean the surface. After sensory analysis the remain steps were same as it was done in Soaking in salt solution.

Roasting: For this treatment (446 g) slices were taken in stainless-steel pan. Pan was placed oven gas stove with high flame to roast them dry until they turn into dark green to golden brown. The surface temperature of slices was recorded 70-90 °C during 15-16 min heating process. Process was stopped and slices were allowed to cool in open air in room (4-5 min). After sensory analysis the remain steps were same as it was done in soaking in salt solution.

Fig. 1 Process flow diagram for processing of Bitter Gourd

Estimation of moisture content of Bitter gourd (AOAC,1999): To determine of moisture content of Bitter Gourd freshly weighed 10 g sample was taken in dish (Aliuminium). Sample was heated at 105 ºC at hot air oven. At the end of the experiments dish was kept in dessicator for allowing it to cool and avoid moisture migrations from surrounding

% Moisture content was calculated as follows.

Moisture (%) = (W1-W2)/W1 × 100

Where, W1 = Weight of sample before drying

W2 = Weight of sample after drying

Estimation of Ash content of Bitter Gourd (AOAC, 942.05): 2 g raw sample was weighed in an empty crucible. Charring of samples was carried out outside the muffle furnace by placing it over a flame source. After this crucible was placed in a muffle furnance at 550 °C for 2 hr. After 2 hr remove the crucible was removed from muffle furnance and placed them into desiccator and allowing it to cool. After cooling crucibles was again weighed. % Ash content calculated as follows

Ash content (%)

= (weight of crucible + final weight of sample - weight of empty crucible / initial weight of sample) * 100

Estimation of Saponin in Bitter gourd (Makkat *et al.*, 2007): To determine the saponin content 5 µL extract was mixed with 250 µl of distilled water followed by addition of 250 µL of vanillin reagent. Later 2.5 mL sulphuric acid (72% v/v) was added into the mixture and mixed well. Solution mixture was kept in a water bath at 60 ± 5 °C for 10 min before it was cooled down. The absorbance was determined at 544 nm wavelength using spectrophotometer. The saponin value was indicated as diosgenin equivalents derived from a standard curve. Standard was prepared by dissolving 0.1 g of diosgenin in 10 mL of 95% ethanol.

Estimation of Cucurbitacin of Bitter gourd (Kamboj *et al.,* 2016): Spectrophotometric method was used to determine the cucurbitacin content of Bitter gourd extract. Absorbance of extract of sample prepared in DMSO was recorded at 263.5nm.

Estimation of total phenolic content of Bitter gourd ((Barua and Yasim 2020)

7 g of sodium carbonate mixed with 93 mL of distilled water for making this solution: 0.5 mL Bitter gourd extract was diluted the extract with 2.25 mL distilled water, followed by added 0.25 mL of folin - ciocalteau reagent. The solution, mix well and allow it to stand for 5min. Further it was neutralized the solution by 25 mL 7% sodium carbonate.After mixing the solution was incubated at ambient condition for 90mints. At the end absorbance of solutions was recorded at 765nm using UV-VIS spectrophotometer. The total phenolic content was expressed as gallic acid equivalents phenol compounds were reported as gallic acid equivalents (mg GAE/g).

Estimation of Alkaloid in Bitter Gourd (Edeoga *et al.,* 2005): 5 g Bitter Gourd powder was mixed in a test tube with 200 mL of ethanol and 10% acetic acid. Test tube was capped and left for 4 hr in room temperature.

Sample was filtered with filter paper whatman no.- 42 and the volume was reduced to a quarter of its original volume using a water bath. 5 mL of concentrated ammonium hydroxide solution was added into the reduced mixture sample drop-wise until precipitation occurred. After filtration and drying in an oven at 40 °C, the precipitate was collected and weighed.

% of total alkaloid content was as follows:

% of total alkaloid = Weight of residue / Weight of sample taken×100

Estimation of flavonoids (Romli and Uthumporn, 2017)

0.5 mL extract of Bitter Gourd was diluted with 2 mL of distilled water. Further 0.15 mL of 5% sodium nitrite was allow to stand for 5 min. In the next step 0.15 mL of 10% aluminium chloride was added and again allow to stand for 6 minutes. Finally, 1 mL molar NaOH mixed in this solution and shake well followed by standing for 15 min. Took absorbance at 510nm using UV-VIS spectrophotometer. A similar procedure was done to prepare a standard curve of quercetin at 2.0, 4.0, 6.0, 8.0 and 10.0 mg / mL. All samples were measured in triplicates and the results were expressed as mg QE / 100 mL.

Estimation of colour of Bitter Gourd

For the colour analysis of the samples were carried out by using (Chroma Meter CR-400) L, a and b value was recorded.

Sensory evaluation of debittered Bitter Gourd: The sensory evaluation of the debittered Bitter gourd was performed by group of 10 members consisting of students and one teacher from Department of Food Technology, Guru Jambheshwar University of Science & Technology. Panelists were asked to gives score to (1-10) as 1 – dislike and 10 – extremely like. All members were asked to rate the items on the following criterian: Colour, Flavour, Texture, Taste, Overall acceptability

RESULTS AND DISCUSSION

Physico-chemical analysis of Bitter Gourd: Bitter Gourd used in this study were immature, dark green colour with wavy surface and cylindrically. The length and width of Bitter gourd fruit was found 150mm-170mm with peel, 135mm-120mm without peel and 35mm-40mm with peel, 25mm-30mm without peel, respectively. Results were in accordance with finding of Goo *et. al.*, 2016. The average weight of individual fruit was 83.33g. The moisture content and ash content of raw Bitter Gourd were recorded 93% w/w and 6.5 % w/w, respectively (Table 1).

It was observed that during primary processing of Bitter Gourd samples, there were weight variation due to liquid loss and evaporative loss during peeling and seed removal operations. The amount of weight loss after peeling and seed removal in different samples were as follows: 78g and 30g (raw), 74g and 40g (sample used for soaking in salt treated), 31g and 40g (MWH), 73g and 40g (Shallow frying treatment), 72g and 40g (Soaking in

buttermilk), 50g and 40g (Roasting). The percentage yield of final slices obtained after peeling and seed removal was found varied from 43% (raw), 50% (sample used for salt treatment), 46% (sample used for MWH), 28% (sample used for frying), 43.7% (sample used for buttermilk treatment) and 44.6% for sample used for Roasting treatment. This variation in % yield and losses during primary processing may be correlated with hot and dry weather during April-June in Hisar. Secondly it might be attributed due to varietal differences, as new sample was procured every day so this much variation was expected.

Table 1. Physico-chemical analysis of Bitter gourd

Sr. No.	Weight (g)	Bitter gourd samples					
		Raw	Soaking in salt water followed by heat treatment	Microwave heating	Shallow-frying	Soaking in buttermilk	Roasting
1	Initial	1000	1000	1000	1000	1000	1000
2	Removed peel	293	295	282	400	311	408
3	Sample without peel	629	631	687	527	617	542
4	loss during peeling	78	74	31	73	72	50
5	Removed seeds	169	91	187	205	140	56
6	Sample without peel and seed	460	540	500	322	477	486
7	Loss during seed removal (g)	30	40	40	40	40	40
8	Final weight of slice (g)	430	500	460	282	437	446

Note: Fresh Bitter gourd parameters: Length: 150 mm, Width: 35 mm, Moisture content: 93%, Ash content: 6.5 %

Effect of different processing treatments on Physicochemical characteristics of Bitter Gourd: Saponins are a class of triterpenoid glucoside molecules that contribute to the bitter flavour of the plant. The saponin content of raw Bitter gourd was found 10.5 mg DE/g. Among the applied processing treatment maximum reduction was recorded in samples treated with salt solution followed by heating (0.18 mg DE/g). Microwave heating, shallow-frying and soaking in buttermilk and roasting had also resulted in decrease in saponin content of Bitter gourd in following order 6.9,9.9 and 6.1 and 7.4 mg DE/g, respectively (Fig. 2). It might be due to that specific Bitter gourd saponins are affected by thermal treatment, which may modify the bioactive compounds or bitter flavour of the Bitter gourd extracts (Liu *et.al*., 2020). It was reported that saponin were extremely sensitive to heat treatment of 100 °C for more than 10 min and under 121 °C for 20 min. Lai *et al.*, 2013 found

that lactic acid fermentation reduced the content of saponins and phytates, which possess antinutritional activity. Mitra and Dungan (1997) stated that due to salt treatment saponin decreased very much because of higher salt concentrations increase the hydrophobicity of the surfactant. In the case of saponin, we found that cmc's of all the sources of saponin decrease notably with increasing NaCl concentration

The cucurbitacin content of raw Bitter gourd was 238.6 µg CuE/ml. Soaking in salt solution clubbed with heating in hot water had resulted in maximum decrease in cucurbitacin content (206 µg CuE/ml) followed by soaking in buttermilk treatment (Fig. 3) It was found cucurbitacin varying 206.04 from to 234.7 µg CuE/ml. Saker *et. al*.2010 reported that cucurbitacins in suspension cultures was elicited by application of different concentrations of NaCl. Anjoo Kamboj et. al. 2016 found cucurbitacins are a group of highly oxygenated tetracyclic triterpenes contains cucurbitane skeleton well known for bitterness and toxicity.

The total phenolic content of raw Bitter Gourd was 62.60 mg GAE/g. After applying many debittering treatments the total phenolic content was found varying from 182.1 to 249.2 mg GAE/g. There was a increase in phenolic content (Table 2). Microwave heating had resulted in maximum increase in phenolic content (249.2 mg GAE/g) as shown in Fig. 4. Results were in accordance with Rashima *et al.,* 2017 and Aminah and Permatasari, 2013.Rashima *et al*.,2017 reported a significant increase of chlorogenic acid content in the Bitter gourd extract after soaking in 3.5% NaCl solution. These indicates that NaCl increase the biosynthesis of these compounds. It could be caused by salt stress condition which is responsible for reducing oxidative process found Phenolic acids in Bitter gourd extract present in the form of chlorogenic acid. Aminah and Permatasari, 2013 reported an increase in total phenolic content of Bitter Gourd. Deep frying had the highest TPC at 98.18 mg/100 g GAE, followed by microwave cooking (25.63 mg/100 g GAE). Total phenolics are usually stored in fruit pectin or cellulose network, they can be released during thermal processing. Individual phenolics may sometimes increase because heat can break supramolecular structures, releasing the bound phenolic which react better with the Folin-ciocalteau reagent (Bunea et al. 2008). Li Lai *et al.,* J Biosci Bioeng (2013) found that lactic acid fermentation enhanced the total phenolic content.

The alkaloid content of raw Bitter Gourd was found 0.5g/100g. Processing treatment resulted in its variation from 0.15 to 2.6 g/100g (Fig. 5). Salt stress promote the metabolism of alkaloid and increase the alkaloid content Bao et al., 2008. Alkaloids compounds in C. Chinensis Franch were not heat-sensitive, so they do not easily decompose and can be extracted at high temperatures above 60 °C, Hee *et al.,*(2012).

The flavanoid content of raw Bitter Gourd was 2235.2 mg QE/mL. There was little variation while in some cases, it was decreased while in others it was found increasing. It was found varying from 200.2 to 377.2 mg QE/mL (Fig. 6). There was a significant increase of catechin content in the Bitter gourd extract after soaking in 3.5% NaCl solution (Rashima *et al.*, 2017). Wang *et al*., 2019 proposed that the process of drying in the shade produced a slow rate of water loss which might result in the increasing of total flavonoid content.

Overall acceptability was maximum for the sample treated with salt and heat treated (9) followed by microwave heated (8.5), soaking in butter milk (7), shallow-frying (6.5) and roasted in pan (6). The colour of fresh raw Bitter gourd for L value was 79, for -a value was 3.67 and b value was 41.02. In processed samples L value

variation was from 46 to 88 while –a value varied from -3.4 to -4.85 and b value from 20.45 to 41.02. There was conversion of chlorophyll in to pheophytins in green vegetables like Bitter Gourd during thermal processing. There could be development of olive-green colour compared to the bright green colour of raw materials due to prolonged heating (Lien et al.,2016). She reported changes in L and b values of the Bitter gourd extract after the NaCl treatment. Was studied by Rashima et al.,2017. Green colour (-a value) of the Bitter gourd extract soaked in NaCl solution decreased significantly as compared to fresh Bitter gourd extract. The decreasing intensity of green colour (-a value) in Bitter gourd treated with 3.5% NaCl solution might be due to destruction of chloroplast and instability of chlorophyll pigment protein complex by the high salinity (Petjukevics *et al.,* 2015). The flavonoid compound which is Catechin is also found partially as the bitter gourd's phenolic content.There was a significant increase of chlorogenic acid and catechin content in Bitter Gourd after soaking in 3.5% (w/v) NaCl solution. R. Siti Rashima, M. Maizura and U. Uthumporn *et al.,(*May 22, 2017) stated that Lightness (L-value) of the Bitter Gourd after blanching treatment and soaking in 3.5% NaCl solution were significantly lower as compared to fresh Bitter Gourd.

Fig. 2 Effect of processing treatments on Saponin content (mg DE/g) of Bitter Gourd

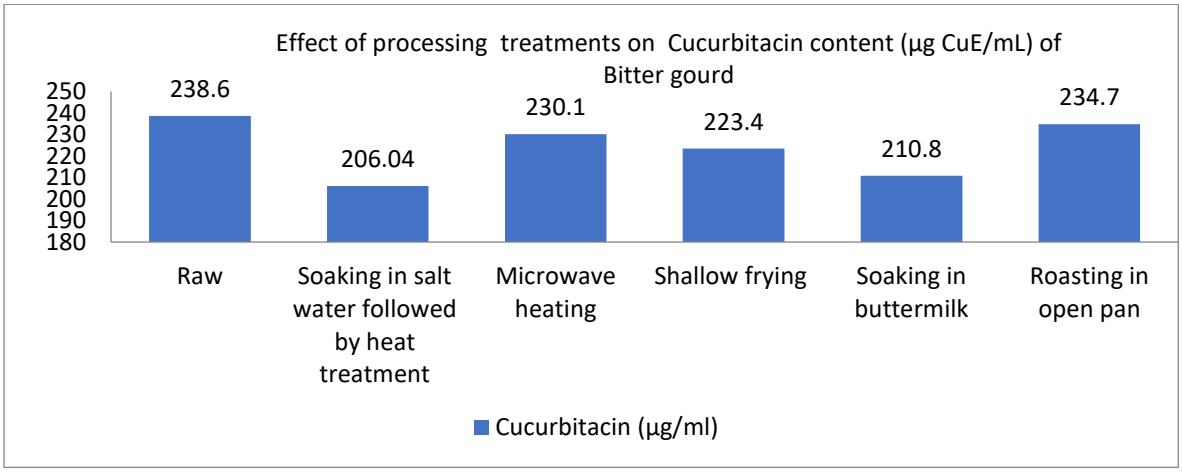

Fig. 3 Effect of processing treatments on Cucurbitacin content (µg CuE/mL) of Bitter Gourd

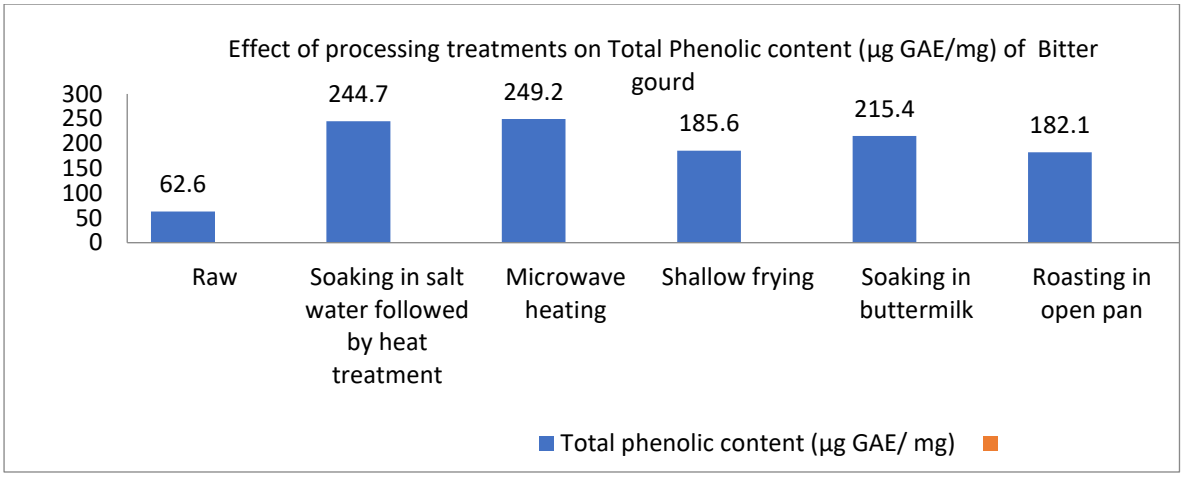

Fig. 4 Effect of processing treatments on Total Phenolic content (µg GAE/mg) of Bitter gourd

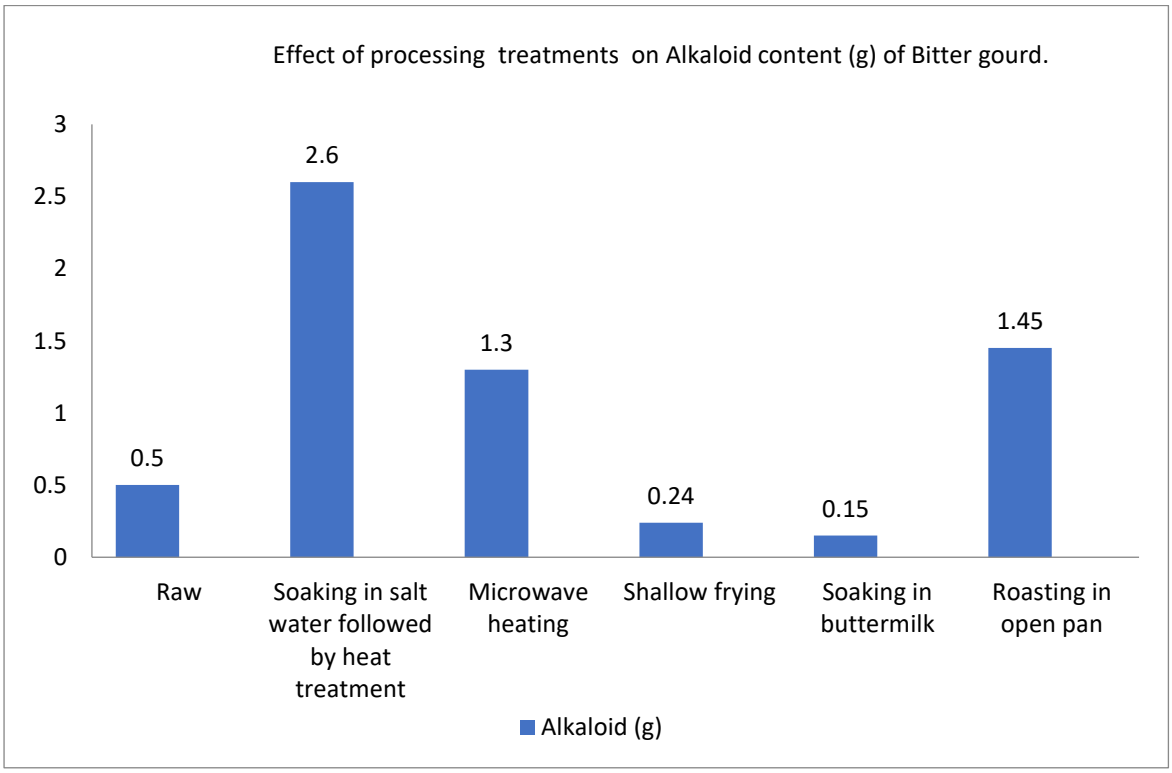

Fig.5 Effect of processing treatments on Alkaloid content (g) of Bitter gourd.

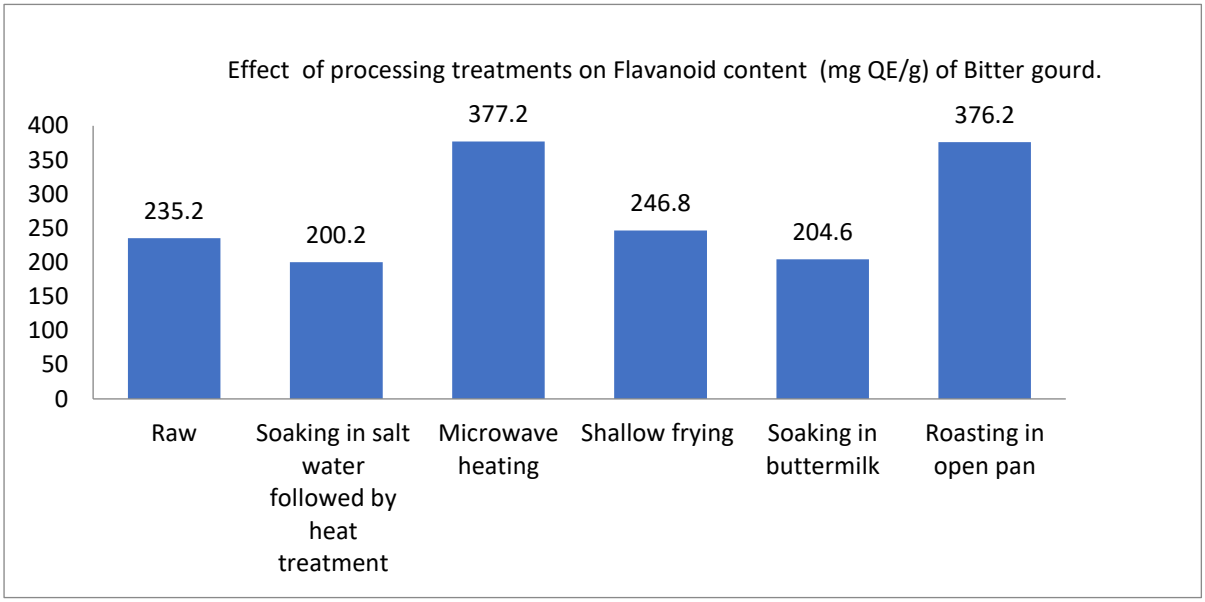

Fig. 6 Effect of processing treatments on Flavanoid content (mg QE/g) of Bitter gourd.

Table 2. Effect of different processing treatments on Physicochemical characteristics of Bitter gourd

Sr. no	Parameters	Processing Treatments					
		Raw	Soaking in salt water followed by heat treatment	Microwave heating	Shallow-frying	Soaking in buttermilk	Roasting
1	Saponin (mg DE/g)	10.5	0.18	6.9	9.9	6.1	7.4
2	Cucurbitacin (µg Cu/ml)	238.6	206.04	230.1	223.4	210.8	234.7
3	Total phenolic content (mg GAE/g)	62.6	244.7	249.2	185.6	215.4	182.1
4	Alkaloid (g/100g)	0.5	2.6	1.3	0.24	0.15	1.45
5	Flavonoids (mg QE/ mL)	235.2	200.2	377.2	246.8	204.6	376.2
6	Sensory score	3	9	8.5	6.5	7	6
7	Colour						
	L*	79	80	88	46	62	79
	-a*	3.67	4.85	3.76	3.4	2.62	2.01
	b*	41.02	35.93	30.02	31.89	20.45	26.34

CONCLUSION

Among five processing methods were selected to compare their efficiency reducing their bitterness in Bitter Gourd. Bitterness was found decreased in all types of processed samples.

Soaking in salt solution followed by heat treatment was considered as most effective technique to reduce bitterness of Bitter Gourd slices. This treatment had resulted maximum reduction in bitterness causing compound i.e., saponin and cucurbutacins in comparision to fresh Bitter gourd. Moreover, it also had registered maximum sensory score with an acceptable colour value.

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