Food Chemistry **26** (1987) 261–269

Frozen Storage Stability of Beefburger Containing Plant Meat Substitutes

Mahmoud A. Hamza, Yehia G. Moharram, Mohamed B. Aman & Magdi O. El-Akary

Department of Food Science and Technology, Faculty of Agriculture, Alexandria University, Alexandria, Egypt

(Received 8 October 1986; revised version received 27 February 1987; accepted 23 March 1987)

ABSTRACT

The effects of addition of broken white rice and decorticated faba bean flours, as meat substitutes, on physico-chemical, technological and organoleptic properties, as well as microbiological count, of beefburger, during frozen storage at −22°C and 92% relative humidity for 3 months, were investigated. The results showed (a) slight and gradual increase in peroxide value (PV) and total volatile nitrogen (TVN), (b) no changes in protein electrophoretic patterns, (c) slight decrease in water-holding capacity (WHC), plasticity (P) and total microbial count, (d) gradual and slight increase in cooking loss and shrinkage, and (e) a noticeable improvement in the organoleptic characteristics of the beefburger during frozen storage.

INTRODUCTION

The utilization of texturized soybean protein in processing different types of meat products such as sausages, minced meat, meat balls, meat patties and beefburger is now common. Many studies have been carried out to estimate the effect of this utilization on the processing, characteristics, keeping quality and sensory properties of these products (Trumic *et al.*, 1982; Kenawy, 1984; Nasser, 1985). The aim of the current work is to study the utilization of low price locally available cereals, such as broken white rice and dehulled faba bean flours, in preparing beefburger. The effect of these materials on the keeping quality of this product under frozen storage at −22°C and 92%

Food Chemistry 0308-8146/87/$03·50

relative humidity for 3 months, the most common storage period of such a product at the Egyptian local markets, was also investigated.

MATERIALS AND METHODS

Materials

Meat

100-kg brisket boneless frozen beef meat cuts (17% fat) were utilized in this study. The meat was obtained from cold stores of Alexandria Meat Preparation and Processing Factory in Qabbari, Alexandria, Egypt, in 1985. It consisted of 72·7% moisture, 79·1% crude protein, 17·2% crude fat, 3·7% ash and it was free from carbohydrates on a dry weight basis.

White rice and faba bean

Broken white rice (*Oryza sativa*) and decorticated faba beans (*Vicia faba*) were obtained from the local market in Alexandria. They were first dry cleaned, washed twice with running tap water, then dried at 40°C in a cabinet drier for 4 h to attain a level of about 9–12% moisture content. The dried products were ground in an electric mill type National, Model MX-291 N, to pass through a 60-mesh sieve. The proximate chemical compositions of white rice and decorticated faba bean were (respectively) 14·4% and 9·06% moisture, 9·11% and 37·5% crude protein, 0·47% and 0·77% ether extract, 89·9% and 58·78% carbohydrates, and 0·47% and 2·9% ash, on a dry weight basis. The water absorptions were 130% and 120% for faba bean and white rice, respectively.

Spices

A mixture (powder) of 50% black pepper, 30% coriander, 5% cubeb, 5% cloves, 5% cinnamon and 5% red pepper was used as a seasoning agent.

Beefburger

Beefburger was composed of 60% meat, 3% spices, 2% NaCl, 10% water and 25% of hydrated flour of either white rice or faba bean. The hydrated flours were prepared before addition of meat by mixing the dried flour from each source with water according to its water absorption to obtain a suitable consistency. Then meat and other ingredients were blended in with an Alaska chopper (four times) to achieve the appropriate texture of beefburger. It was formed into a round shape (10 cm diameter, 0·5 cm thickness) of 60 g weight. Each beefburger was surrounded with two pieces of butter paper before packaging in white polyethylene bags. Each bag contained three pieces. An electronic sealing machine was used to weld the spaces around each piece and also the bag opening. Beefburgers were stored at −22°C and 92% relative humidity for 3 months. The number of replicates of each type of beefburger made and tested was four.

It was found that the beefburger containing faba bean consisted of 64·8% moisture, 52·1% crude protein, 12·1% crude fat, 23·7% carbohydrates and 12·1% ash. That made with white rice contained 65·1% moisture, 43·7% crude protein, 12·1% crude fat, 34·6% carbohydrates and 9·6% ash (on a dry weight basis).

Methods

Physico-chemical properties

Water-holding capacity (WHC) and plasticity. Water-holding capacity (WHC) and plasticity were measured as described by Volovinskaia & Merkolova (1958).

pH value. pH value was determined as reported by Aitken *et al.* (1962).

Polyacrylamide gel electrophoresis (PAGE). Standard PAGE technique was used to fractionate water-soluble proteins of beefburger samples using the PANTA-PHOR apparatus. Sample preparation, electrophoretic conditions, staining and destaining were carried out as described by Stegemann *et al.* (1986).

Chemical characteristics

Moisture content. The moisture content was determined according to the methods of the AOAC (1980).

Total volatile nitrogen (TVN). The total volatile nitrogen (TVN) was determined in beefburger samples as described by Pearson (1976). Results were expressed as milligrams of nitrogen per 100 g sample.

Peroxide value (PV). Peroxide value (PV) was determined in the ether extract of beefburger samples according to the method of Pearson (1976). Results were expressed as milliequivalent peroxide/kg sample.

Microbiological count

The total bacterial, mould and yeast counts were carried out as recommended by Frazier (1967). Culture media were prepared according to the method given by the *Difco Manual* (1977).

Cooking and organoleptic properties

Cooking loss and shrinkage. Cooking loss and shrinkage were determined according to the method of Hegazy (1981).

Organoleptic evaluation. Beefburgers were judged for organoleptic quality after frying in cottonseed oil for 2 min at 240°C. The samples were tested for colour, taste, flavour, tenderness and overall acceptability. The grading system recommended by Deutsche Landwirtschaftlich Geselschaft (DLG) was followed:

(a) fancy grade having at least 90% of the score;
(b) very good grade having at least 80% of the score;
(c) medium grade having at least 70% of the score;
(d) standard grade having at least 50% of the score.

RESULTS AND DISCUSSION

Physico-chemical properties

Water-holding capacity (WHC), pH and plasticity

Table 1 shows the changes in WHC, plasticity and pH value of beefburger during frozen storage. The results indicate that:

(a) WHC was increased due to the addition of meat substitute, particularly in the case of faba bean which had a higher protein content than white rice. According to Hegarty (1963) the WHC depends on the protein binding properties. On the other hand, there was a slight decrease in the beefburger plasticity as a result of meat substitute addition.
(b) Both WHC and plasticity were decreased gradually after freezing and during frozen storage.
(c) The pH values of beefburger were slightly increased due to the addition of meat substitutes and frozen storage, especially when faba bean flour was added. Bell & Shelef (1978) found that the pH of minced meat containing vegetable proteins was relatively higher than the control. Also, Ockerman & Leonerespo (1982) showed that the effect of temperature during frozen storage on the changes of the pH of meat was more significant than salt.

Polyacrylamide gel electrophoresis (PAGE)

As shown in Table 2, addition of faba bean increased the number of separated bands of the beef meat (5 bands) in the upper part of the gel to 10

TABLE 1
Changes in Water-holding Capacity (WHC), Plasticity (P) and pH Value of Beefburger During Frozen Storage at −22°C and 92% Relative Humidity

Storage period (months)	*Beefburger*			*White rice beefburger*			*Faba bean beefburger*		
	WHC (%)	*P* (cm^2)	*pH*	*WHC* (%)	*P* (cm^2)	*pH*	*WHC* (%)	*P* (cm^2)	*pH*
0	84·3	3·80	6·10	88·9	3·60	6·1	94·8	3·70	6·3
1	83·0	3·60	6·30	87·0	3·50	6·4	94·0	3·55	6·5
2	82·5	3·50	6·40	86·0	3·40	6·5	93·7	3·50	6·6
3	81·4	3·20	6·50	84·4	3·00	6·6	92·1	3·10	6·7

bands. On the other hand, rice alone or in blend with meat gave weak and unclear bands. The low protein content of white rice, as well as the effect of milling, may be the main reasons behind these results. The above-mentioned results agree with those obtained by Olsman (1967). The data in this table also illustrate that frozen storage, at −22°C for 3 months, had no effect on the number of resolved bands of the water-soluble proteins of either the control beefburger or the plant-containing samples. The quantitative estimation of these bands may give accurate information about the changes occurring in the protein during frozen storage.

TABLE 2
Effect of Frozen Storage at −22°C and 92% Relative Humidity on the Electrophoretic Patterns of Beefburgers

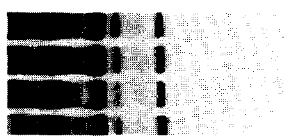
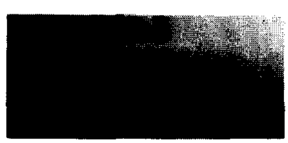
Type of samples	*Storage period (months)*	*Electrophoretic patterns*
Beefburger (control)	0·0	
Beefburger (control)	1	
Beefburger (control)	2	
Beefburger (control)	3	
White rice beefburger	0·0	
White rice beefburger	1	
White rice beefburger	2	
White rice beefburger	3	
Faba bean beefburger	0·0	
Faba bean beefburger	1	
Faba bean beefburger	2	
Faba bean beefburger	3	

TABLE 3
Changes in Moisture Content (MC), Total Volatile Nitrogen (TVN) and Peroxide Value (PV) of Beefburger During Frozen Storage at −22°C and 92% Relative Humidity

Storage period (months)	*Beefburger*			*White rice beefburger*			*Faba bean beefburger*		
	MC (%)	*TVN* (*mg 100* g^{-1} *sample*)	*PV* (*milliequivalent* kg^{-1} *sample*)	*MC* (%)	*TVN* (*mg 100* g^{-1} *sample*)	*PV* (*milliequivalent* kg^{-1} *sample*)	*MC* (%)	*TVN* (*mg 100* g^{-1} *sample*)	*PV* (*milliequivalent* kg^{-1} *sample*)
0	64·0	8·05	0·00	65·7	5·60	0·00	64·9	5·60	0·00
1	62·9	9·80	23·5	63·8	8·40	11·4	63·3	8·40	10·7
2	61·8	11·2	28·5	62·5	9·80	24·8	62·4	9·80	26·8
3	60·9	11·2	32·4	61·7	9·80	26·6	61·2	9·80	28·2

TABLE 4
Changes in the Total Microbial Count of Beefburger During Frozen Storage at −22°C and 92% Relative Humidity

Storage period (months)	*Beefburger*		*White rice beefburger*		*Faba bean beefburger*	
	Total count	*Moulds and yeast count*	*Total count*	*Moulds and yeast count*	*Total count*	*Moulds and yeast count*
0	$2{\cdot}0 \times 10^3$	None	$1{\cdot}5 \times 10^3$	None	$1{\cdot}4 \times 10^3$	None
1	$2{\cdot}9 \times 10^5$	None	$2{\cdot}2 \times 10^5$	None	$2{\cdot}0 \times 10^5$	None
2	$3{\cdot}5 \times 10^5$	None	$3{\cdot}1 \times 10^5$	None	$2{\cdot}5 \times 10^5$	None
3	$3{\cdot}7 \times 10^5$	None	$3{\cdot}3 \times 10^5$	None	$2{\cdot}8 \times 10^5$	None

Chemical characteristics

As shown in Table 3, moisture content and peroxide value of beefburger did not change and total volatile nitrogen decreased when 25% of hydrated rice and faba bean flours were mixed with meat. The storage of these products at −22°C and 92% relative humidity caused a slight decrease in moisture content and a gradual increase in TVN and peroxide value. According to Pearson (1976), and on the basis of the TVN determination, meat can be described as fresh with 0·0–13 mg TVN/100 g meat, acceptable with 13–17 and spoiled with more than 17 mg TVN/100 g meat. From the results in Table 3 it can be noticed that the TVN of both free and plant-containing beefburger samples ranged from 5·5 to 11·2 mg/100 g (fresh). The results in Table 3 also showed that there was an increase in the PV after the first month of the frozen storage due to the fat oxidation. Goldman & Chodlia (1966) reported that extending the frozen storage period of minced meat increased the formation of peroxides, aldehydes, free fatty acids, etc.

Microbiological properties

Results shown in Table 4 indicate that beefburgers containing plant meat substitutes had relatively lower microbial loads than the control. This load was increased gradually during frozen storage with a relatively higher rate in the control than in the rice and faba bean beefburgers. These results agree with those reported by many investigators such as Summer *et al.* (1979) and Taminaga *et al.* (1982). Both control beefburgers and those containing plant substitutes were free from moulds and yeasts (less than 30 colonies/g) before and after frozen storage.

Cooking and organoleptic properties

Cooking loss and shrinkage. Cooking loss and shrinkage of control beefburgers and that containing plant meat substitutes (after frying in cottonseed oil and during frozen storage at −22°C for 3 months) are given in Table 5. It can be said from these results that:

(a) Replacing part of the minced meat with plant sources reduced both the cooking loss and the shrinkage during frying of beefburger. This effect was more pronounced in the case of rice beefburger than in the faba bean one, probably due to the ability of rice starch to absorb water. The swelling of this starch may be the reason behind the lowering of shrinkage in this type of product.

(b) The faba bean beefburger indicates a reduction in cooking loss and shrinkage compared with the control beefburger. Cooking loss was less than shrinkage in the rice beefburger.

TABLE 5
Changes in Cooking Loss and Shrinkage of Beefburger During Frozen Storage at −22°C and 92% Relative Humidity

Storage period (months)	*Beefburger*		*White rice beefburger*		*Faba bean beefburger*	
	Cooking loss (%)	*Shrinkage* (%)	*Cooking loss* (%)	*Shrinkage* (%)	*Cooking loss* (%)	*Shrinkage* (%)
0	38·6	39·5	16·4	18·1	31·0	34·6
1	43·8	43·3	23·4	27·2	35·5	39·6
2	44·5	45·7	27·4	30·8	38·1	41·4
3	45·3	47·9	31·8	35·9	40·4	44·8

(c) Extension of the freezing storage period increased both cooking loss and the shrinkage of beefburger. This increase was more noticeable in the control, followed by that which had 25% hydrated faba bean and, lastly, that containing rice.

Generally these results agree well with those reported by Ray *et al.* (1981).

Organoleptic properties. The panellists found that the substituting of meat with plant materials reduced overall acceptability from very good (control) to good grade. But substitutes retained the same level of organoleptic properties in the product during frozen storage. On the other hand, the total overall acceptability of control was reduced from very good (for fresh) to good after 2 months and then to standard grade after 3 months of frozen storage at −22°C and 92% relative humidity.

In conclusion, the use of rice flour (the cheapest source) as a meat substitute lowered the cooking loss and shrinkage, improved the texture, kept the flavour and reduced the changes occurring in the peroxide values during frozen storage at −22°C and 92% relative humidity. The use of faba bean increased the WHC and improved the colour of beefburger compared with rice beefburger. Both substitutes will also reduce the operation costs on a large-scale production without affecting, significantly, the nutritional, technological and sensory properties of such a product.

REFERENCES

Aitken, A., Gasey, J. C., Penny, I. F. & Voyle, C. A. (1962). Effect of drying temperature in the accelerated freeze-drying of pork. *J. Sci. Food Agric.*, **13**, 439–45.

AOAC (1980). *Official methods of analysis* (12th edn), Washington, DC, Association of Official Analytical Chemists.

Bell, W. N. & Shelef, L. A. (1978). Availability and microbial stability of retail beef–soy blends. *J. Food Sci.*, **34**, 315–20.

Deutsche Landwirtschaftliche Geselschaft (1973). DLG Tropen und Export Prufung-Agrarwerbung, Gmb Hamburg, West Germany.

Difco Manual (1977). Dehydrated culture media and reagents for microbiological and chemical laboratory procedures. Difco Laboratories, Inc., Detroit, I, Michigan, USA.

Frazier, W. C. (1967). *Food microbiology*, New York, McGraw-Hill.

Goldman, E. & Chodlia, L. (1966). The use of smoke concentrates in sausages production. *Meat Industry, USSR*, **4**, 32–6.

Hegarty, G. R. (1963). *Solubility of emulsifying characteristics of intracellular muscle protein.* PhD Dissertation, Michigan State University, East Lansing, Michigan.

Hegazy, H. A. (1981). *Physico-chemical studies of the protein of some Egyptian leguminous seeds with reference to its technological potentials as substitutes for animal proteins.* PhD Thesis, Faculty of Agriculture, Ain-Shams Univ., Cairo, Egypt.

Kenawy, M. N. (1984). *Chemical and technological studies on the Egyptian beef sausage extenders.* MSc Thesis, Faculty of Agriculture, El-Minia Univ., El-Minia, Egypt.

Nasser, E. H. (1985). *Chemical and technological studies on some meat products using different additives of plant proteins.* MSc Thesis, Faculty of Agriculture, Monoufia Univ., Egypt.

Ockerman, H. W. & Leoncrespo, F. (1982). Physicochemical changes occurring during storage of precured beef blends at different temperatures and two levels of salt. *J. Food Sci.*, **47**, 849–53.

Olsman, W. J. (1967). *Proceedings 13th Meeting European Meat Research Institutes, Rotterdam.*

Pearson, D. (1976). *The chemical analysis of foods*, London, England, Churchill Livingstone.

Ray, F. K., Parrett, N. A., Vanstavern, B. D. & Ockerman, H. W. (1981). Effect of soy level and storage time on the quality characteristics of ground beef patties. *J. Food Sci.*, **46**, 1662–6.

Stegemann, H., Burgermeister, W., Francksen, H. & Krogerrecklenfort, E. (1986). PANTA-PHOR (and MONO-PHOR). Gel electrophoresis and isoelectric focusing. *Lab. Manual, Inst. für Biochemie*, BBA, Messeweg II D-3300, Braunschweig, West Germany.

Summer, J., Reay, C. & Perry, I. (1979). A survey of the hygienic quality of food in Christchurch, New Zealand. *Food Technology in New Zealand*, **14**, 3–8.

Taminaga, S. I., Beumer, R. R. & Kampelmacher, E. H. (1982). Microbiological studies on hamburger. *J. of Hygiene*, **88**, 123–7.

Trumic, Z., Polic, M., Skenderovci, C. & Borna, A. (1982). Yugoslav vegetable protein hydrolysates in meat products. *Technologiza Mesa*, **23**, 29–34 (*cf. FSTA*, **15**, 697, 1980: 5 S).

Volovinskaia, V. P. & Merkolova, V. R. (1958). Methods for determination of meat water-holding capacity. Office of Technical Information, All Union Scientific Research Institute of Meat Industry, Bulletin No. 21.