Effect of different fat level on microwave cooking properties of goat meat patties

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Abstract The study was carried out to evaluate the effect of various fat levels on the cooking and sensory properties of goat meat patties cooked by microwave energy. Goat meat patties were prepared with refined vegetable oil to get fat level of 5, 10, 15 and 20%. Each patty was cooked in a microwave oven with full power (700 W) operating at 2450 MHz to an internal temperature of 75–80 °C. pH value of raw patties with 5% fat level were lower compared to patties with 10, 15 and 20% fat level. Fat level did not affect emulsion stability of batter but it decreased as fat level increased. Microwave cooking time decreased as fat levels increased. With an increase in fat contents, protein and moisture in raw patties decreased and in cooked meat patties with 5% fat had higher protein and moisture content than those with more fat. Patties with 5% level showed lower cooking loss than other fat level. Water activity of patties was affected by fat level and patties with 15 and 20% fat had lower water activity than patties with 5 and 10% fat. As fat level increased, shear force value decreased indicating soft texture. Subjective colour evaluation indicated that 5% patties were darker and redder than patties with more fat. Sensory analysis revealed that goat meat patties with 5 and 10% fat had less flavour and juicier than patties with 15 and 20% fat. Goat meat patties with 20% fat were the juiciest. Tenderness and oiliness increased significantly with an increase in fat level. Patties with 15% fat were rated higher overall palatability than others.

Keywords Goat meat patties · Fat level · Microwave energy · Cooking properties

Heat (boiling, grilling and frying) is applied to meat in different ways to enhance its flavour and taste, and increase shelf life and to improve its hygienic quality by inactivation of pathogenic microorganisms (Bogner 1998). Type of cooking affects the basic sensory properties of consumer preferences, such as flavour, colour, texture, nutritional value, palatability and tenderness of meat and meat products (Pietrasik et al. 2005). Today, in India socio-economic changes has made microwave cooking to become a familiar method of cooking because of its speed in preparation and convenience in reheating of prepared food (Ryynanen et al. 2004). Unexpected temperature profiles (non-uniform heating), excessive heating rates, edge overheating, soggy texture and lack of browning are the major microwave problems. Different thermal and dielectric properties of the food components affect microwave energy distribution leading to uneven temperature distribution in the food and cooking properties. Therefore, it is important to know the factors (cooking properties) that affect the quality and safety of microwave cooked foods (Jeong et al. 2007).

Fat, as a meat component, contributes the flavour, juiciness, texture and appearance to meat and increases the feeling of satiety. Fat modifies the perception of flavour compounds by influencing the intensity, release of flavours and by affecting their distribution and migration (Akoh 1998; Lucca and Tepper 1994; Das et al. 2009). Fat has very low dielectric properties and low specific heat compared to water, therefore it will accelerates the microwave heating rate and increases the maximum temperature achieved (Ryynanen et al. 2004). As a result, the presence of fat in ground meat products may have an influence on the cooking and sensory properties (Jeong et al. 2004). Cannell et al. (1989) studied the effects of cooking methods on cooking and nutritional factors of ground beef patties containing 5–25% fat. The majority of

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studies on cooking of meat and meat products were carried out with conventional cooking methods. Recently, Jeong et al. (2007) reported the variability in temperature distribution and cooking properties of ground pork patties containing different fat level and with/without salt cooked by microwave energy.

However, there is little information in the literature concerning emulsion-type goat meat patties cooked by microwave energy (Jeong et al. 2004, 2007; Naveena et al. 2006). Effect of inclusion of dry spices mix, condiments, salt etc on the cooking properties of ground goat meat patties is also sparsely reported. Therefore, the purpose of this study was to evaluate the effect of fat levels on the cooking and sensory properties of emulsion based goat meat patties cooked by microwave energy.

Materials and methods

Processing and preparation of goat meat patties

Meat was collected from hind leg of carcasses of almost similar good conformation of Barbari male goats after 12 h postmortem. Samples were kept for another 6–8 h in a refrigerator at 4 ± 1 °C. The visible connective tissue and separable fat were trimmed off from the separated muscles and then frozen at -18 °C till further use. The frozen samples were used after partial thawing for 15 h at 4 °C. The thawed meats were cut into small cubes ($4\text{--}5\text{ cm}^2$) and minced using automatic meat mincer by passing through 5 mm plate (Talleres Raman Model P-22, Barcelona) to obtain ground goat meat (GGM). The ground goat meat was used in different product formulations. The patties used in this experiment were processed as outlined by Das et al. (2008). All the ingredients and minced meat were thoroughly mixed and chopped by a bowl chopper (Seydelmann K20 Ras, Germany) to prepare the emulsion. Refined vegetable oil was used in such a way during emulsion preparation to get fat levels of 5%, 10%, 15% and 20%. Three kg formulation was made for each treatment. About 70 g of meat batter was moulded in a petridish (75-mm-diameter and 15-mm-height) to form patties from each fat level.

Microwave cooking procedure

Freshly prepared patties from all the fat levels were placed in the centre of a microwave oven (Model C103FL, Samsung Electronics Co. Ltd., New Delhi, India) on a microwave-safe glass container without lid and were cooked with full power until the centre of the patty reached the internal temperature of 80 °C. Only one patty was cooked at a time. During cooking the glass container was

rotated and the patty was turned upside down to avoid colour differences between the two surfaces. The internal temperature of patty was recorded by inserting a probe type thermometer into the geometric centre of the patty. Preliminary trials (time-temperature) were conducted to determine the length of cooking time required to reach the designated internal temperature. After cooling, the patties were packaged in low-density polyethylene pouches under aerobic condition at room temperature. The packaged patties were stored in a refrigerator (LG, LG India Pvt Ltd, India) at 4 ± 1 °C. The patties were analyzed on the same day.

Analytical methods

pH, water activity and proximate composition

pH of meat batters/cooked patties was determined by blending 10 g of sample with 50 mL of distilled water for 1 min using a tissue homogenizer (Model PT-MR-2100, Kinematica AG, Switzerland). The pH of the suspension was recorded by dipping combined glass electrode of digital pH meter (Systronic, India, Model LI 127). Water activity (a_w) of patties was directly estimated using water activity meter (AquaLab, Model CX-3TE, Decagon Devices, Inc., USA). Final readings were recorded when three consecutive readings were same. Moisture, crude fat, protein, and ash of batter and cooked patties were determined as per standard procedure of Association of Official Analytical Chemists (AOAC 1995).

Emulsion stability

Emulsion stability was evaluated as outline by Das et al. (2009) by heating meat batters (25 g), individually placed inside polyethylene bags in a thermostatically controlled water bath at 80 °C for 20 min. The cooked batters were cooled for 15 min under running tap water. After draining out the exudates, the cooked mass was weighed, and the yield of cooked emulsion mass was recorded as emulsion stability percent.

Patty yield, gain in height and diameter changes

The weight of each patty was recorded before and after cooking. The cooking yield was recorded by calculating the ratio of cooked weight to raw weight and expressed as percentage. The thickness of the cooked patties was recorded using digital vernier callipers at 3 different points to get the average thickness. Height (internal) of the mould was taken as thickness of raw patties and expressed as percentage. The diameter of the cooked patties was

recorded using digital vernier callipers at 3 different points to obtain the average diameter. The internal diameter of mould was taken as diameter of raw patties and expressed as percentage.

Shear force measurements

The cooked patties were equilibrated to room temperature for 1 h before preparation of cores. From each patty, 1.25 cm diameter cores were taken and sheared with a Warner-Bratzler shear press (SALTER, G-R Elec Mfg.Co, Manhattan, USA). The force required to shear the cores was recorded (kg/cm^2).

Visual and instrumental color evaluations

The visual colour and amount of air pockets of cooked patties were measured as the method described by Jeong et al. (2004). Five patties per fat level were used for color measurements. Immediately following cooking and weighing, cooked patties (about 13 mm, thickness) were sliced parallel to the flat surface in the center of the samples. The surface and internal color of each cooked patty was evaluated by a 10-member trained panel using a 4-point horizontal scale (1=pink, 4=tan). The amount of air pockets visible on the cut surface were also evaluated (1=none, 4=extremely numerous).

The colour of cooked meat patties were compared using a Lovibond Tintometer (Model F; The Tintometer Ltd, Salisbury, UK). Samples from three different places of patties were taken in the sample holder and secured against the viewing aperture. The sample colour was matched by adjusting red (a) and yellow (b) units, while keeping the blue units fixed at 2.0. The corresponding colour units were recorded. The hue and chroma (saturation) values were determined using the formula, $(\tan^{-1}b/a)$ (Little 1975) and $(a^2+b^2)^{1/2}$ (Froechlich et al. 1983), respectively, where, *a* is the red unit, *b* the yellow unit.

Sensory evaluations

Sensory evaluation method using an 8-point descriptive scale (Keeton 1983) was followed with modifications as reported by Das et al. (2008), where 8=excellent; 1=extremely poor. Immediately after cooking, patties were cut across their centre to make eight equal size and shape (triangular) pieces and served at a temperature of approximately 60 °C to each panelist. The sensory panel consisted of eight experienced scientists and postgraduate students of the division. Water was provided to rinse mouth between the samples. The panelists judged the samples for tenderness, juiciness, oiliness, flavour, and overall palatability.

Statistical analysis

All the results presented are the means of 3 batches of experiments in which triplicate samples were taken for each parameter from each batch. Data obtained were analyzed in one way analysis of variance using SPSS programme (Version 10 for Windows, SPSS, Chicago, III, USA). Significant means were separated using the least significant difference (LSD) test ($p < 0.05$).

Results and discussion

pH values, proximate composition and emulsion stability of raw goat meat patties

Fat levels affected the pH values, proximate composition and emulsion stability and the values are presented in Table 1. Raw patties with 15 and 20% fat levels had the highest ($P < 0.05$) pH values than patties with 5% fat level. Similar results were reported by Jeong et al. (2004). There were no significant ($P < 0.05$) differences in pH between 5–10, 10–15 and 15–20% fat levels of raw patties and similar observation was noticed in the moisture content of raw patties. As expected raw patties with 20% fat level had lowest ($P < 0.05$) moisture and protein content. Similarly, moisture and protein contents in raw pork or beef patties decreased with an increase in fat levels (Jeong et al. 2004; Picouet et al. 2007). Estimated fat contents of raw goat meat patties were according to that of added fat levels. Earlier studies (Cannell et al. 1989; Troutt et al. 1992; Jeong et al. 2004) also reported comparable results. No significant differences were observed in the emulsion stability (ES) but as fat level increases, there was a decrease in the ES values. Contrary to this study, Das et al. (2009) reported that goat meat patties with 10% fat level had higher emulsion stability. Accordingly, ground beef patties with lower fat had higher fat retention values than higher fat patties (Cannell et al. 1989; Berry 1998; Troutt et al. 1992). Slightly lower values were reported for pork patties by Jeong et al. (2004).

Microwave cooking and physico-chemical properties of cooked goat meat patties

Physico-chemical properties of microwave cooked goat meat patties were presented in Table 2. Cooking time significantly affected ($P < 0.05$) by different added fat levels. As the vegetable fat level in the composition increases the cooking time decreases. Cooking time of 49.75 s was saved with 20% fat levels comparing 5%. These results are in general agreement with those of earlier reports (Picouet et al. 2007; Jeong et al. 2007). In the present study refined oil was used instead of pork or animal

Table 1 pH value, chemical composition and emulsion stability of raw goat meat patties with different fat level

Variable	Fat level (%)			
	5	10	15	20
pH	5.9±0.03 ^c	5.9±0.02 ^{bc}	6.0±0.02 ^{ab}	6.1±0.01 ^a
Moisture (%)	69.9±0.31 ^a	69.1±0.30 ^{ab}	66.9±0.67 ^b	61.2±1.65 ^c
Protein (%)	19.0±0.40 ^a	17.5±0.37 ^a	15.5±0.38 ^b	15.0±0.22 ^b
Fat (%)	4.9±0.23 ^d	10.9±0.26 ^c	15.3±0.22 ^b	20.1±0.26 ^a
Emulsion stability* (%)	93.5±0.65	93.1±0.52	91.9±0.69	91.4±0.58

Means ± SE in the same row with different letters are significantly different ($P<0.05$). $n=9$; * $n=12$

fat. The above authors also found that for pork patties cooked with high pork fat levels resulted in shorter cooking time. This might be due to much lower specific heat capacity of fat (Shiffman 1986), increase in the temperature of oil and water mixture during microwave cooking (Jeong et al. 2004), nonionic and less polarity comparing water (Picouet et al. 2007) and increase in fat content results in decrease in dielectric constant and loss factor (Gunasekaran et al. 2005). However, pork fat accelerates the microwave

heating rate and increase the maximum temperature achieved (Jeong et al. 2004; Ryyanen et al. 2004),

Total cooking loss (8.81%) was the lowest ($P<0.05$) with for patties with 5% fat level, which was highest (15.20%) for 20% fat level. As a result, the product yield was decreased significantly ($P<0.05$) for 20% fat patties. Jeong et al. (2004) reported the greater cooking loss for higher fat patties than lower fat patties. Several other studies (Berry and Wergin 1993; Ruusunen et al. 2005;

Table 2 Effect of microwave cooking on quality attributes of goat meat patties with different fat levels

Variable	Fat level (%)			
	5	10	15	20
Physico-chemical properties				
Cooking time (second)	164.4±1.85 ^a	148.5±5.41 ^b	133.9±3.68 ^c	114.6±3.86 ^d
Cooking loss (%)	8.8±0.73 ^b	10.8±1.17 ^b	11.9±1.22 ^b	15.2±1.25 ^a
Product yield (%)	91.2±0.73 ^a	89.2±1.17 ^a	88.1±1.22 ^a	84.8±1.25 ^b
pH	6.2±0.03 ^c	6.2±0.02 ^{bc}	6.3±0.03 ^{ab}	6.3±0.02 ^a
Moisture (%)	66.5±0.31 ^a	63.4±1.45 ^b	61.6±0.51 ^b	56.6±0.58 ^c
Protein (%)	22.7±0.36 ^a	19.6±0.13 ^b	18.4±0.29 ^c	16.9±0.31 ^d
Fat (%)	8.2±0.11 ^d	13.9±1.05 ^c	17.1±1.15 ^b	23.5±0.89 ^a
Change in diameter (%)	21.9±0.92 ^a	20.0±0.71 ^{ab}	17.5±0.89 ^{bc}	15.6±0.65 ^c
Change in thickness (%)	42.2±3.85 ^a	38.4±3.73 ^a	31.1±6.24 ^{ab}	23.3±3.38 ^b
Shear force (kg/cm ²)*	0.82±0.06 ^a	0.69±0.03 ^b	0.58±0.02 ^b	0.41±0.02 ^c
Water activity	0.983±0.001 ^a	0.982±0.003 ^a	0.979±0.002 ^{ab}	0.973±0.002 ^b
Instrumental evaluation				
Redness	4.6±0.15 ^a	4.5±0.19 ^{ab}	4.1±0.21 ^{bc}	3.7±0.11 ^c
Yellowness	4.7±0.13 ^b	4.9±0.19 ^{ab}	5.3±0.12 ^a	5.3±0.19 ^a
Hue	45.6±0.99 ^b	47.9±1.39 ^b	52.3±1.85 ^a	55.4±0.94 ^a
Chroma /saturation	6.6±0.16	6.7±0.22	6.7±0.11	6.5±0.20
Visual evaluation ^a				
Surface colour	4.4±0.16 ^a	4.2±0.10 ^{ab}	4.1±0.15 ^{ab}	3.9±0.11 ^b
Internal colour	3.4±0.26	3.1±0.36	3.0±0.22	2.9±0.23
Amount of air pockets	1.1±0.08	1.1±0.14	1.1±0.20	1.2±0.12
Sensory attributes ^b ($n=30$)				
Tenderness	4.7±0.30 ^c	4.9±0.25 ^c	6.0±0.22 ^b	7.0±0.15 ^a
Juiciness	5.3±0.21 ^c	6.3±0.24 ^b	6.5±0.13 ^{ab}	6.9±0.15 ^a
Oiliness	4.4±0.07 ^c	4.8±0.23 ^c	5.4±0.20 ^b	5.9±0.16 ^a
Flavour	4.9±0.18 ^b	5.5±0.16 ^b	6.3±0.22 ^a	6.7±0.16 ^a
Overall palatability	5.2±0.13 ^c	6.2±0.20 ^b	6.9±0.29 ^a	6.7±0.16 ^a

^a Scores based on an 4-point scale, in which 1=pink and none, and 4=tan and extremely numerous.

^b Scores based on an 8 point scale (1=extremely undesirable; 8=extremely desirable).

Means ± SE in the same row with different letters are significantly different ($P<0.05$). $n=9$; * $n=15$

Jeong et al. (2007) also reported that high fat patties had higher cooking loss than lower fat patties and it has also been found that addition of sodium content (Ruusunen et al. 2005) could reduce the cooking loss. This is due to the reduction in the drip loss (Puolanne and Ruusunen 1980). Zayas (1997) reported that, addition of salt resulted in more stable structure and water binding capacity. The pH values of cooked goat meat patties increased ($P<0.05$) by 0.25 unit at 5% fat level than the raw fat patties. Further there was 0.11 unit pH increase at 20% fat level than 5% fat cooked patties. Similar results were reported by Jeong et al. (2004) for pork patties. Naveena et al. (2006) reported that addition of lactates to chicken patties and microwave cooking lowered the pH of the final product but addition of sodium lactate did not alter the pH.

After cooking, the chemical composition of the high and low fat patties remained significantly ($P<0.05$) different (Table 2). Similar results were demonstrated in the previous studies (Dreeling et al. 2002; Jeong et al. 2007). The fat and protein content of the cooked patties increased ($P<0.05$) than those of the raw patties because of loss of moisture in the product (Keeton 1983). Retention of fat decreases significantly as the fat level of patties increases (Jeong et al. 2004). In the present experiment, 20% fat patties had the highest fat percentage after cooking. Berry (1993) reported that patties with low fat level had higher fat retention values than higher fat patties. Similar observation was made by Cannell et al. (1989) for ground beef patties. Naveena et al. (2006) reported no significant differences in moisture, fat, protein and ash percentage between control and lactates added chicken patties cooked by microwave.

Patties with 15 and 20% fat level had less change in diameter ($P<0.05$) than the other fat level and the 20% fat level patties had the lowest values. Similar results were reported by Berry (1993) for beef patties and by Jeong et al. (2004) for pork patties. The reduction in the thickness of high fat patties (15, 20%) was lower ($P<0.05$) than in lower fat patties (5, 10%). The result is in agreement with Jeong et al. (2004). Similarly, Naveena et al. (2006) reported 29.04% gain in height for chicken patties having 10% fat level. Patties with higher fat level had greater changes in diameter and thickness than patties with less fat regardless of addition of salt and patties processed with 20% fat had the greatest reduction in diameter and thickness (Jeong et al. 2007).

Fat levels significantly affected ($P<0.05$) shear force values of cooked ground goat meat patties (Table 2). The 20% fat level patties had the lowest value. This might be due to increase in the lubrication of the shear force apparatus by addition of fat and thus helps in shearing with ease; whereas, lower fat patties tend to form a skin or crust on the surface and therefore require more force (Berry 1993; Jeong et al. 2004). Addition of lactates did not alter shear force values of chicken patties (Naveena et al. 2006).

Jeong et al. (2007) reported that addition of salt did not affect the shear force values but fat levels affected. Increased ionic strength (added salts) alone did not affect protein solubility but tended to lower the comprehensive strength of shear force values (Farouk and Swan 1998). Increasing the fat level upto 15% did not affect ($P>0.05$) a_w values of goat meat patties but 20% fat patties had lowest ($P<0.05$) a_w values. Significant reduction in the moisture content of 20% fat patties can be correlated for the above findings. Naveena et al. (2006) reported that addition of calcium lactates did not alter the a_w values but the sodium lactates reduce the same in chicken patties.

Instrumental and visual colour evaluation

Instrumental colour of the cooked patties revealed that redness, yellowness values were significantly affected ($P<0.05$) by fat levels. Patties with 5% fat level had the highest redness value and the yellowness was highest in 20% fat level. Similar results were reported by several authors (Jeong et al. 2004; Troutt et al. 1992; Dreeling et al. 2002). But there was no significant differences ($P>0.05$) among 10, 15 and 20% fat patties. Hue values were the lowest ($P<0.05$) for 5% fat patties but showed no significant differences ($P>0.05$) with 10% fat patties. Similarly 15 and 20% fat patties were not having significant ($P>0.05$) hue values. However, chroma or saturation was lower for 20% fat patties but showed no significant differences ($P>0.05$) among the different fat levels.

Visual colour evaluations on patties containing various fat levels revealed that no significant differences ($P>0.05$) in internal colour and amount of air packets were found, however the surface colour values were lowest ($P<0.05$) for 20% fat patties. As the fat level increases the amount of air pockets increases non-significantly ($P>0.05$). Contrarily, Jeong et al. (2004) reported that the amount of air pockets in cooked pork patties increased significantly ($P<0.05$) with increasing fat levels. Troutt et al. (1992) suggested that the more open internal structures of high fat patties appeared to be voids resulting from the translocation of rendered fat during cooking and may be partially responsible for the more tender bite of these patties.

Sensory evaluation

Sensory evaluation of ground goat patties of different fat levels indicated that tenderness, juiciness, oiliness, flavour and overall acceptability were significantly affected by fat level (Table 2). Patties with 15 and 20% fat did not differ from each other for juiciness, oiliness, flavour and overall acceptability. Tenderness increased ($P<0.05$) with an increase in fat levels and was scored as juiciest. Several

researchers have also confirmed that higher fat patties are generally juicier than low fat products (Jeong et al. 2004; Cross et al. 1980). The scores obtained for tenderness was consistent with shear force values. As the fat level increases, the tenderness scores increased ($P<0.05$). Similar results were also reported earlier (Jeong et al. 2004). Oiliness score followed the similar trend. Overall acceptability score were higher as the fat level increases.

Conclusion

Microwave cooking of goat meat patties having varying level of fats had different cooking, physiochemical and sensory properties. Microwave cooking time decreased as the fat levels increased. As the fat level increases, moisture and protein level decreased. Lower fat patties were darker and redder in color and had higher a_w and shear force value. Patties with 15% fat were rated higher overall palatability than others but the 20% level had higher oily surface. Therefore, it can be concluded that goat meat patties with 15% fat level would be suitable for microwave cooking.

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References

- Akoh CC (1998) Fat replacers. *Food Technol* 52:47–53
- AOAC (1995) Official methods of analysis, 16th edn. Association of Official Analytical Chemists, Washington
- Berry BW (1993) Fat level and freezing temperature affect sensory, shear, cooking and compositional properties of ground beef patties. *J Food Sci* 58:34–7, 42
- Berry BW (1998) Cooked color in high pH beef patties as related to fat content and cooking from the frozen or thawed state. *J Food Sci* 63:797–800
- Berry BW, Wergin WP (1993) Modified pre-gelatinized potato starch in low-fat ground beef patties. *J Muscle Foods* 4:305–320
- Bogner A (1998) Comparative study of frying to other cooking techniques influence on the nutritive value. *Grasas y Aceites* 49:250–260
- Cannell LE, Savell JW, Smith SB, Cross HR, St. John LC (1989) Fatty acid composition and caloric value of ground beef containing low levels of fat. *J Food Sci* 54:1163–1168
- Cross HR, Berry BW, Wells LH (1980) Effects of fat level and source on the chemical, sensory, and cooking properties of ground beef patties. *J Food Sci* 45:791–793
- Das AK, Anjaneyulu ASR, Thomas R, Kondaiah N (2009) Effect of different fats on the quality of goat meat patties incorporated with full-fat soy paste. *J Muscle Foods* 20:37–53
- Das AK, Anjaneyulu ASR, Verma AK, Kondaiah N (2008) Effect of full-fat soy paste and soy granules on quality of goat meat patties. *Intl J Food Sci Technol* 43:383–392
- Dreeling N, Allen P, Butler F (2002) The effect of post-cooking holding time on sensory assessment of low- and high-fat beef burgers. *J Food Sci* 67:874–876
- Farouk MM, Swan JE (1998) Effect of muscle condition before freezing and simulated chemical changes during frozen storage on protein functionality in beef. *Meat Sci* 50:235–243
- Froehlich DA, Gullet EA, Usborne WR (1983) Effect of nitrite and salt on the colour, flavour and overall acceptability of ham. *J Food Sci* 48:152–154
- Gunasekaran N, Mallikarjunan P, Eifert J, Summer S (2005) Effect of fat content and temperature on dielectric properties of ground beef. *Trans ASAE* 48:673–680
- Jeong JY, Lee ES, Paik HD, Choi JH, Kim CJ (2004) Microwave cooking properties of ground pork patties as affected by various fat levels. *J Food Sci* 69:C708–C712
- Jeong JY, Lee ES, Choi JH, Lee JY, Kim JM, Min SG, Chae YC, Kim CJ (2007) Variability in temperature distribution and cooking properties of ground pork patties containing different fat level and with/without salt cooked by microwave energy. *Meat Sci* 75:415–422
- Keeton JT (1983) Effect of fat or sodium chloride or phosphate level on the chemical sensory properties of pork patties. *J Food Sci* 48:878–881, 885
- Little AC (1975) Off on a tangent. *J Food Sci* 40:410–412
- Lucca PA, Tepper BJ (1994) Fat replaces and functionally of fat in foods. *Trends Food Sci Technol* 1:12–19
- Naveena BM, Sen AR, Muthukumar M, Vaithyanathan S, Babji Y (2006) The effect of lactates on the quality of microwave-cooked chicken patties during storage. *J Food Sci* 71:S603–S608
- Picouet PA, Fernandez A, Serra X, Sunol JJ, Arnau J (2007) Microwave heating of cooked pork patties as a function of fat content. *J Food Sci* 72:E57–E63
- Pietrasik Z, Dhanda JS, Pegg RB, Shand PJ (2005) The effects of marination and cooking regimes on the water-binding properties and tenderness of beef and bison top round roasts. *J Food Sci* 70: S102–S106
- Puolanne E, Ruusunen M (1980) Kochsalz und phosphata in ihrerwirkung auf das vasserbindungsvermogen von bruhwurst. *Fleischwirtschaft* 60:1359–1362
- Ruusunen M, Vainionpaa J, Lyly M, Lahteenmaki L, Niemisto M, Ahvenainen R (2005) Reduction the sodium content in meat products: the effect of the formulation in low-sodium ground meat patties. *Meat Sci* 69:53–60
- Ryynanen S, Risman PO, Ohlsson T (2004) Hamburger composition and microwave heating uniformity. *J Food Sci* 69: M187–M196
- Shiffman RF (1986) Food product development for microwave processing. *Food Technol* 40:94–98
- Trout ES, Hunt MC, Johnson DE, Claus JR, Kastner CL, Kropf DH (1992) Chemical, physical, and sensory characterization of ground beef containing 5–30 percent fat. *J Food Sci* 57:25–29
- Zayas JF (1997) Water holding capacity of proteins. In: Zayas JF (ed) *Functionality of proteins in food*. Springer, Berlin, pp 76–133