CHARACTERISTICS OF REDUCED-SALT BEEF PATTIES AS AFFECTED BY REDUCTION AND SUBSTITUTION OF NA

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Abstract

Hypertension is a major contributor to heart attack, heart failure and kidney failure , and there is a complete relation between sodium consumption and hypertension, specially where level of sodium consumption exceeds the recommended safe level . Therefore , reduction and / or substitution of sodium in processed foods, specially meat products, are important while retaining their optimum properties with normal salt content. In the present work , beef patties were manufactured as control (100% Na Cl), A (65% Na Cl), B (50% NaCl + 50% KCl) , C (100% KCl) , D (the same of B + treatment with citric acid), E (the same of B + treatment with liquid smoke) and F ((the same of B + treatment with a special blend of spices and herbs) . Samples were stored at - 18°c for 3 months . Sodium and Potassium contents , physico-chemical properties and microbial attributes of samples were determined . Also , sensory evaluation of samples and testing the significance between the samples were investigated . The effect of frozen storage for 3 months on some physico - chemical and microbial properties for testing the shelf life and safety of samples were studied .

The results indicated that no single solution may exist for optimization of all the properties when Na Cl levels in beef patties are reduced, and a multiple solution of replacement 50% NaCl with KCl, using a special blend of spices and herbs and using potassium pyrophosphate and ascorbic acid may provide the best solution at present. This solution is presented in the F treatment and is suggested for commercial production.

INTRODUCTION

Hypertension has become a major public health policy concern because it may increase the incidence of symptoms associated with coronary heart disease and stroke. Excessive intakes of sodium are associated with hypertension , and it is known that sodium can aggravate existing hypertension (Isabel *et al.* , 1983) . IFT , 1980 reported that the average consumption or the total daily intake of sodium is estimated to range from 3900 to 4700 mg sodium (10 - 12 gm salt) per person per day , and this intake level is 20 - 25 times greater than the minimum adult requirement (200 mg of sodium or 0.5 gm of salt) which is needed to maintain physiological balance (Sebranek *et al.*,

1983) . Sodium intakes of 1100 - 3300 mg / day and potassium intakes of 1865 - 5625 mg / day are considered safe and adequate for adults (FNB , 1980). Therefore, sodium intake probably should be reduced (Guerrero *et al.* , 1998).

Reducing the sodium content in processed meat products may affect the shelf - life , the binding properties , the flavour and the safety of these products (Terrell, 1983 and Boatella *et al.* , 1996) . Many researchers reported that replacement of NaCl with other chloride salts may not be totally desirable for flavour , only potassium chloride appears to offer the best alternative for replacing NaCl because it is currently generally recognized as safe (GRAS) for use in processed meats , but with exception its effect on flavour (bitter taste on high levels, Terrell , 1983) . It is apparent that no single solution may exist for optimization of all functional and economic parameters when NaCl levels are reduced in processed meat. A multiple solution such as using KCl, phosphates , other compounds and altering processing techniques is the best solution at present(Ishioroshi and Samejima , 1994). The objective of the present study is to produce reduced - salt beef patties while retaining their optimum properties with a full - salt content . Shelf - life and safety of reduced - salt beef patties during frozen storage are also to be studied .

MATERIALS AND METHODS

Fresh beef, spices and herbs were obtained from the local market in Giza . Beef patties were prepared by the common method – either control (full salt) or treatments (reduced salt)- according to the formulation presented in table (1) . Control and treatments were evaluated immediately after processing for sensory , physico-chemical and microbial properties . Also, some Physico–chemical and microbial attributes were determined during storage at - 18 °c for three months .

Sodium and potassium contents were determined according to the method of Anonymous (1982) using atomic absorption Spectrophotometer . Perkin E ., Model 2380. Thiobarbituric acid value (T.B.A.) as an indicator for lipid oxidation was assessed as described by Pearson (1970) . The PH value was measured by a Fisher accumet PH-meter (Mode 600). Water holding capacity (W.H.C.) and plasticity were measured according to the filter press method of Soloviev (1966). Cooking loss and shrinkage %

Table 1. Reduced-Salt beef patties formulations.

Control	Treatments					
	A	B	C	D	E	F-
Ground beef + white pepper 0.5% -+• Sodium pyrophosphate 0.5% +NaCl 2.0% (100% Na Cl)	Ground beef + white pepper 0.5% + Potassium pyrophosphate 0.5% +NaCl 1.3% (65% NaCl) + Ascorbic acid 0.05%	Ground beef + white pepper 0.5% + Potassium pyrophosphate 0.5% +NaCl%+KCl 1% (50%NaCl + 50%KCl) + Ascorbic acid 0.05%	Ground beef + white pepper 0.5% + Potassium pyrophosphate 0.5% +KCl 2.0% (100% KCl) + Ascorbic acid 0.05%	The same of B + Citric acid 0.5%	The same of B + Smoke concentrate 1%	The same of B + Special spices and herbs mix 0.5%

* The special spices and herbs mix. was composed from white mustard, shreaded thyme, sweet basil, saffron and common rosemary in equal amounts, the mix was used as powder at level of 0.5%

were calculated as a percentage of weight and diameter change from the raw to cooked state (in little of plant oil at 180 °c for 3 min. each side) . Freeze / thaw stability of beef patties batter was determined according to the method described by Trius *et al.* (1994). With respect to the microbiological properties, total aerobic plate count (T.A.P.C.) was performed according to APHA (1971) . Skim milk - nutrient agar medium was used to grow and count the aerobic proteolytic bacteria while lipolytic bacteria were grown on the nutrient emulsified oil agar .*Salmonella* was detected and counted by using S.S. agar as a selective medium . *Staph aureus* and *E coli.* were detected and counted by using staph. 110 and violet red bile agar medium respectively . Sensory evaluation of products was carried out using 20 member panel to evaluate the texture , taste , flavour , color and overall acceptability on a 9 points hedonic scale according to Watts *et al.* (1989). Further, to find out the best product and test the significance between all the products , the ranking method and critical differences were used according to Basker (1988).

RESULTS AND DISCUSSION

1. Physico - chemical properties :

Data presented in table(2) show physico-chemical attributes of reduced-salt beef patties as affected by reducing and substituting of Sodium .It could be observed that treatments had lower Sodium contents (105.5 - 632.15 mg / 100 g) and higher Potassium contents (363.5 - 1613.30 mg / 100 g)when compared with control which had the reverse trend , high Sodium (993.58 mg / 100 g) and low Potassium (215.05 mg / 100 g) respectively . It might be due to reducing NaCl of sample A with 35% and substituting NaCl of samples B , D , E and F with 50 % KCl and C with 100% KCl, also sodium pyrophosphate added in control sample was replaced with Potassium Pyrophosphate in the treatments . However, reducing sodium and increasing potassium should occur in the diet (FNB, 1980) . For the T.B.A. values, samples of full - salt beef patties (control) and reduced - salt beef patties (treatments) were not significantly different after immediate processing (0.2 - 0.3 mg malonald./kg), however , the increased NaCl levels enhanced the development of oxidative rancidity (higher T.B.A. values).With respect of other physico–chemical properties, it could be noticed that water holding capacity (W.H.C.) and plasticity increased with increasing of pH and the re-

Table 2. Physico-chemical attributes of reduced-salt beef patties as affected by reduction and substitution of sodium.

Samples* / Item**	Control	A	B	C	D	E	F
Sodium	993.58	632.15	508.10	105.50	521.12	533.51	506.30
Potassium	215.05	363.50	1078.20	1613.30	1095.50	1051.22	1063.35
T.B.A.	0.343	0.304	0.280	0273	0.249	0.234	0.241
WHC	0.1	0.9	0.7	0.8	6.6	4.8	0.1
Plasticity	4.0	3.1	3.9	3.2	1.8	1.8	3.9
pH	6.65	6.50	6.54	6.52	5.95	6.2	6.66
Cooking loss %	12.3	25.6	21.7	19.2	38.7	36.5	12.5
Shrinkage %	15.70	31.15	16.50	25.10	39.21	34.84	15.70
Freeze/thaw loss %	0.05	2.2	1.6	2.5	5.8	4.0	0.04

* For explanation, see table (1)

** - Sodium (mg/100 g sample)

- Potassium (mg/100 g sample)

- WHC = water holding capacity (cm^2 / 0.3g sample), high values mean low WHC.

- Plasticity (cm^2 / 0.3g sample)

- TBA = Thiobarbituric acid (mg malonaldehyde / kg sample)

verse was correct . Therefore , with exception of reduced - salt beef patties made with a special blend of spices and herbs (F), all treatments had lower WHC (higher values) than control, consequently, treatments (A, B, C, D and E) had higher cooking loss, shrinkage and freeze / thaw loss than control and F treatment . These results agree with the finding of Terrell *et al.* (1984) . Reduced – salt beef patties made with a special blend of herbs and spices and replacing 50% of NaCl with KCl (F) recorded the best treatment according to physico-chemical attributes.

2. Microbial evaluation :

Microbial evaluation of reduced - salt beef patties as affected by reduction and substitution of sodium is given in Table (3) .From the results , it could be indicated that reducing sodium or substituting sodium with potassium had little effect on microbial load of beef patties immediately after processing . D and E treatments recorded the lowest counts of total aerobic plate count (TAPC), lipolytic bacteria (L.B.) and proteolytic bacteria (P.B.) and this might be due to the effect of citric acid (D treatment) and liquid smoke (E treatment) in decreasing the pH value and accordingly increasing the acidity of patties leading to inhibiting and reducing microbial growth , however ,low pH of these treatments (D and E) led to low physical and sensory properties . With exception of treatments D and E , treatment F had lower bacterial counts than other treatments and control , and this might be due to the effect of spices and herbs mixed with it . On the other hand , *Salmonella* , *Staph aureus* and *E. coli* (pathogenic bacteria) were not detected in the samples after processing either control or treatments .These results were confirmed by the findings of Terrell (1983).

3. Sensory evaluation :

Sensory properties are the most important attributes that affect consumers choice .Reducing or substituting NaCl in meat products may affect the sensory properties , however , we need to reduce NaCl in our products while retaining the properties of products with high sodium content (Boatella *et al* 1996).Data presented in Table (4) show the sensory evaluation of reduced - salt beef patties as affected by reducing and replacing of sodium . From the results , it could be observed that control (100% NaCl) and F(50% NaCl + 50% KCl + a special blend of spices and herbs) samples had the highest scores - given by the panelists - followed by A (65% NaCl) , B (50% NaCl + 50

Table 3. Microbial evaluation of reduced-salt beef patties as affected by reduction and substitution of sodium, (cfu / g)+

Samples* / Item**	Control	A	B	C	D	E	F
TAPC	5.3×10^4	6.5×10^4	6.0×10^4	5.8×10^4	3.0×10^4	3.3×10^4	5.5×10^4
L.B.	8.5×10^2	9.8×10^2	9.3×10^2	8.8×10^2	5.2×10^2	4.0×10^2	6.6×10^2
P.B.	2.1×10^3	4.0×10^3	3.2×10^3	3.0×10^3	9.0×10^2	8.1×10^2	9.3×10^2
S. spp.	—	—	—	—	—	—	—
St. Aureus	—	—	—		—	—	—
E. coli	—	—	—	—	—	—	—

• For explanation, see table (1)

+ - TAPC = Total Aerobic Plate Count

- L. B. = Lipolytic Bacteria
- P. B. = Proteolytic Bacteria
- S. SPP = Salmonella spp.
- St. A. = Staphylococus aureus
- E. C. = E. coli
- CFU = Colonies forming units

Table 4. Sensory evaluation of reduced - salt beef patties as affected by reduction and substitution of sodium . (Scores average)+

Samples	Texture	Color	Taste	Flavour	Overeall acceptability
Control	8.4	8.6	8.5	8.6	8.5
A	7.0	7.3	8.0	7.9	7.6
B	7.2	7.1	6.4	7.0	6.9
C	6.3	6.0	2.0	3.1	4.3
D	4.7	4.6	5.8	5.6	5.2
E	4.8	4.5	5.9	6.0	5.3
F	8.5	8.5	8.8	8.7	8.6

* For explanation, see table (1)

+ Values are the average of scores given by panelists on a 9 points hedonic scale

KCl) , E (50% NaCl + 50% KCl + liquid smoke) , D (50% NaCl + 50% KCl + citric acid) and C (100% KCl) respectively .It was evident that citric acid and liquid smoke reduced the pH and accordingly might affect the properties of D and E samples and therefore , D and C samples recorded the lowest scores respectively . Replacement of all the NaCl with KCl (in C sample) affected the taste and flavor negatively ,this might be due to the bitter taste of KCl used at high level. However , onlyKCl appears to offer the best alternative for replacing NaCl because it is currently generally recognized as safe (GRAS) for use in processed meats but with exception its effect on flavor (Terrell ,1983) therefore replacement 50 % of NaCl with KCl and the use of a special blend of spices and herbs (F sample) recorded the highest scores and offered the best solution that is called "the multiple solution". This means that altering processing techniques ,partial replacement of NaCl with KCl ,using special blends of spices and herbs , and using other compounds such as phosphates may provide the best solution to reduce sodium content of meat products with retention of the properties of high-sodium meat products .

Moreover , the same panelists were used to find out the best products and testing the significance between all the products according to the ranking method and critical differences of Basker , 1988 . Results of ranking method and critical values of reduced – salt beef patties as affected by reduction and substitution of sodium are given in Table (5). It could be noticed that F samples had the lowest sum of ranks (28) followed by control (32), A (66), B (74) , E (108), D (112) and C (140) .The lowest sum of ranks means the best product, therefore, the best product was recorded for F sample followed by control, A , B , E , D then C respectively . On the other hand , according to the critical difference at significance level of 0.05, it could be reported that no significant differences was recorded between F ,control and A samples. At the same time, there were significant differences between F sample and B, E, D and C samples as well as between control and the previously mentioned samples, at level of 0.01 of significance . However, NaCl could be reduced with about 35% (A sample) than that found in control (100% NaCl) with little changes of sensory properties of samples but, replacement 50% of NaCl with KCl without other additives (B sample) resulted in some bitter taste, while, replacing 50% of NaCl with KCl and the use of a special blend of spices and herbs and some potassium pyrophosphate (F sample) recorded the best solution

Table 5. Results of ranking method and critical differences + of reduced - salt beef patties as affected by reduction and substitution of sodium . (at zero time)+

Samples *	Control	A	B	C	D	E	F
Sum of ranks	32	66	74	140	112	108	28
Difference Vs: Control	—	34	42	108	80	76	4
A	—	—	8	74	46	42	38
B	—	—	—	66	38	34	46
C	—	—	—	—	28	32	112
D	—	—	—	—	—	4	84
E	—	—	—	—	—	—	80
Significance Level	P = 0.05				P=0.01		
Critical difference	40.3				47.2		
Products arranged Descendingly							
F	a				a		
Control	a				a		
A	ab				abc		
B	bcd				abc		
E	cde				bcd		
D	de				cd		
C	e				d		

* For explanation, see table (1)

+ The lowest sum of ranks = the best product.

+ In the same column, samples differ significantly when it has different letters.

for reducing the sodium chloride content in beef patties without undesirable effect on its optimum attributes .

4. Effect of frozen storage on some physico - chemical and microbial properties of reduced - salt beef patties as affected by reduction and substitution of sodium :

To determine the shelf - life and safety of reduced - salt beef patties as affected by reduction and substitution of sodium, some physico - chemical and microbial properties were studied during storage at - 18 °C for three months . From the results given in table (6), it could be noticed that TBA increased with increasing of storage period but at different rates . The TBA of control increased at the rate of 83% by the end of storage while it increased at the rates of 74, 78, 79, 55, 41 and 47% of A, B, C, D, E and F samples respectively . These results of T.B.A were confirmed by the finding of Terrell *et al.*(1984) who reported that increased NaCl levels enhance the development of oxidative rancidity (higher TBA number).At the same time , the effect of liquid smoke, citric acid and spices and herbs blend in reducing the development of oxidative rancidity of E, D and F samples respectively was evidently observed, however, citric acid and liquid smoke affected the physical and sensory properties. The pH values of samples slightly increased (about 0.2 - 0.4) by the end of storage at - 18 °C for 3 months . With respect of microbial properties during storage period, reducing or substituting NaCl slightly increased the bacterial load while using liquid smoke, citric acid and spices and herbs blend decreased the bacterial load but using citric acid and liquid smoke in D and E treatments affected the physical and sensory properties (tables, 2,4 and 5) negatively . Accordingly, F sample was considered the best because it improved the physical and sensory attributes and reduced the microbial growth, therefore shelf life will be longer .In connection to safety, *Salmonella* and *E. coli* were not detected at any time of storage period for all the samples while *staph. aureus* was detected at low counts in control, A, B, and C samples at the end of storage period (3 months).

Generally, to produce reduced - salt beef patties (reduced sodium) and subsequent overcome the hypertension associated with excessive intake of sodium, no single solution may exist for optimization of all functional and economic parameters when NaCl levels in processed meat are reduced . A multiple solution of partial replacement

of NaCl with KCl, using phosphates, herbs and spices blends, ascorbic acid and altering processing techniques may provide the best solution in this investigation, and therefore, F treatment may be suggested for production on commercial scale.

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تأثير تقليل واستبدال الصوديوم علي خصائص أقراص اللحم البقرى المنخفضة الملح

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يعتبر ضغط الدم المرتفع المساهم الرئيسي لحدوث النوبة القلبية ، السكتة والفشل الكلوي ، وهناك ارتباط تام بين ضغط الدم المرتفع واستهلاك الصوديوم ،كما أن معدلات استهلاك الصوديوم قد فاقت حاليا المعدلات الآمنة إلى حد كبير ، لذلك مطلوب تقليل أو استبدال الصوديوم في الأغذية المصنعة لكن مع المحافظة علي الخصائص المثلي المرغوبة لهذه الأغذية خاصة منتجات اللحوم المصنعة.

في هذه الدراسة تم تصنيع أقراص اللحم البقرى الكنترول(١٠٠٪ ص كل)، A (٦٥ ٪ ص كل)، B (٪ ص كل + ٥٠ ٪ بو كل)، C (١٠٠٪ بو كل)، D (٥٠ ٪ ص كل + ٥٠ ٪ بو كل مع المعاملة بحمض الستريك) ، E (٥٠ ٪ ص كل + ٥٠ ٪ بو كل مع المعاملة بسائل التدخين) ، F (٥ ٪ ص كل + ٥٠ ٪ بو كل مع المعاملة بخلطة خاصة من التوابل والأعشاب) وتم تخزين هذه المنتجات بالتجميد علي -١٨°م لمدة ٣شهور . وقد تم محتوي الصوديوم ومحتوي البوتاسيوم والخصائص الطبيعية الكيميائية والميكروبية للعينات كما تم تقيم هذه العينات من الناحية الحسية وكذلك اختبار المعنوية بينها جميعا . كذلك تم تقييم تأثير التخزين بالتجميد لمدة ٣ شهور عتي بعض الخصائص الطبيعية الكيماوية والميكروبية لهذه العينات لمعرفة مدة الصلاحية ومدي أمان هذه المنتجات .

وقد أوضحت النتائج أنه لا يوجد حلا فرديا للحصول علي خصائص مثالية لأقراص اللحم البقري عند تقليل مستويات كلوريد الصوديوم بها وأن الحل المتعدد كاستبدال ٥٠ ٪ من كلوريد الصوديوم بكلوريد البوتاسيوم مع استخدام خلطة خاصة من التوابل والأعشاب مع استخدام بيرو فوسفات البوتاسيوم وحمض الأسكوربيك هو الأحسن في ظروف البحث الحالي وينطبق ذلك علي المعاملة F والتي يمكن أن تكون مقترحة للإنتاج التجاري .