Storage stability of dehydrated soyabean extended beef patties in a tropical environment

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Abstract

Dehydrated raw or precooked patty formulations comprising unextended beef patties (ALLBEEF) and extended ones with 30% beef protein replaced by protein in cooked unhydrated soyabean (CUSBEEF), water extracted soyabean (WESBEEF) or proteolysed extracted soyabean (PESBEEF) were heat sealed in polyethylene bags stored at room temperature (29C) and monitored at 4wk intervals for a total of 16wk. Microbial load and pH were not (P>0.05) affected by patty formulation. WESBEEF and PESBEEF had TBA values higher (P<0.05) than ALLBEEF. CUSBEEF has the least TBA value. Dehydrated cooked patties had lower TBA but higher pH values than dehydrated raw patties. TBA values increased gradually while pH declined only after 12wk storage. Rehydratability and shear force were not affected by storage period. The variation observed in the moisture content, volatile nitrogen, rehydratability and shear force among the dehydrated raw patty formulations was reduced among dehydrated cooked patties. Patties cooked prior to dehydration were more stable in moisture content, volatile nitrogen and microbiological status than dehydrated raw patties during storage.

Keywords: Beef-soyabean patties, dehydration, rehydratability, storage stability

Introduction

An earlier report by Kembi and Okubanjo (2002a) indicated considerable variation in chemical and sensory properties of dehydrated raw or precooked beef patties containing different types of processed soyabean products. The physical nature of the different patty formulations also suggested a stable texture capable of withstanding possible post processing handling.

One of the primary objectives of meat dehydration is the preparation of products that will, for an extended time period, discourage the growth and activities of microbes which might spoil it or harm its consumers (Gailani and Fung, 1986). However, Mossel and Shennan (1976) have cautioned that dried foods are not necessarily sterile. Keeping microorganisms off our foods could be more problematic as many of the organisms present in the original meat could still be present in the dehydrated products if adequate steps are not taken to reduce their population either prior to or during dehydration process (Mossel and Shennan, 1975). This becomes especially significant in ground meat products which by its peculiar nature is an excellent medium for microbial growth particularly within the temperature optima found in the tropical environment. The microbes mostly find their ways into the product during the process of grinding, mixing and fabrication. Sankaran *et al* (1976) have shown that apart from curing as a chemical approach to reducing microbial load, precooking a product meant for dehydration could lead to additional drop in microbial load.

The overall quality of dehydrated meat products depends upon the residual moisture, the concentration of different tissue components, sanitation and storage time and temperature. Ibrahim *et al* (1985) observed no detectable changes in chemical and bacteriological qualities of dehydrated beef patties stored at 22 to 25C for two months. The structure and mechanical properties of freeze-dried soyabean and milk protein extended beef patties were, however, observed to be different after four months of storage. The objective of this study was to evaluate the magnitude of microbiologicaland physicochemical changes occurring during storage of dehydrated raw or cooked beef patties containing different processed soyabean products.

Materials and methods

Sample preparation and storage

Raw and precooked variation of beef patty formulations comprising beef without soyabean (ALLBEEF) and minced beef with 30% of the beef protein replaced by protein in cooked unhydrated soyabean (CUSBEEF), water extracted soyabean (WESBEEF) or proteolysed extracted soyabean (PESBEEF) were prepared. Sourcing of the various ingredients and preparation of the different patty formulations, precooking and dehydration processes have been described (Kembi and Okubanjo 2002a).

Two packs of ten dehydrated patties from each of the eight patty formulation-by-dehydration state (PF x DS) treatment combinations were heat sealed in thick polyethylene bags and stored for four months at room temperature (26 – 30C). The two packs from each treatment combination were drawn for physical, chemical and microbiological analysis at 0, 4, 8, 12, and 16wk of storage.

Analytical technique

Determination of residual moisture and pH: Residual moisture in ground samples of the different patties were determined according to the methods of AOAC (1984). PH was determined on aqueous slurries containing 10% solids using Kent E12 pH-meter-electrode system.

Rehydratability and shear-force: Rehydratability of dried patties and the shear force of the rehydrated patties were measured according to the methods described by Kembi and Okubanjo (2002b) using two patties per pack.

Microbiological analysis: Microbiological status of stored dehydrated patties were assessed based on procedures recommended by the International Commission on Microbiological Specification in Foods (ICMSF, 1978). Bacterial load was determined on nutrient agar medium using poured plate technique and incubated at 37C for 48hr. Yeast and moulds were enumerated on potato dextrose agar containing 0.2% streptomycin in poured plates incubated at 28C for 4 days.

TBA Value: Rancidity in dehydrated beef patties was measured and expressed as TBA value (mg/kg sample). A distillation method for the quantitative determination of malonaldehyde in rancid foods (Tarladgis *et al.* 1960) as modified by Chompreeder and Fields (1984) was adopted. The TBA values of dehydrated patties were measured in duplicate per pack at 4 week interval for a total of 16 weeks.

Volatile Nitrogen: Volatile nitrogen in stored dehydrated patty samples was measured and expressed as mg N/kg sample. Assessment was based generally on the Lucke and Geidel macro distillation method as described by Pearson (1970).

Statistical Analysis: A4 x 2 x 5 factorial arrangement in a completely randomized design was used to evaluate physical, chemical and microbiological properties of four (ALLBEEF, CUSBEEF, WESBEEF and PESBEEF) patties exposed to two (Raw or çooked) dehydration states and monitored at five (0, 4, 8, 12 and 16 wk) storage periods. Analysis of variance as described by Steel and Torrie (1980) were used to test responses of all measurements to the main treatments and their interactions. When F values were significant ($P<0.05$), the Duncan's New multiple range test as described by Steel and Torrie (1980) was used to separate the means. Simple correlation coefficients were determined amrong residual moisture, rehydratability of dehydrated patties and shear force of rehydrated patties.

Results

Variation in microbiological status, TBA, pH, rehydratability and shear force values of dehydrated patties as affected by the three main treatment factors are shown in Table 1. Bacteria count, Yeast and moulds and pH values among the four patty formulations did not differ ($P>0.05$). WESBEEF and PESBEEF had similar TBA values which were higher ($P<0.05$) than values recorded for CUSBEEF, ALLBEEF patties had a midway value that did not differ from values recorded for other patty formulations. Patties cooked prior to dehydration had lower TBA but higher pH values than patties dehydrated from the raw state. The TBA value of dehydrated patties steadily increased during storage. Significant increase in TBA value appeared to occur from the twelveth week. The pH of the patties declined significantly only at 16wk of storage. Rehydratability and shear force values did not change (P>0.05) during storage.

Table 1: Effects of main factors on Physicochemical and microbiological properties of dehydrated Patties

Measurement	Patty Formulation ALLBEEF	CUSBEEF	WESBEEF	PESBEEF	Sem
TBA, mg/kg	1.88_{ab}	1.47_{b}	2.38_{a}	1.98	0.121
pH	6.17	6.20	6.27	6.24	0.048^{NS}
Plate count, log CFU/g	3.06	2.89	2.74	2.99	0.119^{NS}
Yeast and Mould count/g	120	109	103	112	16.554^{NS}

Dehydration State	Raw	Cooked	Sem
TBA, mg/kg	2.12a	1.87b	0.086
PH	6.06b	6.37a	0.034

Storage Period (wk)	0	4	8	12	16	Sem
TBA, mg/kg	1.57_{d}	1.68_{cd}	1.91_{bc}	2.26_{ab}	2.53_{a}	0.136
PH	6.31_{a}	6.26_{a}	6.30_{a}	6.18_{ab}	6.03_{b}	0.054
Rehydratability, g/100g	38.7	38.49	38.74	38.07	36.97	0.67^{NS}
Shear force, kg	3.41	3.36	3.43	3.59	3.72	0.192^{NS}

a, b, c, Means on the same row with different subscripts differ (P<0.05)
NS Indicates non-significant (P>0.05) main factor effects

Patty formulation interacted significantly (P<0.05) with dehydration state to affect moisture content, rehydratability, shear force and volatile nitrogen (Table 2). All dehydrated raw patty formulations had significantly (P<0.05) more moisture than their counterparts dehydrated after cooking except for WESBEEF patties in which both dehydrated raw and cooked patties retained similar amount of moisture. The WESBEEF patties (cooked or raw) also recorded the lowest amount of moisture among the four patty formulations. Difference in moisture content observed between dehydrated raw ALLBEEF and CUSBEEF patties was suppressed by predehydration cooking.

Table 2: Moisture and volatile nitrogen contents, rehydratability and shear force of dehydrated raw or cooked beef patties of different formulations

Patty Formulation						
Measurement	Dehydration State	ALLBEEF	CUSBEEF	WESBEEF	PESBEEF	Sem
Moisture, %	Raw	15.94_a	14.55_b	7.61_d	13.82_b	
	Cooked	9.92_c	10.21_c	7.51_d	10.24_c	0.377
Volatile Nitrogen, mg/kg	Raw	91.37_a	77.13_b	60.96_c	73.91_b	
	Cooked	56.46_c	63.50_c	59.08_c	61.44_c	3.277
Rehydratability, %	Raw	31.73_d	35.16_c	42.61_a	38.33_b	
	Cooked	37.01_{bc}	39.12_b	42.80_a	39.38_b	0.859
Shear Force, kg	Raw	5.15_a	3.8_b	2.90_{cd}	3.83_b	
	Cooked	3.62_{bc}	2.63_d	2.72_d	3.31_{bcd}	0.243

a, b, c, Means of the same measurement (raw or cooked) with different subscripts differ (P<0.05)
Sem: Pooled standard error of the mean

Rehydratability of dehydrated raw patties varied among all formulations. The dehydrated raw and cooked WESBEEF rehydrated to similar extent. The dehydrated raw ALLBEEF patties recorded significantly (P<0.05) the least rehydratability value. When patties were cooked prior to dehydration, rehydratability increased significantly in ALLBEEF and CUSBEEF but not in WESBEEF and PESBEEF patties.

The ALLBEEF patties required significantly more force to shear than any other patty formulation. Cooking of ALLBEEF patty or the replacement of 30% of its protein by cooked unhydrated soyabean or proteolized extracted soyabean tend to equalize the force required to shear the patties. Among all party formulations, cooking did not (P<0.05) alter the shear force in WESBEEF and PESBEEF but the process reduced (P<0.05) the shear force in ALLBEEF and CUSBEEF patties.

Protein breakdown as measured by the concentration of volatile nitrogen varied significantly only among the dehydrated raw formulations in which ALLBEEF patties recorded the highest value. Volatile nitrogen in dehydrated raw CUSBEED and PESBEEF patties though similar, were lower (P<0.05) than the value recorded for the dehydrated raw ALLBEEF patties. All dehydrated cooked patties and dehydrated raw WESBEEF patties exhibited lowest values of volatile nitrogen.

Variation in moisture, volatile nitrogen, bacterial load and Yeast and mould count during storage were significantly (P<0.05) affected by the state of the patties prior to dehydration (TABLE 3). Whereas significant increase in moisture was observed for dehydrated raw patties only after 12wk of storage and did not change any further in storage, moisture in dehydrated cooked patties did not increase significantly (P<0.05) until after 16wk of storage.

Table 3: Changes in moisture and volatile nitrogen contents, and micro-biological status of dehydrated raw or cooked patties during storage

Measurement, %	Dehydration State	Storage Period (wk) 0	4	8	12	16	Sem
	Raw	11.98_{bc}	12.71_{ab}	12.31_{ab}	14.10_{a}	13.40_{ab}	0.422
	Cooked	8.86_{d}	8.70_{d}	9.87_{cd}	9.10_{cd}	10.83_{c}	
Volatile Nitrogen, mg/kg	Raw	63.24_{c}	70.27_{cd}	73.99_{bc}	83.35_{ab}	88.36_{a}	3.608
	Cooked	58.74_{c}	60.43_{c}	59.61_{c}	59.70_{c}	62.23_{c}	
Bacteria count, log CFU/g	Raw	5.63_{a}	3.20_{b}	2.41_{cd}	2.54_{cd}	2.85_{bc}	0.189
	Cooked	3.46_{b}	2.03_{d}	2.35_{cd}	2.17	2.20_{d}	
Yeast and mould count/g	Raw	629_{a}	127_{bc}	52_{cd}	26_{d}	46_{d}	26.175
	Cooked	154_{b}	32_{d}	11_{d}	18_{d}	15_{d}	

a, b, c, Means of the same measurement (row and column) with different subscripts differ ($P<0.05$)
Sem;Pooled standard error of the mean

Volatile nitrogen content increased significantly ($P<0.05$) in dehydrated raw patties but was all steady in dehydrated cooked patties during the entire storage period. The effect of precooking in lowering volatile nitrogen production in patties became more pronounced as storage period lengthened.

In the dehydrated raw patties sharp reductions in bacteria, and yeast and moulds counts were observed during the first four to eight weeks. Thereafter the microbiological status appeared to level off. On the other hand, dehydrated cooked patties with significantly ($P<0.05$) lower initial microbiological loads displayed sharp decline after four weeks storage. The high point in the general decline in microbiological status is the significantly higher load observed in the dehydrated raw patties in comparison to the dehydrated precooked ones during the first four weeks of storage. Thereafter differences due to precooking became insignificant except for dehydrated raw patties which had significantly ($P<0.05$) higher bacteria count than the dehydrated cooked patties even after 16 weeks of storage.

Discussion

Breakdown of stored meat products would be apparent mainly in protein and fat with resultant increase in amino and fatty acids and concomitant changes in pH values. The increase in amino acid concentration may easily be determined by measuring the trichloroacetic acid (TCA) soluble nitrogen. However it has been pointed out that the pattern in amino acid content in meat was not always consistent with advancement in spoilage (Pearson, 1968). The breakdown of protein and subsequent utilization by microorganisms of the breakdown products may lead to production of volatile nitrogenous compounds with distinctive and disagreeable odours associated with spoilage (Pittard *et al* 1982). Determination of nitrogen content of such volatile products would not only indicate extent of protein breakdown but also degree of spoilage because of the possibility of overestimation arising from the use of proteolysed extracted soyabean product which has appreciable amount of TCA soluble nitrogen (Kembi and Okubanjo 2002a). Therefore, volatile nitrogen was used as an indicator of spoilage in the stored products instead of TCA soluble nitrogen.

Minimal protein deterioration is expected in dehydrated meat products. The rise in pH and the decline in volatile nitrogen as observed in precooked patties could be traced to the heat application during cooking. Such cooking might have encouraged the loss of most free acidic and volatile compounds in the meat products among which nitrogenous compounds constitute a group. The highest volatile nitrogen value of 88.36mgN/kg was recorded for dehydrated raw patties even after 16 weeks of storage. This value was about 40% increase over the entire storage period and about 44% of 200mgN/kg recommended as indicative of detectable spoilage in meat (Pearson, 1968). Comparatively much less value of these indices of spoilage were recorded for dehydrated cooked patties during storage. This attests to the protein stability of the products.

Apart from microbial spoilage, the primary process by which muscle foods suffer quality loss is through lipid oxidation (Buckley et al. 1995). The TBA value which measured the actual extent of fat deterioration in the patties were generally high and above 1.0mg/kg which is the recommended threshold value (Pearson, 1968, 1970). The pattern of TBA values among various patty formulations showed relatively low TBA value for CUSBEEF patties in comparison with other formulations. Soyabean is known to contain many compounds such as isoflavones, glycosides and tocopherols among others which are potent antioxidants (Kinsella, 1979, Romijn et al 1991). Many of these antioxidants are also known to be water extractable (Pratt, 1972). The relatively higher TBA values recorded for WESBEEF and PESBEEF patties (Table 1) are probably indicative of the absence of such antioxidants. The soyabean products used as extenders in these two patty formulations are products of series of water extraction and as such, they lack what it takes to offer adequate protection against fat deterioration.

The relatively low TBA value for dehydrated precooked patties (Table 1) may be attributed to the lower fat content some of which have been washed off the surface of the patties unlike their dehydrated raw counterparts. Also changes in the status of pro-oxidants such as heme iron and the rise in pH as a result of loss in volatile acidic compounds during cooking could contribute to the observations. Since microbial-induced fat deterioration may not be appreciable in the precooked patties, other factors like residual moisture, presence or absence of antioxidants and or pro-oxidants especially meat iron compounds and the extent of heating could also determine the degree of fat deterioration in the dehydrated patties.

The microbial status of dehydrated patties were affected by predehydrated state and storage period interaction. Table 3 shows that the initial count in the dehydrated raw samples were significantly higher than that in dehydrated precooked samples. The first four weeks of storage showed drastic decline in the bacterial count which amounted to 43.2 and 42.3% reductions for the raw and precooked samples respectively. The decline in bacterial load with storage was in line with the observation of Ibrahim et al (1985). High microbial count are usually related particularly to poor postmortem handling of the meat and could be a reflection of serious contamination and or time-temperature abuse. These factors readily permit addition or multiplication of microbes leading to nutrient breakdown within the materials and possible health hazards to consumers. Chemical treatment such as the use of Nitrites and or Potassium Sorbate at the permitted concentration as well as processing involving heat treatment are some of the ways employed to reduce food-related health hazards due to microbial activities. The bacterial load observed even at 16th week of storage may not pose real danger more importantly because they are far below the recommended level for potential hazards and also because of the fact that the patties are likely to be exposed to further heat treatment before consumption. According to Pace (1975) and Soulberg et al (1976), bacterial counts exceeding 5.0 log10 CFU/g in delicatessen food products are indicative of dangerous contamination.

The general decline observed for yeast and mould count among various patty formulation during the first 4 weeks suggests that the environment was not conducive for the growth of yeast and mould particularly early in storage. The general differences in yeast and mould count patterns that followed beyond four weeks of storage may be attributed to possible access by mould from external sources or survival of some contaminating Xerophiles.

The observed increase in moisture content of dehydrated patties during the 16 weeks storage (Table 3) appear to raise questions about the suitability or efficiency of the storage condition. Most microbes are practically inactivated or destroyed at moisture contents below 11% (Mossel and Shennan, 1976; Christian, 1980). Increase in moisture content of patties beyond this critical minimum therefore could provide a supporting medium particularly for growth of yeast and mould. The relative decline observed in yeast and mould count despite moisture increase during storage could be due to the possibility that the increased moisture was still too low to support the growth of the microbes or to the presence of Potassium Sorbate which is a strong antimycotic agent.

The patties were observed to show little or no change in texture and rehydratability during the storage period. Meat during storage is known to experience both protein breakdown and cross-linking (Obanu et al, 1975). Crosslinking of protein results in more stable protein which may likely determine the textual trend in meat. In dehydrated meats protein breakdown is minimized as a result of reduction in microbial activity. It is likely, therefore, that crosslinking of proteins will override its breakdown and perhaps result in increased texture stability. That this was not detectable in the present study may be indicative of a slow crosslinking process. Zhuravskaya (1984) recorded significant increases in shear stress of dehydrated patties during storage thus suggesting possible crosslinking even in dry meat.

In conclusion, the dehydrated patties prepared and assessed in this study displayed appreciable indices of storage stability. The microbial status showed an early and sustainable decline during the storage period studied and were within the acceptable and safe limits for consumption. Nutrient deterioration, particularly in respect of protein, was maintained below the limit indicative of extensive spoilage. However, the TBA values were above the recommended threshold value for off flavour and may thus indicate possible flavour problems with long storage.

References

AOAC 1984. Official Methods of Analysis 14th ed. Association of Official Analytical Chemists. Arlington, VA.

Buckley, D.J., Morrisey, P.A. and Gray J.I. 1995. Influence of dietary vitamin E on the oxidative stability and quality of pig meat. J. Anim. Sci. 73:122-130.

Chompreeda, P.T. and Fields, M.L. 1984. Effects of heat and natural fermentation on amino acids, flatus producing compounds, lipid oxidation and trypsin inhibitor in blends of soyabean and cornmeal. J. Food Sci. 42: 816 – 820.

Christian, J.H.B 1980. Reduced Water Activity. In "Microbial Ecology of Foods' Vol. 1. ICMSF(ed). Academic Press, New York pp. 70 – 109.

Gailani, M.B. and Fung, D.Y.C. 1986. Critical review of water activities and microbiology of drying meats. CRC Critical Review in Food Sci. Nutri, 25(2): 159 – 183.

Ibrahim, A.A., El-Zanfaly, H.T. and Abd El-Latif, R. 1985. Keeping quality studies on dried meat patties. Chem.. Microbiol Technol. Lebens. 9: 76 – 80.

International Commission on Microbiological Specification for Foods. 1978. Microorganisms in Foods. 1. Their significance and methods of enumeration 2nd ed. Univ. of Toroub Press. Toroub.

Kembi, S.O. and Okubanjo A.O. 2002a. Effects of sequential application of heat treatment, water extraction and proteolysis on functional properties of soyabean. Trop. Anim. Prod. Invest. 5: 9 – 20.

Kembi, S.O. and Okubanjo A.O. 2002b. Physicochemical and sensory properties of dehydrated beef patties containing soyabean products. Trop. Anim Prod. Invest. 5: 137 – 148.

Kinsella, J.E. 1979. Functional properties of soy proteins. J. Am. Oil. Chem. Soc. 56(3): 242 – 258.

Mossel, D.A.A. and Shennan W.J., 1976. Microorganisms in dried foods. Their significance, limitation and enumeration. J. Food Technol 11:205-219.

Obanu, Z.A., Ledward, D.A. and Lawries, R.A. 1975. The protein of intermediate moisture meat stored at tropical temperature. II. Effect of protein changes on some aspects of meat quality. J. Food Technol. 10:667-674.

Pace, P.J. 1975. Bacteriological quality of delicatessen foods: Are standards needed? J. Milk Technol. 38: 347-353.

Pearson, D. 1968. Assessment of meat freshness in quality control employing chemical techniques: A review. J. Sci. Food Agric 19:357-363.

Pearson, D. 1970. Flesh foods: Table Jellies. In 'The chemical analyses of foods'. 6th ed. J & A. Churchill, London. Pp. 374 – 410.

Pittard, B.T., Freeman, L.R., Later, D.W. and Lee, M.L. 1982. Identification of volatile organic compounds produced by fluorescent pseudomonads on chicken breast muscle. Appl. Environ. Microbial. 43: 1504-1510.

Pratt, D.E. 1972. Water soluble antioxidant activity in soyabeans. J. Food Sci. 37:322-325.

Romijn, A., Cuppett, S.L., Zeece, M.G., Parthurst, A.M. and Lee, M.L. 1991. Impact of soy protein isolates and specific fractions on rancidity development in a cooked refrigerated beef system. J. Food Sci. 56:188-190.

Sankaran, R. Thangamani, Leela, R.K. Parihar, D.B. and Nath, H. 1976. Microbial profile of dehydrated cured mutton mince from raw material to the finished product. J. Food Technol. II: 161-169.

Soulberg, M. Miskinuri, D.K., Martin, B.A. Page, G. Ooldere, S. and Libfeld, M. 1976. What do mimcrobiological indicator tests tell us about safety of foods? Food Prod. Dev. 10: 27 – 30.

Steel, R.G. and Torries, J.H 1980. Principles and procedures of statistics. 2nd ed. McGraw-Hill Book Co. New York.

Tarladgis, B.G. Watts, B.M. Yonnathan, M.T. and Dugan, L. (Jr). 1960. A distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Soc. Oil Chem. 37:44 – 52.

Zhuravskaya, N.K., Gorshor, I.k. Yulikov, Yu. I., Efimov, A.V and Yulikova, V.V. 1984. The influence of milk and soy protein preparations on the physicochemical and structure mechanical characteristics of freeze dried ready-to-cook meats. Proc. European Meeting of Meat Research Workers. No. 30, 4(3), 168 – 16.