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Chemical Indicators for Determining the Presterilization Quality of Canned Curried Meat: Factors Affecting the Quantity of the Chemical Indices

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ABSTRACT

Free fatty acids estimated by TLC-gravimetry have been found to serve as suitable markers for determining the pre-processing quality of meat used for canning curried meat preparations. Effects of various factors, viz. composition of the vegetable fat used for curry preparation, the degree of spoilage of mutton, delay in canning etc., on the total FFA content and also on the important fatty acids present in this fraction, were studied. Of the various factors examined, the degree of spoilage of mutton prior to curry preparation has a profound effect on the total FFA content and the individual fatty acids. The results are statistically evaluated and, based on the laboratory investigations, a tentative acceptability limit for FFA content in canned mutton curry (2000 ± 200 mg/100 g lipid) is suggested. The suitability of the above indicators for quality control of meat products on an industrial scale is discussed.

INTRODUCTION

The acceptance of a processed product is highly dependent upon its colour and flavour attributes. The consumer always associates a particular colour and flavour with a particular product and will tolerate only a limited amount of variation from the norms. Canned curried meat prepared from mutton,

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spices, condiments and vegetable fat is an item of issue for the Indian Defence Services. Since it is a highly spiced, thermally processed item, which renders the product sterile, it is possible to mask the deteriorative changes already seen in fresh meat to some extent through processing. In some batches of commercial samples putrid off-odours have been noticed upon opening the cans even though the product conformed to all the specifications stipulated by Government regulatory agencies. This is attributed to the use of sub-standard meat for processing. Hence a need has arisen to establish an objective methodology for ascertaining the pre-sterilization quality of meat in a canned meat curry. There are no recommended methods available at present for ascertaining quality. Microbiological methods do not provide information on pre-processing quality of a finished product and a lot of attention has now been focused on identifying chemical indicators which should meet all the essential criteria (Fields, 1964) to be suitable for quality control. Earlier, from our laboratory, free fatty acids estimated by chromatographic procedures have been reported to be useful as markers of quality to detect the use of putrid meat in canned meat curry (Vasundhara *et al.*, 1983; Kumudavally *et al.*, 1984). In order to utilize these chemical indices of quality for industrial quality control purposes, it was necessary to establish a safe acceptability limit with respect to these markers in the canned meat curry. Therefore various factors that can affect the quantity of these markers in this product were examined. Samples prepared under laboratory conditions in seven different batches were analysed to determine the extent of variation from batch to batch and from sample to sample. Relationships between the initial bacterial load in the meat prior to processing, quantity of total FFA in the product and sensory quality with respect to off-odours, which determine acceptability, were established. The results are reported in the present paper.

MATERIALS AND METHODS

Chemicals

Chemicals used for experiments were AnalaR grade; silica gel G was E. Merck grade; solvents were AnalaR grade; Methyl esters of palmitic, stearic, oleic acids were Sigma grade (Sigma Chemical Company, USA).

Equipment

A CIC gas chromatograph (Chromatography Instruments Co., Baroda, India) provided with a flame ionization detector was used for GLC analysis.

Initial quality of meat
Fresh mutton was procured from the market. Post-mortem age of the mutton was about 4–6 h. No authentic information was available about the history of the animal slaughtered (sex, health status, etc.). Meat was minced in a meat mincer and used for experiments.

Spoilage of meat
Required quantities of minced meat were incubated at 37°C in open trays for 0–18 h. Samples were removed at six hourly intervals for microbiological analysis and for curry preparation. Based on the total microbial counts and organoleptic acceptability, they were classified into fresh, spoiling and spoiled (Vijaya Rao, D. & Bhagirathi, B., 1985, pers. comm.).

Microbiological analysis of raw meat
10 g quantities of fresh raw meat, and also samples incubated at 37°C for different periods, were analysed for SPC, gram negative, coliforms and lipolytic flora following standard microbiological methods (Harrigan & McCance, 1976; Speck, 1976).

Preparation of canned meat curry

General
Composition of meat curry was kept the same in all samples and it was as per Indian ASC specification (ASC specifications, 1980), the details of which are given in our earlier publication (Kumudavally *et al.*, 1984). Only meat samples exposed to 37°C or fresh were used for curry preparation. For every kilogram of minced mutton used for processing, about 357 g dressed onion, ginger and garlic, 47·4 g dry spices and condiments, 20 g salt and 200 g vegetable fat were used for curry preparation. Meat curry was prepared using fresh (Sample A), spoiling (Samples B & C, 6 h & 12h/37°C) and spoiled meat (Sample D, 18h/37°C), respectively. In all samples the meat to gravy ratio was maintained at 55:45; 348 g of curry was packed in 301 × 309 OTS, SR lacquered cans. After vacuum exhaustion with steam, the cans were seamed and sterilized at 15 lbs pressure for 1 h which was adequate to keep the product commercially sterile (F°–7). In total, seven batches of mutton curry were prepared using oil hydro (Dalda) as a cooking vegetable fat.

Analysis of canned meat curry

(*a*) *Organoleptic qualities*
All the canned meat samples were observed for colour, appearance, texture, aroma, flavour and taste. A piece of meat from each type of sample was washed in running water and visually observed for any discoloration.

(*b*) *Residual microbiological activity and alterations in pH*
Representative samples from every batch of meat curry processed were analysed for total plate count and spores of aerobic, anaerobic, mesophilic and thermophilic organisms as per ISI specifications (ISI Specification, 1976). pH of the samples was also recorded.

(*c*) *Hydrolytic breakdown of lipids—TLC and GLC analysis*
Lipids were extracted and the free fatty acids present in every canned meat sample were measured using a TLC-gravimetry procedure (Kumudavally *et al.*, 1984). The FFA fractions were esterified (Morrison & Smith, 1964) and resolved by GLC on a 10 ft × 1/8 in S.S. column packed with 5% DEGS on AW-DMCS Chromosorb operated at 200°C wherein the quantities of palmitic, stearic and oleic acids were quantitatively measured. In each batch, for every type of sample, at least three cans were prepared. From each can, duplicate samples were taken for analysis and mean values recorded.

(*d*) *Alterations during storage*
In one of the batches of A–D, samples were subjected to storage for six months under ambient conditions (28 ± 3°C). During storage the samples were analysed for changes in pH, total FFA and quantities of palmitic, stearic and oleic acids present in FFA fractions and also for oxidative changes.

(*e*) *Statistical analysis*
Correlation coefficients were calculated between the total FFA content and the initial bacterial load in the meat.

RESULTS AND DISCUSSION

A. Meat handling in India

Handling of meat in India is still not very satisfactory due to several complicating factors (Sharma *et al.*, 1985) such as primitive slaughtering practices that are still prevalent in meat trading, lack of refrigeration facilities for handling and transport, tropical weather conditions, preference to eat meat in hot conditions, etc. As a result, the meats sold in the market generally carry a bacterial load heavier than those found elsewhere.

B. Microbiology of meat prior to processing

Fresh meat, as sold in the market, carried a total bacterial load of 10^3–10^4 organ/g. Upon mincing, the counts increased to about 10^{4-5} organ/g. Under

ambient conditions up to 12 h, there were no detectable alterations whereas, at 37°C, in 6 h, meat began to give off-odours and in 12 h a distinct putrid smell was evident. It required 12–18 h to spoil completely at 37°C whereas 18–24 h were needed for total spoilage under ambient (28 ± 3°C) conditions.

C. Variation in pH, organoleptic quality and chemical quality of the canned meat curry

As a result of using spoiling and spoiled meat for processing there was a change in the pH of the product, organoleptic quality and also quantity of chemical indicator, i.e. FFA. Measurement of the pH indicated that, in general, for every batch, a progressive increase in pH was observed as the degree of spoilage of meat increased. It was not possible to establish an acceptability limit for pH since wide variation was noticed from batch to batch which was found to overlap spoiled meat. This was due to variation in the ultimate pH found in meat which was dependent on several antemortem and post-mortem factors.

Figure 1 depicts the relationship between the initial microbial load in meat prior to processing, the total quantity of FFA found in the product prepared in seven batches and the sensory quality particularly with respect to odours which determined the acceptability. As is evident when the total counts are less than 10^8 organisms/g, the quantities of FFA have been found to be

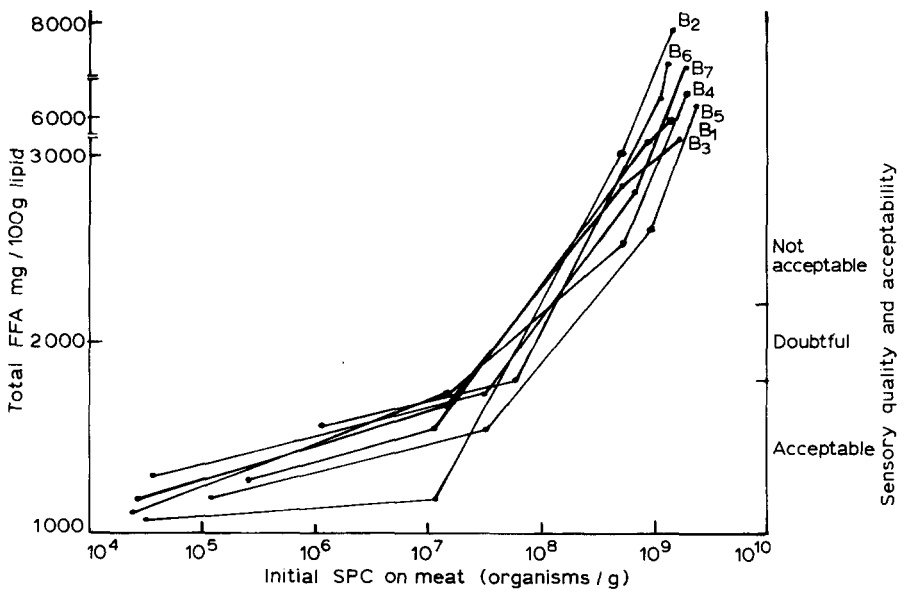

Fig. 1. Effect of microbial load in meat (in the pre-processing stage) on the FFA content and organoleptic acceptability of curried meat processed in 7 batches B_1–B_7.

between 1000 and 1800 mg per 100 g lipid and the product did not possess any off-odours but an increase in total counts from 10^8–10^9 drastically brought about irreversible flavour deterioration which was detectable in the product. The FFA contents then corresponded with an increase from 1000–1700 to 2400–4000 mg/100 g lipid. When the total counts were more than 10^9, the quantity of FFA was found to be between 4000 and 8000 mg FFA/100 g lipid with a distinct putrid smell in the product. From this it appears that there is not much lipolytic activity in the initial stages of spoilage of meat. FFA in samples prepared from fresh meat or in samples prepared from meat exposed to 6 h at 37°C could be a result of low microbial lipolysis and autolytic degradation that have occurred in the meat prior to processing, coupled with thermal processing which also brings about lipid degradation. But between 10^8 and 10^9, there is an appreciable increase in lipolytic activity which leads to faster accumulation of FFA, as well as proteolytic activity, which leads to accumulation of compounds causing off-odours and unacceptability of the product.

Figure 2 gives data on the changes in FFA during storage of samples under ambient conditions. During storage, about 10–15% decrease in FFA was noticeable in samples A, B and C. In sample D there was an increase in total FFA content. However, in general, for samples of type C, which lie on

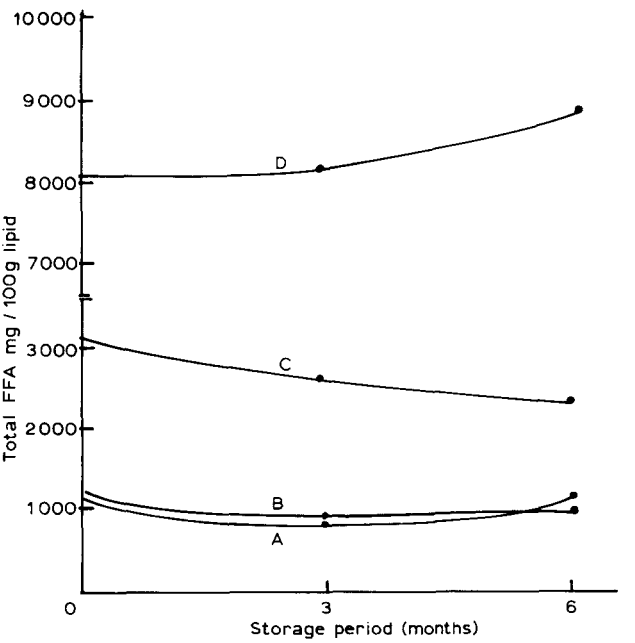

Fig. 2. Changes in total FFA from TLC during storage in samples A–D: A—fresh meat curry, B—spoiling meat curry 6 h/37°C, C—spoiling meat curry 12 h/37°C, D—spoiled meat curry 18 h/37°C.

the borderline, most have more than 2500 mg FFA. Even if a 10–15% decrease were to occur during storage, the samples should still contain 2300 mg FFA or more. Such samples would invariably possess off-odours. This only gives an idea of the changes that perhaps can occur during storage and which must be taken into account when formulating any limits for acceptance.

Table 1 gives data on the pre-processing quality of meat generally found in minced meat. Organoleptic quality of the product, the minimum and the maximum values for FFA found in samples prepared in various batches and deviations noticed in samples as well as correlation coefficients are calculated from the above data.

It is evident that once the total count in meat reaches beyond 10^8 organisms/g, the off-odours detectable in the product can be correlated with increased quantities of FFA in the product.

D. Fraction of FFA mixture by GLC

GLC analysis (mean values) of FFA mixtures obtained from samples prepared in various batches revealed significant increases in three fatty acids, viz. palmitic, stearic and oleic acid, as established earlier and depicted in Fig. 3. The increase in stearic acid was less than those of palmitic acid and oleic acid. In samples B, the increases in all three acids were negligible compared to the control (Sample A) but, in samples C, it was very distinct and in samples D several fold increases were very clear. If the quantities of palmitic, stearic and oleic acids were collectively taken versus degree of spoilage of meat prior to processing, the specific fatty acid marker was able to distinguish samples C and D from the control without any ambiguity. This is particularly helpful for samples of type C, since it is sometimes difficult to judge quality from doubtful organoleptic characteristics and total FFA content by TLC.

However, there was a poor correlation between the TLC + gravimetry and GLC results in samples A, B and C which gave the total FFA content and the quantities of certain important fatty acids present in this fraction, respectively. This was traceable to the fact that, in samples A, B, C, since the quantities of FFA were small, in order to get sufficient amounts for GLC analysis (4–10 mg), the lipid extract (about 3–4 ml) had to be separated on several plates (7–8 plates) and then the FFA bands eluted were pooled together and weighed. However, in sample D, this could be achieved in one step (about 0·5 ml, only on one plate) thereby limiting errors in separation and elution, and recovery was 70%. Either TLC + gravimetry alone or concentrations of palmitic, stearic and oleic acids as obtained by GLC alone were indicative of the pre-sterilization quality of mutton. However, caution must be exercised when comparing TLC with GLC results.

TABLE 1

Pre-sterilization Quality of Mutton Mince, Organoleptic Acceptability, Quantity of FFA (42 Samples Prepared in Seven Batches) and Statistical Correlation Coefficients Found in Canned Mutton Curry

Sample No.	*Microbial/Organoleptic/ Chemical quality*	*Raw meat (fresh) or meat curry (A)*	*Raw meat (37°C/6 h) or meat curry (B)*	*Raw meat (37°C/12 h) or meat curry (C)*	*Raw meat (37°C/18 h) or meat curry (D)*
1.	SPC of raw meat mince prior to processing organ/g (Min–Max)	10^3–10^6	10^7–5×10^8	5×10^8–10^9	10^9
2.	Sensory qualities of the raw meat prior to processing	Acceptable	Slight off-odour	Detectable alterations	Totally putrid and discolored
3.	Sensory qualities of the meat curry prepared	Acceptable	Generally acceptable	Off-odours could be masked to some extent but not completely	Gives distinct putrid smells
4.	Free fatty acid content mg/100 g lipid (Min–Max)	900–1 000 (20 samples) 1 100–1 200 (7 samples) 1 200–1 300 (13 samples) 1 300–1 500 (2 samples)	1 100–1 200 (12 samples) 1 400–1 500 (23 samples) 1 500–1 700 (2 samples) 1 900–2 000 (2 samples)[a]	3 000–4 000 (33 samples) 2 700–3 000 (5 samples) 2 000–2 700 (3 samples) 2 170 (1 sample)[b]	7 000–8 000 (25 samples) 5 000–7 000 (11 samples) 4 000–5 000 (6 samples)
5.	Correlation coefficient[c]	+0·01	+0·26	+0·66	+0·86
6.	Recommended limit of FFA		2 000 ± 200 mg/100 g lipid		

[a] Possessed distinct off-odours.

[b] Did not possess off-odour.

[c] Calculated from the values obtained in 7 batches.

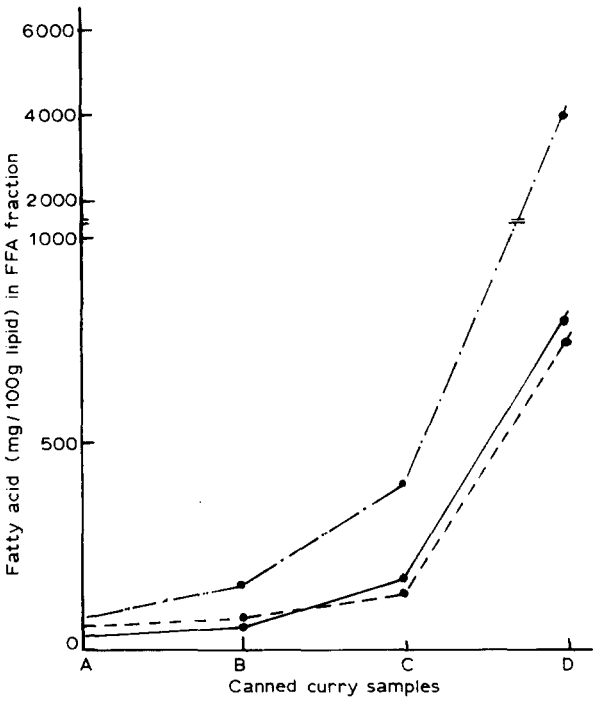

Fig. 3. Changes in specific fatty acid concentrations present in the FFA fraction of canned curried meat: A—fresh meat curry, B—spoiling meat curry 6 h/37°C, C—spoiling meat curry 12 h/37°C, D—spoiled meat curry 18 h/37°C. -·-·-, oleic, ———, palmitic, - - - - -, stearic.

E. Statistical validity of FFA analysis

A positive linear correlation was found to exist between milligrams of FFA formed in samples A–D with the SPC found in meat prior to processing. Based on the laboratory investigations, an acceptability limit of 2000 ± 200 mg of FFA/100 g lipid is recommended (Table 1) which has taken into account the organoleptic quality and the quantity of the chemical indicator found in several samples prepared on different occasions and their shelf stability. However, this is only a tentative limit suggested by the authors based on samples prepared under laboratory conditions and must be evaluated now with commercial samples which possess such defects.

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