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ORIGINAL ARTICLE

# Effects of citric acid, cucumis powder and pressure cooking on quality attributes of goat meat curry

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**Abstract** In the present study, comparative effects of marination in citric acid (1 %), spray of *cucumis* powder (2 %) and pressure cooking (at 15 psi) were observed on quality attributes of goat meat curry. Significant difference ($p<0.05$) was observed in pH of citric acid treated samples compared to other samples. Significant difference ($p<0.05$) was observed in protein and soluble collagen content of meat curry treated with pressure as compared to other treated samples including control. Cooking yield was significantly ($p<0.05$) higher in control samples. The significant difference was observed in chewiness and gumminess at ($p<0.05$) level and hardness at ($p<0.01$) level within and between the various treatment groups. However, overall values were higher in control samples. Similarly, shear force value was significantly ($p<0.05$) higher for control compared to treated samples. The significant difference ($p<0.05$) was observed in various sensory attributes of goat meat curry and pressure treated cooked meat curry was highly preferred followed by *cucumis* powder, citric acid and control samples.

**Keywords** Citric acid · *Cucumis* powder · Pressure · Chevon curry · Tough meat · Tenderization · Cooking effects

## Introduction

Goat is rightly referred as 'Asian Animal' in the world livestock arena because almost 95 % of goat population belongs to the developing countries of Asia. Though regarded as poor man's cow, goat has the distinction of being the most important meat animal of India because it provide choicest meat and fetch maximum retail price in the home market. In India out of 124.4 million of goat, 41 % are slaughtered every year for meat, producing 0.6 million metric tones of meat which contributes about 8 % of the total meat production (GOI 2006). More than 40 % of the total meat is produced from spent animals at the end of their productive economic life in India. Meat from such animals is usually tough and fibrous and commonly used for preparation of meat curry. However, tenderness has been cited as an important factor affecting consumer satisfaction and perception of taste (Gerelt et al. 2005). Processing of goat meat for value addition is very limited as it is largely utilized in traditional home cookery like *curries*, *fries*, *kormas* and *polaws* or *biryanis*. For preparation of meat curry, meat chunks are first partially fried with oil and condiments and then cooked under pressure with water in a home pressure cooker (at about 10 psi pressure). Although pressure cooking cause solubilization of some connective tissue (Mahendrakar et al. 1989), but products from meat of adult animals have very tough texture even after cooking for long time.

*Cucumis trigonus Roxb*. is an annual/perennial and a trailing herb with oval shaped fruits marked longitudinally with dark green/pale yellow strips of dots. The plant is found growing wild or sometimes cultivated as a secondary crop in maize or cotton crops. Dried fruits of *Cucumis trigonus Roxb*. are being used traditionally for preparation of vegetable curries or fried snacks. Recently proteolytic enzymes derived from *cucumis* have been reported to be a good tenderizer for poultry, sheep, pork and buffalo meat (Sinku et al. 2003; Naveena et al. 2004; Garg and Mendiratta 2006). Proteolytic enzymes present in *cucumis* have been reported to have effect on both myofibrillar and connective tissue components of toughness (Naveena et al. 2004). A number of acidulants such as lactic acid, acetic acid and citric acid have been successfully tried by different workers to improve tenderness and keeping quality of meat

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(Das 2002; Das and Jayaraman 2003). Due to the low pH causes weakening and swelling of muscular tissue and uptake of marinades leading to solubilization of collagen and their conversion into gelatin during cooking (Burke and Monahan 2003). Pressure cooking has also been recommended for tenderization by different workers for beef (Roberston et al. 1984), buffalo muscles (Raj et al. 2000; Ziauddin et al. 1994) and for sheep muscles (Mahendrakar et al. 1988). The tenderization effects of pressure cooking were due to thermal shrinkage of muscle (Ziauddin et al. 1994) and solubulization of collagen (Mahendrakar et al. 1989). In spite of most popular dish in Asian countries, meat curry has not received the required attention of meat researchers. Considering all these aspects, the present study was conducted to investigate the effects of use of acid marination, *cucumis* powder and pressure cooking (at comparatively higher pressure) on quality of meat curry from tough goat meat.

## Materials and methods

*Meat Sources and Details of Treatments* In this experiments, goats of similar age group (between 3 and 4 years) and conformation (non-descript breed) were slaughtered in the experimental abattoir of the Institute. The experiment consisting of four treatments including control was repeated five times. In each trial seven animals were slaughtered at a time. Muscles from specific hind leg cuts of carcasses were chilled overnight at home refrigerated temperature (4±1 °C) and then meat chunks of similar size and shape (2 $cm^3$) were prepared. These chunks were randomly divided into four groups and subjected to different tenderizing treatments to prepare meat curry.

Dried oval shaped fruits of *Cucumis trigonus Roxb* (wildly grown herb) were purchased from local market, dried in oven at 40±2 °C and grind in mixer to a fine powder. This oven dried powder was applied at the level of 2 % (w/w) on the mutton chunks for 30 min before cooking.

Readily available Citric acid powder (analytical grade) from standard firm (Qualigens fine chemicals Bombay, India) was used for preparation of citric acid solution. Meat chunks were marinated in 1 % (0.48 M) citric acid solution (1:2 w/v) for 2 h before cooking. Chunks were thoroughly washed (3–4 times) with water before cooking. Especially designed pressure cooker capable of cooking meat up to 15 psi was used to study effect of pressure cooking.

The level of pressure obtained during cooking was monitored from the pressure gauge fixed in the lids of these pressure cookers. The control meat chunks, citric acid marinated meat chunks and *cucumis* powder treated (sprayed or mixed) meat chunks were cooked in ordinary pressure cooker at 10 psi, while the especially designed pressure cooker (at 15 psi) were used for cooking the meat chunks for forth treatment.

*Preparation of Goat Meat Curry* Series of preliminary trials were conducted to select optimum level of different ingredients and cooking time. The composition of spice mix (in per cent) used for meat curry preparation were: Coriander powder –25.53; Turmeric −17.08; Capsicum −12.76; Cumin seed −6.38; (Black 93 pepper, Cardamom and Cloves)-each 5.10; (Caraway seed, Mace, Cinnamom, Aniseed)-each 4.25; Bay leaf-4.25; Nutmeg-1.70. The total ingredients used and their levels (For 1 kg meat are: water-2400 ml; condiments mix-200 g; oil-100 ml; salt-17 g; turmeric-4.01 g; chilly powder-2.99 g and dried spice mix-16.49 g).

Goat meat chunks (1 kg chunks of approximately 2 $cm^3$ size for each condition) were first partially fried with condiment mix, turmeric, chili powder and salt. For frying, open frying pan of 2 kg capacity was used. Frying of meat chunks with above mentioned mix was continued until colour changes to golden yellow (about 5 min) and then water was added and pressure cooking (in Hawking make kitchen pressure cooker of 4 l capacity) was done at 121 °C for 28 min with occasional shaking of cooker. After opening of the lid, spice mix was added and content was heated with continuous stirring for 8 min. Cooked meat curry with sufficient thick gravy was collected, cooled at room temperature and evaluated.

*Cooking Yield* The weight of samples was recorded before and after cooking and percent cooking yield was caculated as follows:

$$\text{Cooking yield}(\%) = (\text{Weight of chunks after cooking}/\text{Weight of chunks before cooking}) \text{ X } 100$$

*pH* The pH of cooked chunks was determined by homogenizing ten gram of sample with 50 ml distilled water with the help of Ultra Turrex T25 tissue homogenizer (IKA labor Technik, Germany) for 1 min. The pH of the suspension was recorded by immersing combined glass electrode of digital pH meter (Model CP-901, Century Instruments Ltd., India).

*Proximate Analysis* The proximate composition of raw & cooked meat samples were estimated by following gravimetrically method for moisture, Kjeldahl's method for protein and solvent extraction method for fat (AOAC 2002).

*Shear Force Value* The cooked chunks at 121 °C for 28 min were chilled at refrigerated temperature overnight and cut

into size of 1 $cm^3$ and then sheared in a Warner-Bratzler Shear Press (Model: 81031307, G.R. Elect. Mfg. Co., USA) with the fibers parallel to the longitudinal axis and results were expressed in $kg/cm^2$.

*Texture Profile Analysis (TPA)* Texture profile analysis was done as per the procedure described by Bourne (1978) using the texturometer TA-XT Texture Analyzer (Stable Microsystem Ltd, Surray, England). Uniform sized pieces 1.5 $cm^3$ from the middle portion of each cooked chunks were placed on the platform fixture and compressed to 80 % of their original height at a cross head speed of 2 mm/s through two cycle sequence using 25 kg load cell and 75 mm compression platen probe (P75). The test conditions were Version: W 11, Option: TPA, Pretest speed: 10 mm per sec and Trigger type: Auto Textural variables from force and area measurement were represented as TPA parameters. Three samples were analyzed under each treatment and the readings were averaged.

*TBARS Values* The distillation method of Tarladgis et al. (1960) was followed to estimate thiobarbituric acid reducing substance (TBARS) value as outlined by Garg and Mendiratta (2006). For estimating TBARS value, obtained Optic Density was multiplied by the factor of 7.8 and TBARS value was expressed as mg malonaldehyde/kg of sample as suggested by Koniecko (1979).

*Soluble Collagen Content* Collagen content of the cooked meat sample was determined based on the procedure of Nueman and Logan (1950) and Mahendrakar et al. (1989). HP contents were expressed in g/100 g of tissue, by referring to a standard graph. A standard graph was plotted with concentration of HP against the corresponding absorbance values. A conversion factor of 7.25 (Goll et al. 1963) was used to estimate the collagen content. The calculation for estimating the hydroxyproline in the meat sample was outlined as per reported by Woessner (1961).

*Sensory Evaluation* A trained sensory panel consisting of meat scientists/post graduate students of the division evaluated the meat curry for appearance (colour), flavour, juiciness, tenderness, connective tissue residue and overall palatability using 8 point descriptive scale (Keeton 1983), where 8 denoted excellent; 1 denoted extremely poor. For connective tissue residue, 8 means minimum connective tissue; 1 denoted excessive connective tissue. The sensory evaluation was done in environmentally controlled (20±2 °C) sensory evaluation laboratory with facility of individual booth for each panelist. The temperature of the sample was about 55–60 °C during sensory evaluation and four samples were presented per season.

*Statistical Analysis* Duplicate treatments were done during each trial. Each experiment was replicated 5 times. Thus a minimum number of 10 observations were recorded for different physicochemical and textural parameters. A minimum of 15 observations for shear force and 25 observations for sensory attributes for each treatment were recorded. The data obtained was analyzed by SPSS statistical software package using standard procedures (Snedecor and Cochran 1989). Duncan's multiple range tests was used to determine significant difference among means for different treatments.

## Results and discussion

*Effect of Citric Acid, Cucumis Powder and Cooking Under 15 psi Pressure on the physico-chemical properties of Goat Meat Curry* The results of comparative effects of 1 % citric acid, 2 % *cucumis* powder, and 15 psi pressure treatment and control on physico-chemical properties of goat meat curry is presented in (Table 1).

*pH* The mean pH value was significantly higher for control than other treated samples. Significantly lower value was

**Table 1** Effect of citric acid, cucumis, and pressure treatments on physico-chemical properties of goat meat curry (mean ± se)

| Parameter | Control | Citric acid | Cucumis | Pressure | Raw meat | F-value |
|---|---|---|---|---|---|---|
| pH | $5.7\pm0.05^a$ | $4.8\pm0.03^c$ | $5.4\pm0.08^b$ | $5.5\pm0.06^b$ | $5.5\pm0.05^b$ | 35.5* |
| Moisture (%) | $48.4\pm0.15^b$ | $48.1\pm0.11^b$ | $47.9\pm0.13^b$ | $46.5\pm0.07^b$ | $56.5\pm6.02^a$ | 2.2* |
| Protein (%) | $16.2\pm0.88^b$ | $16.4\pm0.31^b$ | $16.5\pm0.15^b$ | $15.0\pm0.21^c$ | $20.9\pm0.17^a$ | 94.0* |
| Fat (%) | $7.6\pm0.45^a$ | $7.5\pm0.48^a$ | $6.7\pm0.16^a$ | $7.0\pm0.35^a$ | $3.9\pm0.42^b$ | 15.4* |
| Soluble collagen (g/100g) | $0.30\pm0.02^b$ | $0.32\pm0.03^b$ | $0.34\pm0.03^b$ | $0.47\pm0.03^a$ | $0.14\pm0.02^c$ | 18.9* |
| Cooking yield (%) | $71.6\pm0.56^a$ | $69.5\pm0.15^b$ | $69.4\pm0.55^b$ | $68.9\pm0.11^b$ | ——— | 13.8* |

Means with different superscripts in the same row indicate significant difference (*$P<0.05$, **$P<0.01$). ———: Nil value

Total number of samples (N)=10

**Table 2** Effect of citric acid, cucumis, and pressure treatments on shear force and textural properties of goat meat curry (mean ± se)

| Parameter | Control | Citric acid | Cucumis | Pressure | F-value |
|---|---|---|---|---|---|
| WB-shear force value (kg/cm2) | 4.6±0.23$^{a}$ | 3.7±0.16$^{b}$ | 2.4±0.19$^{c}$ | 2.5±0.22$^{c}$ | 26.4* |
| Adhesiveness(Ns) | 0.05±0.01 | 0.04±0.01 | 0.05±0.01 | 0.03±0.01 | 1.5 |
| Chewiness(N/cm) | 18.6±1.04$^{a}$ | 15.9±1.39$^{ab}$ | 14.1±1.07$^{b}$ | 15.9±1.59$^{ab}$ | 2.0* |
| Cohesiveness(Ratio) | 0.40±0.02 | 0.38±0.02 | 0.38±0.02 | 0.37±0.02 | 0.8 |
| Fracturability (N) | 0.40±0.03 | 0.35±0.04 | 0.43±0.02 | 0.38±0.04 | 1.0 |
| Gumminess (N/cm2) | 28.0±1.08$^{a}$ | 22.9±1.83$^{b}$ | 24.0±0.86$^{ab}$ | 25.5±1.75$^{ab}$ | 2.3* |
| Hardness (N/cm2) | 75.4±2.35$^{a}$ | 59.2±3.04$^{b}$ | 42.9±3.14$^{c}$ | 45.4±2.91$^{c}$ | 27.1** |
| Springiness (cm) | 0.67±0.03 | 0.70±0.03 | 0.69±0.02 | 0.70±0.02 | 1.2 |

Means with different superscripts in the same row indicate significant difference (*$P$<0.05, **$P$<0.01).

Total number of samples for Shear Force (N)=15, while Textural properties (N)=10

observed for citric acid treated goat meat curry. Significantly ($p$<0.05) lower pH of citric acid treated sample might be due to lower pH (2.8–3.1) of marinade. Significant reduction in the pH of *cucumis* treated sample was attributed to lower pH of *cucumis* extract (4.8–5.0). Garg and Mendiratta (2006) reported almost similar trends in enrobed pork chunks treated with *cucumis* extract.

*Proximate Analysis* The mean value of moisture percent was significantly ($p$<0.05) higher in raw goat meat in comparison to cooked samples. The difference between control and treated goat meat curry was not significant. The protein content of raw goat meat was significantly higher ($p$<0.05) than cooked goat meat curry chunks. The difference between control, citric acid and *cucumis* treated samples was not significant, however, significantly ($p$<0.05) lower value was observed for pressure treated goat meat curry. Significantly lower protein content of pressure treated curry might be due to greater degree of protein coagulation at higher temperature (Asghar and Pearson 1980). The mean values of fat content were significantly higher ($p$<0.05) for cooked samples than raw goat meat, however, no significant difference was observed between control and treated samples of meat curry.

*Soluble Collagen Content* Soluble collagen content values were significantly higher ($p$<0.05) for pressure treated samples than control, citric acid, and *cucumis* treated samples. However the difference between control, *cucumis* and citric acid treated samples did not turn out to be significant. Higher swelling and solubilization of collagen content of meat due to marination might contribute to tenderization of meat. Greater solubilization of collagen in pressure treated muscles could be due to thermal shrinkage of muscles at higher cooking temperature (Ziauddin et al. 1994; Mahendrakar et al. 1989).

*Cooking Yield* The mean cooking yield values were significantly higher for control as compared to *cucumis*, citric acid and pressure treated samples. Significant reduction in cooking yield of citric acid treated goat meat curry was due to effect of low pH on water binding capacity (Aktas et al. 2003). Garg and Mendiratta (2006) also reported similar findings in enrobed pork chunks. Significantly lower cooking yield of pressure treated goat meat curry was attributed to greater degree of shrinkage of muscle fibers and protein coagulation in muscles cooked at high temperature in pressure-cooking (Asghar and Pearson 1980). Raj et al. (2000) reported that cooking loss values were lower, for normal cooked compared to pressure cooked muscles. Mahendrakar et al. (1988) also reported similar findings in sheep muscles and Ziauddin et al. (1994) in buffalo muscles. Thus all the tenderizing treatments caused negative effect on the cooking yield (decrease in weight of meat chunks), but

**Table 3** Effect of citric acid, cucumis, and pressure treatments on sensory attributes of goat meat curry (mean ± se)

| Parameter | Control | Citric acid | Cucumis | Pressure | F-value |
|---|---|---|---|---|---|
| Appearance | 7.1±0.04 | 7.1±0.038 | 7.0±0.05 | 7.0±0.04 | 0.88 |
| Flavour | 6.8±0.06$^{b}$ | 6.8±0.06$^{b}$ | 7.0±0.03$^{a}$ | 7.0±0.06$^{a}$ | 5.5* |
| Juiciness | 6.7±0.07$^{b}$ | 6.6±0.07$^{b}$ | 7.0±0.04$^{a}$ | 7.1±0.08$^{a}$ | 11.7** |
| Tenderness | 6.4±0.10$^{c}$ | 6.6±0.87$^{c}$ | 6.9±0.92$^{b}$ | 7.3±0.08$^{a}$ | 16.2** |
| C.T. residue | 6.3±0.10$^{c}$ | 6.5±0.83$^{c}$ | 6.8±0.09$^{b}$ | 7.2±0.08$^{a}$ | 19.6** |
| Overall acceptability | 6.4±0.09$^{c}$ | 6.6±0.08$^{c}$ | 6.9±0.07$^{b}$ | 7.2±0.08$^{a}$ | 22.4** |

Means with different superscripts in the same row indicate significant difference (*$P$<0.05, **$P$<0.01). C.T. residues: Connective tissue residue

Total number of samples (N)=25

practically this effect has little significance, as thick gravy of meat curry (exudates released) is a desirable characteristic.

*Effect of Citric Acid, Cucumis Powder and Cooking Under 15 psi Pressure on the W-B Shear Force Value and Textural properties of Goat Meat Curry* The results of comparative effects of 1 % citric acid, 2 % *cucumis* powder, and 15 psi pressure treatment and control on W-B shear force value and textural properties of goat meat curry is presented in (Table 2).

*W-B Shear Force Value* The shear force values were significantly higher for control and significantly lower for *cucumis* and pressure treated curry. Shear force value of citric acid treated chunks was significantly lower than control but higher than *cucumis* and pressure treated chunks. Significant lower shear force value of *cucumis* treated curry is in agreement Garg and Mendiratta (2006) in enrobed pork chunks. Significant lower shear force value of pressure treated chunks might be attributed to greater thermal shrinkage of muscles and greater solubilization of collagen at higher cooking temperature (Mahendrakar et al. 1989).

*Texture Profile analysis* There was no significant difference between control, citric acid, *cucumis* and pressure treated samples for adhesiveness, cohesiveness, fracturability and springiness values. The mean value for chewiness and gumminess were significantly higher for control than treated samples. There is no significant difference among treated samples. Hardness values were significantly higher for control than treated samples. Significantly lower hardness values were obtained for *cucumis* and pressure treated samples than citric acid and control. Significantly lower values of chewiness and hardness in citric acid treated curry could be due to degradation of intrinsic collagen structure without extensive degradation of muscle fiber (Cronlsund and Woychik 1987). Serdaroglu et al. (2007) also reported similar results in turkey meat marinated with 0.1 M grape fruit juice. Significantly lower values of chewiness and hardness in *cucumis* treated curry could be due to proteolytic activity of *cucumin* (Naveena et al. 2004). Similarly, lower value in pressure treated meat curry could be due to more solubilization of collagen fibers (Mahendrakar et al. 1988; Ziauddin et al. 1994).

*Effect of Citric Acid, Cucumis Powder and Cooking Under 15 psi Pressure on the Sensory attributes of Goat Meat Curry* The results of comparative effects of 1 % citric acid, 2 % *cuccumis* powder, and 15 psi pressure treatment and control on sensory attributes of goat meat curry is presented in (Table 3).

Mean Sensory scores for appearance of goat meat curry did not differ significantly among control and treated samples. Flavour scores were significantly higher for *cucumis* and pressure treated samples than control and citric acid treatment. The mean Juiciness scores were significantly higher for pressure and *cucumis* treated samples than control and citric acid treated samples. Tenderness score was significantly higher for pressure treated sample than control, citric acid and *cucumis* treated samples. Mean score for *cucumis* treated sample was also significantly higher than control and citric acid treated samples. Almost same trend was observed for connective tissue residue score as for tenderness i.e. Score were highest in pressure treated fallowed by *cucumis* treated, citric acid and control. The overall acceptability scores were significantly higher for pressure and *cucumis* treated samples than control and citric acid and samples.

From these results it can be concluded that pressure treated samples scored highest for most of the sensory attributes followed by *cucumis* treatment. Although citric acid treated samples also scored higher than control but the difference did not turn out to be significant for most of the parameters. Serdaroglu et al. (2007) reported similar results in turkey meat marinated with 0.1 M grape fruit juice. Aktas et al. (2003) also reported similar findings in marinated intramuscular connective tissue of beef. Significant improvements in flavour, juiciness, tenderness and overall acceptability scores of *cucumis* treated curry are in agreement with (Garg and Mendiratta 2006).

In conclusion, the treatments given in this work was proved to be very effective in improving the qualities of goat meat curry from spent animals. In general, use of *cucumis* powder or cooking meat under comparatively higher pressure proved more effective than citric acid marinated samples. Therefore, it can be concluded that when meat curry is intended to consume immediately or with 1–2 days of cooking, treatment with *cucumis* powder or cooking under higher pressure is recommended. Thus for effective utilization of tough goat meat, any one of these three treatments should be followed. However, it is interesting to observe the combined effects of these three treatments on quality attributes of goat meat curry from spent animals and work was in progress in the division.

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