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Water activity and Hunter colour values of beef patties extended with Samh (*Mesembryanthemum forsskalei* Hochst) flour

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Abstract

Ground beef patties with or without 3.5% soy protein concentrate (SP), 10 and 20% Samh (*Mesembryanthemum forsskalei* Hochst) flour (SF) were packaged in foam trays, over-wrapped with polyvinyl chloride (PVC) film and displayed refrigerated at $3 \pm 1°C$ in a retail case for 0, 2 and 5 days. At the end of each displaying period, different raw patty characteristics were studied. Initially, i.e. day 0 of display, ash content of the patties increased significantly ($P < 0.05$) with the extension of the beef patties with SP or SF. On the other hand, moisture content and water activity (a_w) decreased ($P < 0.05$) as a result of the addition of SP or SF to the beef patties. SF was more effective in reducing a_w than SP. Hunter colour a^* value and saturation index (SI) decreased with the incorporation of SP or SF in the beef patties; however, Hunter colour L^* and b^* values showed no or minimal changes with such incorporation of SP or SF. Saturation index (SI) and hue angle decreased and increased, respectively, with the extension of the beef patties with SF or SP. Irrespective of the treatments, most of the parameters mentioned above were significantly ($P < 0.05$) affected by the display period.

1. Introduction

Addition of non-meat proteins, such as whey or SP, to formulated meat products has been widely practised by meat processors. However, other plant proteins such as oat, corn germ and wheat germ protein were found able to provide functional properties and were recommended in the production of meat products (Berry, 1990; Comer & Wojtas, 1988; Lapvetelainen, PurLanne & Solovaara, 1994; Lin & Zayas, 1987). Several investigators studied the effects of such additions. McCord, Smyth and O'Neill (1998) observed that such an addition has a marked effect on the gel strength of salt-soluble muscle proteins. Berry (1990) concluded that inclusion of soy in beef patties reduced many of the negative effects of storage on quality. Beef patties extended with 20 and 30% corn germ protein flour (CGPF) had lower total heating losses, higher cooked yield, lower protein content with no effect on the amino acid composition, increased water holding capacity and increased fat and water retentions (Brown & Zayas, 1990).

Samh (*Mesembryanthemum forsskalei* Hochst) is an interesting cereal crop that grows naturally and is widely distributed in the Northern province of Saudi Arabia. Botanically, Samh plants belong to the family Aizoaceae in the flora of Saudi Arabia. Samh is an annual papillose herb, very succulent, erect or ascending with stems 10–25 cm high. Seeds from the Samh plant are collected by the Bedouins and ground into a flour to make bread. Compositional data reveal that SF has a higher concentration of protein (≅ 22.0%) and is rich in essential amino acids such as lysine, methionine and threonine which are lacking in many other cereal proteins (Al-Jassir, Mustafa & Nawawy, 1995). In addition, SF has high fibre and fat contents. Generally, Al-Jassir et al. concluded that SF had a high nutritional value. In spite of these interesting qualities and its wide distribution in the Northern province of Saudi Arabia, particularly the Tabarjal area in the Al-Jouf region, SF is used almost exclusively for bread-making in this region and only one study has been carried out to promote its use in food formulation.

One potential use for SF is as an extender of ground meat; however, no information is available concerning the actual effects that this additive would have on the characteristics of ground meat products. Therefore, this study was designed to investigate the functional properties of whole SF added in the formulation of beef

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patties and compare them with that of SP. Accordingly, SF and SP were used at two and one level of extension to study their effects on water activity and colour properties of beef patties.

2. Materials and methods

2.1. Materials and patty formulations

Samh seeds (*M. forsskalei* Hoechst) were obtained from Tabarjal, Al-Jouf region, in the Northern Province of the Kingdom of Saudi Arabia. SP concentrate was obtained from Dan Protex H-47, Central soya Aarhus A/S, Denmark through Halawani Brothers Ltd. Com., Jeddah, Saudi Arabia. Fresh beef meat loins and round (without knuckle) were purchased from Al-Hofuf Central Meat Market in the Eastern Province. All subcutaneous and intermuscular fat, as well as thick, visible connective tissue, was removed from the meat. Lean meat and fat trimmings were ground, well homogenized and equally divided into four portions. Each portion was assigned randomly to one of the following treatments: (1) control, i.e. without additives; (2) one portion was extended with 3.5% rehydrated SP concentrate; (3) one portion was extended with rehydrated SF at a level of 10%; (4) one portion was extended with rehydrated SF at a level of 20%. Each portion was reground and processed into patties (9 cm in diameter, 80–82 g in weight) using a hand operated patty machine. Patties were then packaged in groups of two in foam trays, overwrapped with thin polyvinyl chloride film (PVC) and displayed refrigerated at $3 \pm 1°C$ for a period of up to 5 days.

2.2. Colour measurement

Patties were assessed at 0 day (i.e. immediately after formulation and shaping into patties) and after 2 and 5 days of refrigerated display. The colours of the patties were measured objectively using a Hunter Lab colour measurement device (Hunter Colour Quest 45/0, Hunter Associates Laboratory, Reston, VA. USA) to measure Hunter values L^*, a^* and b^*. These values were then used to calculate the saturation index and Hue angle according to Little (1975) as follows:

$$\text{Saturation index}: \text{SI} = (a^2 + b^2)^{1/2}$$

$$\text{Hue angle}: H = \frac{(\tan^{-1} b/a) \times 180}{\pi}$$

2.3. Water activity measurements

Water activity reflects the active part of the moisture content as opposed to the entire moisture contents of a product . The water activity of two patties from each treatment, at the end of each display period, was determined with the A2101 water activity meter (Rotronic, USA) which is a combination of a ventilated humidity and temperature probe (AWVC) with a micro processor-based indicator (AW Quick).

2.4. Proximate analysis

Moisture, protein, fat and ash contents of raw and cooked beef patties at each display period were determined according to the AOAC procedures (AOAC, 1995).

2.5. Statistical analysis

The data collected from the different treatments were subjected to analysis of variance and, whenever appropriate, the mean separation procedure of Duncan was employed (Steel & Torrie, 1980). The SAS program (SAS, 1988) was used to perform the GLM analysis.

3. Results and discussion

3.1. Raw material composition

The proximate composition of Samh flour (SF) and soy protein concentrate (SP) are presented in Table 1 The two products compare favourably with regard to moisture and ash contents; however, SP concentrate had a much higher protein content than SF. On the other hand, SF had higher carbohydrate, fat and fibre contents than SP. Differences observed in proximate composition could be explained simply by the fact that SF was obtained by grinding samh seeds, without any further processing, to extract fat or carbohydrate. If the two products are compared on an equal basis of carbohydrate, fat and fibre contents, the two products could have had similar protein contents. Addition of SF at the 10% level to the beef patty added 2.2% protein, which compared favourably to that added by SP concentrate

Table 1
Proximate composition and pH of SF and SP concentrate

Parameter	SF	SP concentrate
Ph	6.26	6.35
Protein (%)	22.0	63.6[a]
Moisture (%)	6.00	8.00[a]
Carbohydrate (%)	52.3	18.4[a]
Ash (%)	6.0	5.5[a]
Fat (%)	4.2	0.5[a]
Fibres (%)	9.5	4.0[a]

[a] According to Dan Protex H-47, Central Soy Aarhus A/S, Denmark.

at 3.5% level. The pH values of SF and SP slurry are very similar. When the colours of rehydrated SF and rehydrated SP concentrate were compared, the latter had higher L^*, b^*, SI and hue angle values (Table 2) SF had higher a^* and lower hue angle values than SP.

3.2. Proximate composition

Addition of SP or SF significantly ($P<0.05$) altered the moisture content of the raw beef patties (Table 3), probably due to increased solids contents. The addition of 10 or 20% SF was more effective in reducing the moisture contents of raw beef patties than SP. (Boyle et al. (1993)) observed that 20% dried beef heart meat or glycerol were most effective in reducing the moisture content of alginate structured beef heart products. Apparently, display period, within each treatment group, had no effects ($P>0.05$) on the moisture, protein, ash or fat contents of the raw beef patties (Table 3). The ash and fat contents of raw beef patties increased slightly with the addition of SP or SF. The ash content of the raw beef patties extended with 20% SF almost doubled when compared with that of the control.

Table 2
Colour values, saturation index and Hue angle of SF and SP concentrate.[a]

Parameter	SF	SP concentrate
L^*	44.71	52.27
a^*	9.81	9.28
b^*	17.40	25.80
Saturation index	19.97	27.42
Hue	60.59	70.22

[a] $n=2$.

3.3. Water activity (a_w)

Meat, SF and SP concentrates are hygroscopic products that may absorb water in different ways, such as sorption with formation of a hydrate, binding by surface energy, or diffusion of water molecules within their structure. Accordingly, water is bound to them with more or less strength. It is well known that moisture content of a meat can include both an immobilized part, e.g. water of hydration, and an active part which, under normal circumstances, can be exchanged between the meat and its environment. The a_w (Table 3) of the control patties at day 0 of display (i.e. immediately after formulation and forming) was significantly higher ($P<0.05$) than all the other treatments (3.5% SP, 10% SF or 20% SF). Patties extended with SF (irrespective of the level) had an a_w that is lower than that of SP at day 0 of display. This may indicate that SF bound water to the patties much more strongly than SP. Also, it is to be noted that the a_w of the control patties decreased with display period, while the opposite was true for the patties extended with SF or SP. However, the a_w of 3.5% SP and 10% SF patties increased from day 0 to day 2 of the display period but thereafter plateaued until the end of the display period. The a_w of patties extended with 20% SF showed continued increase until the end of the display period. Addition of SF at both levels achieved an a_w level less than 0.95 (actually 0.94 and 0.93 for the 10 and 20% SF, respectively) while the a_w of patties extended with SP was about 0.95. (Leistner and Rodel (1975)) concluded that, for a product to be shelf stable, its a_w must be $\leqslant$ 0.95 in combination with other parameters. Lowering the a_w to $<$ 0.90 reduces risk of microbial spoilage; however, none of our treatments achieved that level.

Table 3
Proximate composition and water activity (a_w)[a] of raw beef patties with or without SF or SP concentrate displayed refrigerated for up to 5 days[b–d]

Treatment	Display period (days)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	a_w
Control	0	72.96aA	20.9aA	5.04aA	1.10aA	0.973aA
	2	72.59eA	20.7bA	5.57cA	1.10cA	0.962dB
	5	72.66hA	20.9cA	5.35eA	1.10fA	0.950fC
3.5% Soy protein (SP)	0	71.38bB	21.3aB	6.11 bB	1.26aB	0.948bA
	2	71.57eB	21.1bB	5.94dB	1.31cB	0.953eA
	5	71.98hB	20.8cB	5.97fB	1.28fB	0.952fA
10% Samh flour (SF)	0	68.12CC	20.4aC	6.24 bC	1.70bC	0.940cA
	2	68.38fC	20.6bC	6.00dC	1.63dC	0.954eB
	5	68.83IC	20.4cC	6.13fC	1.65gC	0.954fB
20% Samh flour (SF)	0	62.80dD	20.5aD	6.27bD	2.12bD	0.938cA
	2	62.53gD	20.4bD	6.19dD	2.20eD	0.955eB
	5	62.65jD	20.6cD	6.34fD	2.20hD	0.962gC

[a] a_w = water activity.
[b] $n=3$.
[c] Means in the same column for the same display period bearing different lower case letters are significantly different ($P<0.05$).
[d] Means in the same column within each treatment group bearing different upper case letters are significantly different ($P<0.05$).

3.4. Colour evaluation

The effects of addition of SF or SP on the colour of raw beef patties displayed chilled for a period of up to 5 days are shown in Table 4. Few differences were found among raw beef pattie's treatments in Hunter colour L^* values. Initially (day 0) raw beef patties extended with 20% SF are slightly lighter ($P<0.05$) than all the other treatments (control, 3.5% SP and 10% SF), a result which is difficult to explain in the light of the result presented in Table 2 concerning L^* value of SF. No changes ($P>0.05$) in Hunter colour L^* values were found for raw beef patties extended with SF over the 1st days of display. Hunter colour a^* values (redness) of the control and 3.5% SP treatments were significantly higher ($P<0.05$) than those of the 10 and 20% SF treatments. The 20% SF treatment had the lowest redness reading among all the treatments followed by the 10% SF whereas the control and 3.5% had similar ($P>0.05$) a^* values. The a^* value of broiled beef patties extended with corn germ protein flour (CGPF) decreased as the level of CGPF increased (Brown & Zayas, 1990). Within each treatment group a^* values decreased ($P<0.05$) over the display period. Initially (day 0) all the treatments, with the exception of the 20% SF treatment, had similar b* values. The 20% SF beef patties had the lowest b^* value. Gnanasambandam and Zayas (1992) observed that all beef (control) comminuted meat products had higher b^* values than samples containing wheat germ protein flour or SP flour. For the first two days of display, the b^* values of the 20% SF treatment showed no change. However, thereafter, the b^* values decreased. The b^* value of the other treatments decreased with the increases in the display period. In conjunction with Hunter colour L^*, a^* and b^* values, saturation index and hue angle can improve our understanding the changes in the colour of the patties as a result of the main effects, i.e. treatments and display period. Hue angle is the attribute of colour perception by means of which an object is judged to be red, yellow, green, blue or purple, while saturation index is the attribute of colour perception that expresses the degree of departure from the grey of the same lightness. Generally, saturation index and hue angle (Table 4) decrease and increases, respectively, with the extension of the beef patties with SF or SP. Apparently, saturation index and hue angle decrease and increases ($P<0.05$), respectively, over the display period, the only exception being the SI of the 20% SF treatment decreased numerically ($P>0.05$) in the first 2 days of display. At any one given display period, the saturation index and hue angle of the control patties and 3.5% SP patties are similar ($P>0.05$). However, beef patties extended with SF have saturation indices and hue angles, at any one given display period, that are significantly different from those of the control patties or the 3.5% SP patties. Initially the control patties had higher and lower Hunter colour a^* values and hue angle (Table 4), respectively, than those of the other treatments (3.5% SP, 10% SF and 20% SF), indicating a higher redness. Additionally, and as indicated early, change in b^* value was found to be minimal among the treatments with the exception of the 20% treatment. Accordingly the observed change in the colour of the raw beef patties extended with SP or SF is caused by dilution of meat pigments in the patties. The effects of SF on the parameters of beef patties,

Table 4
Effect of different additives on the colour of raw beef patties displayed chilled for a period upto 5 days.[a–d]

Display period (days)	Colour value	Control	3.5% Soy protein (SP)	10% Samh flour (SF)	20% Samh flour (SF)
0	L^*	30.82 (0.38)aA	31.27 (0.24)aB	31.12 (0.14)aC	32.15 (0.24)bD
	a^*	20.01 (0.61)aE	19.04 (0.30)bE	16.25 (0.11)cE	12.94 (0.38)dE
	b^*	18.00 (0.63)aF	17.32 (0.39)aF	17.46 (0.19)aF	15.07 (0.07)bF
	Saturatian index	26.84aK	25.74aK	32.85bK	19.86cK
	Hue angle	41.94aN	42.30aN	47.07bN	49.36cN
2	L^*	31.81 (0.08)aA	31.65 (0.05)aB	23.09 (0.28)aC	32.08 (0.34)aD
	a^*	16.35 (1.22)aG	16.30 (0.36)aG	13.23 (0.74)bG	11.42 (0.51)cG
	b^*	16.90 (0.71)aH	16.46 (0.69)aH	16.19 (0.25)aH	15.45 (0.39)bF
	Saturation index	23.51 aL	23.12aL	20.91bL	19.21 cK
	Hue angle	45.98 aO	45.17aO	50.76bO	53.55cO
5	L^*	30.38 (0.26)aB	30.38 (0.05)aC	30.37 (0.41)aC	32.15 (0.24) bD
	a^*	10.59 (0.97)aI	9.81 (0.64)aI	9.92 (0.28)aI	12.94 (0.39) bE
	b^*	15.73 (0.99)aJ	13.84 (0.06)bJ	14.37 (1.74)bJ	13.28 (0.27) bcJ
	Saturation index	18.96aM	16.97bM	17.47 cM	13.28 dN
	Hue angle	56.08aP	54.69bP	55.24 bP	55.27 bP

[a] $n=3$.
[b] Values in parentheses are S.D.
[c] Means in the same column for the same colour value bearing different upper case letters are significantly different ($P<0.05$).
[d] Means in the same row bearing different lower case letters are significantly different ($P<0.05$).

measured in this study, followed a trend similar to that of SP. However, further studies are needed before SF is proposed to be a substitute for SP in meat formulations.

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