ISSN: 2577-4182

Madridge Journal of Food Technology

Research Article

Open Access

Evaluation of Mustard powder as natural ingredient to reduce antimicrobial levels and physichochemical properties in beef

Amir Hosseinvand[1]* and **Adeleh Sorkhinejad**[2]

[1]*Department of Agriculture, Islamic Azad University of Shahr-e-Qods branch, Tehran, Kalhor BLVD, Shahre Qods City, Tehran province, Iran*
[2]*Department of chemistry, Islamic Azad university of Karaj branch, karaj, Iran*

Article Info

***Corresponding author:**
Amir Hosseinvand
Department of Agriculture
Islamic Azad University of Shahr-e-Qods branch
Tehran, Kalhor BLVD, Shahre Qods City
Tehran province, Iran
Tel: +989123033161
E-mail: Amir.Hosvnd@yahoo.com

Received: February 2, 2019
Accepted: May 6, 2019
Published: May 13, 2019

Citation: Hosseinvand A, Sorkhinejad A. Evaluation of Mustard powder as natural ingredient to reduce antimicrobial levels and physichochemical properties in beef. *Madridge J Food Technol.* 2019; 4(1): 171-176.
doi: 10.18689/mjft-1000126

Published by Madridge Publishers

Abstract

Nowadays, Most of people would passion to using and purchase organic and natural foods without any artificial ingredients. Moreover, Mustard used in produce medicine, pickles, source of edible oil since ancient times, seasoning of meats and chicken. So the present study was undertaken to determine chemical components of mustard powder, and then used it in grilled beef as a seasoning to improve sensory evaluation, and physicochemical properties, as well as inhibited Escherichia coli, Staphylococcus aureus and increase shelf life of meat. The results indicated that added mustard powder improving sensory evaluation of the grilled meat slices significantly, especially in odour, in the acceptability of meat treated with 2% level of mustard powder. Meanwhile, addition of mustard powder to fresh meat reduced the natural flora to undetectable levels at 4 or 30 °C till 2days from storage. Application of mustard powder was able to reduce E.coli numbers to uncountable levels at zero time during keeping samples.

In view of pH, TBA and TVN values, all of the grilled meat slices with added mustard powder decreased by increasing level on mustard powder concentration during storage times. Mustard powder at 2% level has antibacterial, anti- microflora, natural preserve spices in food, improve taste, smell and physical properties of meat and increase shelf life of meat. Finally mustard powder is acceptable to use as spice and natural ingredient to reduce antimicrobial loading in foodstuff. Further study in this area may be helpful for finding of new principle compound.

Keywords: Mustard powder; Antimicrobial; Physicochemical; Meat; E.coli.

Introduction

The most important Food-borne diseases, it is caused by agents such as (*E.coli, Salmonella,* and *Staphaureus*) that enter the body through the intake of contaminated food materials are one of the primary public health concerns in the world [1]. In present study, application of Yellow mustard seed (Sinapisalba L.) as natural ingredient was studied in beef. There is little published data in the literature on application of natural and functional antibacterial ingredients in food science. White and red meats were one of the principal food stuff in human meals. The mustard seed is a source of natural antioxidants such as; tocopherole, compounds of hydroxyl benzoic family, Trihydroxy phenolic compounds like flavones, flavonols (kaemferol, isorahmnetin) and ascorbic acid which protect oil from rancidity in emulsion. Moreover, this plant can be a good source of active components such as, isothiocyanates,phenolics, dithiolthiones and dietary fiber [2-4]. Mustard powder contained higher amounts of protein 36.69% and oil 40.64%. Moreover, oil of mustard seed was contained high amount of erucic acid 51.3%, and the major dominant unsaturated fatty acids were, oleic acid followed by linoleic and linolenic acids.

The objective of the present research was to reduce bacterial loading of E.coli and Staphylococcus aureus in grilled beef with mustard powder as antibacterial seasoning, and then assessment of addition of yellow mustard powder on some physicochemical properties on beef.

Materials and Methods

Chemical composition of mustard seeds powder

The analysis of moisture, ash, total carbohydrates, crude protein, crude fiber and fat were determined for the dried mustard seeds powder is described by the [5].

Determination of FA content

Fatty acid content of samples was determined by GCŽ. CarloErba Fractovap after KOH methanol hydrolysis and BF derivation. Supelco wax 10column capillary Ž3 length 15m, diameter0.25 mm, film thickness 25m. The temperature of the injector and detector was 225^{O}C [6].

Ground beef and mustard powder preparation

Fresh beef was purchased from local butcher shop the day before each experiment. The meat was stored at 4^{O} Cover night. Also, all of meats were kept at-18˚C for 3h, until the outer surface was frozen. Ground beef was prepared using aseptic procedures, sterile utensils and sanitized equipment. The meat was cut into 5X5cm pieces, each on equal 100gm, and then held it 4^{O}C for 1hour. After that inoculated with bacterial strains and treatment with mustard powder. In the present study the Sinap is alba seed (yellow mustard) spicy were collected from local market in Tehran, Iran. The seed was cleaned and grained to get mustard powder rich with active components. Antibacterial effects of mustard powder were one by well diffusion method. Whereas, it was showed antibacterial activity against *E.coli & Staph.aureus* with 28&22 mm zone inhibition, respectively.

Sensory evaluation

The fresh beef used was previously described. For control sample, 2gms alt was added to each piece. For treatment samples 2 gms alt plus different concentrations of mustard flour with 0.5,1.0,1.5,2.0 and 2.5% levels. All samples were cooked on grilled at 200^{O}C until the internal temperature reached to 71^{O}C. Grilled meats were kept at 60^{O}C until they were served to the panelists. Sixty staff at the food technology research institute who had received no formal training in sensory evaluation participated. Panelists were 30-60 years old and 75% were female. Each panelist received three 10gm samples of grilled beef in a container coded with a randomly chosen three digit number, plus water. The panelists tasted samples and recorded the overall acceptability of each treatment product according to colour,smell,flavor and consistency. The experiments were repeated at least five times [7].

Bacterial strains

For this research, two reference strains *Staphylococcusaureus* ATCC 25923 and *E.coli* ATCC 25922 were obtained from microbial culture collection, Department of Microbiology, Faculty of Agriculture, Tehran University, Tehran, Iran. Strains were Activate on nutrient broth(NB) at 37°C for 24h.

Effect of mustard powder on bacterial counts in meat slices

This experiment was divided into two parts; first part meat slices were thawed at 4^{o}C overnight, then adding 0.5, 1.0,1.5,2.0 and 2.5% levels of mustard powder and salt before grilling. Total count (natural flora) of each sample was evaluated before and after treatment (seasoning) and stored for 2days at 4^{o}C or 30^{o}C. Second part, grilled meat slices, then adding 0.5,1.0,1.5,2.0 and 2.5% mustard powder and salt plus inoculation with 0.5ml (1×10^{5}cfu/ml) reference strains. All samples were kept in aluminum foultrays under sterilize conditions for 24hours at 4^{o}C or 30^{o}C. Total bacterial counts were determined periodically after 0,1,2,3 and 6 days according to the procedure mentioned by APHA(1971). In addition, salt was added in testifier samples.

Physical properties

pH Value

pH value of meat product samples was examined according to the method as reported by Ockerman (1985).

Chemical properties

Determination of total volatile bases Nitrogen (TVB-N)

Total volatile nitrogen was determined according to the method described by (Winton andWinton, 1958). The milligrams of TVB-N per 100gm sample were obtained by number of milliliters of bound acid x 7.0.

Determination of Thiobarbituric Acid Value (TBA)

Malonaldehyde (The compound used as an index of lipid per oxidation) was determined following the procedure of Egan et al. (1987). TBA value was expressed as mg malonaldehyde/kg sample by using the following equation.

TBAvalue (Mg malonaldehyde/kg sample)=absorbance x 7.8

Statistical analysis

The data obtained from treatments were analyzed by one-way ANOVA using 'Proc Mixed' (SAS8.2,Cary,NC,USA). In all cases, the level of statistical significance was of $P<0.05$. SAS program was used to statistical analyzed (SAS2001) LSD means comparisons were conducted with the duncan option in SAS.

Results & Discussions

Physicochemical composition

The proximate analysis of beef samples with and without mustard powder with different concentrations presented in Table 1. Mustard powder is contained a large amounts of both protein and oil contents. It could be also observed that, Mustard flouris containing an adequate percentage of ash, dietary fiber and total carbohydrates [8-10].

The fatty acids composition of yellow mustard seeds oil was determined by gas chromatographic analysis, then presented data in Table 1. It is clearly from result, erucic acid (C22:1) was most predominant fatty acids in mustard seed oil,

which it was represented~51.03%. Mustard oil rich in erucic acid is considered undesirable and indigestible for human or animal organisms. It could be remarked that mustard seed oil contained a little amounts from total saturated fatty acids determined with~ 6.93% as compared to the other edible oils. These results are [11] whereas they were recommended that mustard oil has low saturated fat as compared to other cooking oils [12]. In contrary, the total unsaturated fatty acids in mustard seeds oil were considerable a highly amount, which represented~85%. The major types of unsaturated fatty acids were namely; Oleic, linoleic, linolenic and gadoleic acids were. In addition, linoleic acid and linlolinic were the most prevalent unsaturated fatty acids, and it is the most important of the essential fatty acids. These results are in accordance with the data previously obtained [10,13].

Table 1. Percentage of chemical composition and fatty acid of mustard flour content

Components %			Fatty acids%(g/100g)		
Saturated fatty			Unsaturated fatty acids		
Moisture	1.78 2.27	Palmitic C16:0 2.27	Erucic	C22:1	51.03
Protein	42	Stearic C18:0 0	Palmitoleic	C16:1	0.04
Ash	4.42	Lignoceric C24:0 0.94	Oleic	C18:1	8.08
Crude oil	40.64	Arachic C20:0 1.062	Nervonic	C24:1	2.27
*Carbohydrate	40.64	Behenic C22:0 1.58			

*Carbohydrate is calculated by difference

All components are determined on dry weight.

Sensory attributes

Sensory evaluation scores of the beef with and without mustard powder shown in Table 2. In this table, color, smell, flavor, consistency and over all acceptability of grilled meat slice samples are shown as effected by the different concentrations of yellow mustard powder (0.00%, 0.5%, 1.0%, 1.5%, 2.00% and 2.50%) and testifier samples. Along with the increase in mustard content from 0%to2.0%, all characteristics of sensory evaluation score improved considerably from 3.08 to 4.94. According to data,the sensory attributes has highly significant effects on smell of grilled meat slices were scored at 2.0% level of mustard powder. This result indicated to benefit of added yellow mustard as the strong flavoring component of meat slices. With the increase of mustard powder by 2.0%, the mean of flavors core increased to 4.94. The application of heating treatment in grilled meat slices led into myrosinase enzyme activation, Isothiocyanate reduction and thus reduction of pungent flavor in mustard powder. The results were not in line with the findings of [14-16], they were stated that, may on naise, containing mustard powder gave a higher smell in comparison with the samples, containing mustard powder and control sample. They explained that in higher concentrations of the yellow mustard powder, this proliferation causes a pungent flavor in may on naise. It was a result of an increase in the content of isothiocyanate, following the activity of myrosinase enzyme in mustard powder. So use of heating treatment and the production of mustard powder improve the smell of final product.

Table 2. Sensory attributes of grilled meat slices with mustard powder %

Samplese	Colour	Smell	Flavour	Consistency
0	3.08±.03	3.08±.03	3.08±.03	3.54±0.20
0.5	$3.64\pm0.18^{a**,c,d***}$	$3.78\pm0.25^{a**,c,d***}$	3.58±0.25	$3.82\pm0.16c^{**,d***}$
1	$3.80\pm0.27a^{*,*a,d**}$	$3.50\pm0.24^{c,d***}$	3.82±0.28,d**	3.64±0.22c*,d**
1.5	$4.42\pm016.^{a,b,e***}$	$4.66\pm0.18^{a,b,c,e***}$	$4.00\pm0.28,a^{***},d^{**}$	$4.38\pm0.18^{a,e***,b*,c,**}$
2	$4.76\pm0.19^{a,b,c,e***}$	$4.94\pm0.04^{a,b,c,e***}$	$4.66\pm0.1^{a,b,e***,c,**}$	$4.30\pm0.18^{a,b,c,e***}$
2.5	$3.28\pm0.19^{d***}$	$3.34\pm0.17^{d***}$	3.40±0.18	$3.89\pm0.17^{d***}$

Values are expressed as means ± SE. (Standard Error of the Mean) of the three replicates).a: significantly different from the control group;b: significantly different from the concentration. 5%c: significantly different from the concentration 1%.d: significantly different from the concentration 1.5%e: significantly different from the concentration 2%. Asterisk indicate the level of significance (*p >0.05; **p0.01 >***p >0.001.).

Influence of Mustard powder on Antimicrobial loading activities

From the obtained results in Figure 1, fresh meat was seasoning with mustard flour at 1.5 and 2.0% levels, it was able to reduce the natural flora to undetectable levels until two days of storage at different temperatures, while the control sample spoilage after 24h at 30°C. It is clearly from this study, when adding mustard powder to fresh meat slices; this preserved it from contamination and reduced the natural microfloa 2days before cooked at any temperature. This finding is in mutual and good agreement with [14], they reported that the increase in amount of mustard powder in may on naise leads into decrease in microbial population as compare as to control sample. It showed a decrease in microbial population with 68% in May on naise that containing1.5% mustard powder. Also, [17] concluded that, the natural anaerobic microflora in meat treated with 10%mustard powder was significantly lower on days 3,12 and 21storage as compared to control sample.

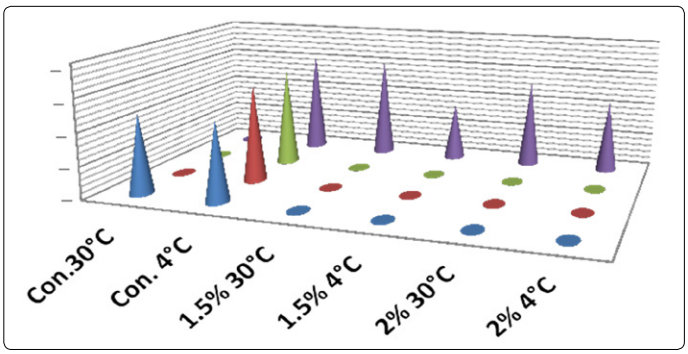

Figure 1. Effect of seasoning by mustard powder on the natural flora present in meat slices.

The antimicrobial effects of mustard powder on the each E.coli or Staph. aureus,when inoculated at 3.6 Log cfu/g in meat slices before grilled are As shown in Figure 2. Mustard powder 1.5 and 2% levels were able to reduce E.coli number

to uncountable levels at zero time and till 3 days at 4C. The same effect was scored by mustard powder at 2% level against Staph. aureus. Meanwhile, used low initial 3 log cfu/gm of E. coli O157:H7 was reduced to undetectable level after 18, 12 and 3 days with 5, 10, 20 % mustard flour the ground beef [17]. They also concluded that it is possible to use mustard powder at levels > of 5-10% to eliminate E.coli O157:H7 in fresh ground beef [18]. Inoculated 7.5 log cfu/g of E.coli with 4.4%(W/W) deodorized mustard powder was surface applied and monitored 80 days. At 21days bacteria was reduced by 3 log cfu/g as compared to control sample to only a 1 log cfu/g were reduction from cells[14]. They were summarized that, the higher concentration of yellow mustard, led to less the microbial population and the longer the shelf life of mayonnaise. At this present study cells Staph. aureus were less significant affect by mustard powder at 1.5% level than E.coli, it showed that reduced in their number by one log cfu/gm within 2days at 4°C. It is similarity to [19] they found that good antibacterial effect from mustard against Staph. aureus. Meanwhile, Gram-positive bacteria of Staph.aureus was found to be less susceptible to mustard powder in meat than E.coli. This results are not accordance with findings of other investigations [20] They pointed that, the Gram-positive bacteria of Staph. aureus was found to be more susceptible to spice samples, and explained this due to their structural features, are more susceptible to phenolic compounds than Gram negative bacteria.

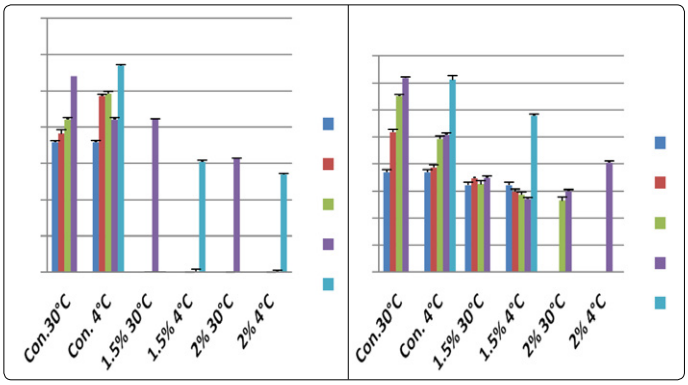

Figure 2. Effect of seasoning by mustard flour on the survival of inoculated bacteria in grilled meat slice

pH, TBA and TVN values

As well as, the results of pH, TBN and TVN measurement are showed in Table 3, Table 4 and Table 5. The pH in grilled meat slices inoculated with E.coli was ranged from 5.9 to 6.2 at 4°C and 30°C were with 1.5% and 2% levels of mustard Powder. These results were not significant difference ($P < 0.05$) than control sample. These results nearly agree with the results were scored by She deed, (1999) with value 6.10, [21] with value of 6.15. The lowest pH was revealed in grilled slices at 4°C treated with 1.5, 2% mustard powder till 6 days of storage and reached to 5.3, except samples kept at 30°C were spoilage after 6 days were shown in table 5. The decrease in pH value may be attributed to the breakdown of glycogen with the formation of lactic acid and, Poultry meat with a pH below 5.8 had a pale color. In conclusion mustard powder 1.5 and 2% levels used to kept the pH of grilled in ideal state till 6 days storage at 4C. This result could be used also if the meat was exposed to infected with pathogens. At this study, samples were treated by Staph. aureus plus mustard powder shown the idea pH ranged from(6.0-6.3) except, samples kept at 30°C were increase in pH (6.2-6.7) during the storage time. The increase of pH may be due to the partial proteolysis However, the ideal pH for meat is between 5.8 and 6.3 [22]. The meat with higher pH had dark color and has a great risk on human health. The TBA was lowest significant value ranged from 0.22 to 0.62 after 3 day of incubation at 30°C and 4°C; this result was the same obtained result from control samples. While the TBA value 2.5-1.9 were scored level higher than ideal value in grilled meat without any treatment. Moreover, TBA (mg%) in the grilled meat slices were decreased to the lowest significant value (0.62) at 2% mustard powder, 30 °C and 4°C till 6 days as compare to control sample(1.6). On the other hand, lower results were scored by [21,23] were ranged 0.119 mg and % 0.09mg % respectively. The oxidative rancidity in meat was evaluated by measuring malonaldehyde in fat meat with an improved thiobarbituric acid (TBA) assay with antioxidant protection Abd El-Kader, (1996). Value of TVN (mg%) in grilled meat slices treated with 2% mustard powder were decreased at different temperature. Furthermore, sample with 2% mustard powder kept at 4°C and inoculated with E.coli has low TVN value ranged from 5.2,7.3 after storage at 3,6 days respectively. Higher results were obtained by [23, 21] with TVN value of 9.11 and13.87 (mg%). Ammonia is one of the most spoilage end products in contaminated meat; it is an indicator for amino acid degradation by bacteria. So, it is directly pointer for spoilage odors and flavors [24-27]. The grilled meat without seasoning by mustard powder showed highly significant increase in physical properties after 3days of storage, and spoilage after 6 days [28-32].

Table 3. Physical properties of grilled meat slices with mustard flour and *E.coli*

Samples		pH				TBA%				TVN%			
		0	3	6	LSD	0	3	6	LSD	0	3	6	LSD
30°C	Control	6.06^{Aa}	6.20^{Aa}	6.25^{Aa}	0.22	0.32^{Ab}	0.43^{Ab}	1.64^{Aa}	0.23	8.40^{Ac}	10.50^{Ab}	14.00^{Aa}	0.06
	1.5%	6.01^{Ab}	6.06^{ABab}	6.20^{ABa}	0.17	0.22^{Bb}	0.29^{BCb}	0.94^{Ca}	0.10	6.65^{Bc}	9.10^{Bb}	11.55^{Ba}	0.98
	2%	5.99^{Ab}	6.02^{ABab}	6.09^{ABab}	0.09	0.18^{Cb}	0.23^{Cb}	0.87^{CDa}	0.05	4.90^{Cc}	5.95^{Cb}	8.05^{Da}	1.27
4°C	Control	6.06^{Ab}	6.09^{ABab}	6.19^{ABa}	0.12	0.33^{Ab}	0.38^{ABb}	1.12^{Ba}	0.06	8.40^{Ac}	9.10^{Bb}	11.55^{Ba}	0.90
	1.5%	6.01^{Aa}	6.02^{ABa}	6.07^{BCa}	0.14	0.217^{Bb}	0.27^{Cb}	0.77^{DEa}	0.08	6.65^{Bc}	8.40^{Bb}	10.50^{Ca}	0.90
	2%	5.99^{Ab}	5.99^{Bb}	6.00^{Ca}	0.01	0.18^{Cb}	0.219^{Cb}	0.64^{Ea}	0.07	4.90^{Cb}	5.25^{Cb}	7.35^{Ea}	0.57
LSD		0.10	0.44	0.124		0.01	0.09	0.15		0.36	1.13	0.51	

Table 4. Physical properties of grilled meat slices with mustard flour and *Staph.aureus*.

Samples		pH				TBA%				TVN%			
		0	3	6	LSD	0	3	6	LSD	0	3	6	LSD
30°C	Control	6.06^{Aa}	6.21^{ABa}	6.25^{Ba}	0.22	0.33^{Ac}	0.76^{ADEb}	1.64^{Aa}	0.23	8.4^{Ac}	10.5^{Ab}	14.0^{Ab}	0.06
	1.5%	6.02^{Ac}	6.27^{Ab}	6.85^{Aa}	013	0.28^{Bc}	0.44^{Cb}	1.067^{BCa}	0.15	7.3^{Bc}	9.8^{ABb}	11.9^{Ba}	0.98
	2%	6.01^{Ab}	6.19^{ABb}	6.73^{Aa}	0.23	0.22^{Cb}	0.28^{Db}	0.93^{CDa}	0.06	5.9^{Cc}	7.0^{Db}	9.8^{Da}	1.27
4°C	Control	6.06^{Ab}	6.09^{BCab}	6.20^{Ab}	0.12	0.33^{Ab}	0.38^{CDb}	1.12^{Ba}	0.06	8.4^{Ac}	9.1^{BCb}	11.5^{Ba}	0.90
	1.5%	6.02^{Aa}	6.03^{Ca}	6.09^{Ba}	0.08	0.28^{Bc}	0.57^{Bb}	0.84^{Da}	0.11	7.3^{Bc}	8.7^{Cb}	10.8^{Ca}	0.90
	2%	6.01^{Ac}	6.03^{Cb}	6.05^{Ba}	0.02	0.22^{Cb}	0.25^{Eb}	0.62^{Ea}	0.09	5.9^{Cc}	6.6^{Db}	8.4^{Ea}	0.57
LSD		0.08	0.14	0.28		0.04	0.12	0.15		0.41	0.95	0.36	

Table 5. Physical properties of grilled meat slices plus mustard flour.

Samples		pH				TBA%				TVN%			
		0	3	6	LSD	0	3	6	LSD	0	3	6	LSD
30°C	Control	5.46^{Ab}	5.80^{Aa}	Sp	0.20	0.07^{Ab}	2.59^{Aa}	sp	0.14	11.20^{Ab}	41.30^{Aa}	sp	1.58
	1.5%	5.26^{Bb}	5.31^{Ca}	Sp	0.03	0.06^{Ab}	1.95^{Ca}	sp	0.011	9.80^{Bb}	32.20^{Ca}	sp	1.58
	2%	5.10^{Bb}	5.13^{Ea}	Sp	0.01	0.04^{Bb}	1.72^{Da}	sp	0.06	8.40^{Cb}	24.85^{Da}	sp	1.68
4°C	Control	5.46^{Ab}	5.71^{Ba}	Sp	0.20	0.07^{Ab}	2.27^{Ba}	sp	0.481	11.20^{Ab}	34.30^{Ba}	sp	1.58
	1.5%	5.26^{Ba}	5.24^{Da}	Sp	0.03	0.06^{Ab}	1.268^{Ea}	sp	0.064	9.80^{Bb}	25.90^{Da}	sp	1.58
	2%	5.10^{Ba}	5.12^{Fa}	Sp	0.01	0.04^{Ab}	1.10^{Ea}	sp	0.225	8.40^{Cb}	20.30^{Ea}	sp	1.12
LSD		0.18	0.01	-		1.017	1.368	-		1.017	1.368	-	

Sp is spoil age sample

Conclusion

From the results of the present work, it can be conclude that mustard powder at 1.5 and 2.0% levels possessed good antimicrobial activity against natural microflora present in fresh meat, and reduced bacteria to undetectable levels until two days of storage at different temperatures, while the testifier sample was spoilage after 24h at 30°C. Moreover, at 1.5 and 2% levels from mustard powder were able to reduce E.coli number to uncountable levels at zero time and till 3 days of storage at 4°C, the same effect was scored by mustard powder 2% level against Staph.aureus.

References

1. Tan SL, Lee HY, AbuBakar F, AbdulKarim MS, Rukayadi Y, Mahyudin NA. Microbiological quality on food handlers'hands at primary schools in HuluLang at District, Malaysia. *International Food Research Journal*. 2013; 20(5): 2973-2977.
2. Hendrix KM, Morra MJ, Lee HB, Min SC. Defatted mustard seed meal-based biopolymer film development. *Food Hydrocolloids*. 2012; 26: 118-125. doi: 10.1016/j.foodhyd.2011.04.013
3. Honda T, Tatsuzawa F, Kobayashi N, et al. Acylatedantho cyanins from the violet-blue flowers of Orychophragonus violaceus. *Phytochemistry*. 2005; 66(15): 1844-1851. doi: 10.1016/j.phytochem.2005.05.026
4. Kirca A, Ozkan M, Cemeroglu B. Effects of temperature, solid content and pH on the stability of black carrot anthocyanins. *FoodChem*. 2007; 101(1); 212-218. doi: 10.1016/j.foodchem.2006.01.019
5. Association of Official Agricultural Chemists. Official Method of Analysis. 2nd Edition, AOAC, USA: Washington,
6. Xu X, Beardall J. Modification of fatty acid composition in halophilic anthracitic microalgea. *Phytochemistry*. 1997; 49: 1249-1252.
7. AMSA. Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Beef. *American Meat Science Assoc*. Chicago,U.S.A, 1995.
8. Cserhalmi ZS, Ma´rkus ZS, Czukor B, Bara´th A, To´th M. Physico-chemical properties and food utilization possibilities of RF-treated mustard seed. *Innovative Food Sci.and Emerging Techn*. 2000; 1: 251-254. doi: 10.1016/S1466-8564(00)00028-X
9. Sen M, Bhattacharyya DK. Nutritional effects of a mustard seed protein on growing rats. *Inter.J. FoodSci.and Tech*. 2003; 38: 225-232. doi: 10.1046/j.1365-2621.2003.00660.x
10. Sharma S, Singh J, Munshiand GD, Munshi SK. Effect of biocontrol agents on lipid and protein composition of Indian mustard seeds from plants infected with Alternaria species. *Archives of Phytopathology and Plant Protection*. 2010; 43(6): 589-596. doi: 10.1080/03235400801972350
11. Zheljazkov VD, Vick B, Ebelhar MW, Buehringd N, Astatkie T. Nitrogen applications modify seed and oil yields and fatty acid composition of winter mustard. *Industrial Crops and Products*. 2012; 36(1): 28-32. doi: 10.1016/j.indcrop.2011.08.002
12. Kanrar S, Venkateswari J,Dureja P, Kirti PB, Chopra VL. Modification of erucic acid content in Indian mustard (Brassica juncea) by up regulation and down-regulation of the Brassica juncea FattyAcid Elongation1 (Bjfae1)gene. *Plant Cell Rep*. 2005; 25(2):148-155. doi: 10.1007/s00299-005-0068-3
13. Ildiko SG, Kla´ra KA, Marianna TM, Agnes B, Zsuzsanna MB, Ba´lint C. The effect of radio frequency heat treatment on nutritional and colloid-chemical properties of different white mustard (SinapisalbaL.) varieties. *Inn J FoodSci Emerge Techno*. 2006; 7(6): 74-79. doi: 10.1016/j.ifset.2005.06.001
14. Milani MA, Mizani M, Ghavami M, Eshratabadi P. Comparative analysis of antimicrobial characteristics of mustard paste and powder in mayonnaise. *European Journal of Experimental Biology*. 2014; 4(2): 412-418.
15. Ildiko SG, Klara KA, Marianna TM, Agnes B, Zsuzsanna MB, Bálint C. The effect of radio frequency heat treatment on nutritional and colloid-chemical properties of different white mustard (Sinapis alba L.) varieties. *Inn J FoodSci Emerge Techno*. 2006; 7(1-2): 74-79. doi: 10.1016/j.ifset.2005.06.001
16. Cserhalmi Z, Markus Z, Barath A, Czukor B, Toth M. Physico-chemical properties and food utilization possibilities of RF-treated mustard seed. *Inn J Food Sci Emerge Techno*. 2000; 1:251-254. doi: 10.1016/S1466-8564(00)00028-X
17. Nadarajah D, Han JH, Holley RA. Used of mustard flour to inactivate Escherichia coli O157:H7 in ground beef under nitrogen flushed packing. *Int J Food Microbiol*. 2005; 99(3): 257-267. doi: 10.1016/j.ijfoodmicro.2004.08.018
18. Nilson AM, Richard A, Holley A. Use of deodorized yellow mustard powder to control Escherichia colio157:7H in dry cured Westphalian ham. *Food Microbiol*. 2012; 30(2): 400-407. doi: 10.1016/j.fm.2011.10.016
19. Mohamed Esa SAR, Thangaraj S, Salique SM, Khan KF, Natheer SE. Antimicrobial and Biochemical Analysis of Some Spices Extract against Food Spoilage Pathogens. *Internet Journal of Food Safety*. 2010; 12: 71-75.

20. Ouattara B, Simard RE, Holley RA, Piette GJP, Begin A. Antibacterial activity of selected fatty acids and essential oils against six meat spoilage organisms. *Int.J. Food.Microbiol*. 1997; 37(2-3): 155-162.

21. Afifi-Jehan SA. Chemical studies on some poultry meat products. M.V.Sci. Thesis Fac. Vet. Med, Zagazig University. 2000.

22. Pearson AM, Gillette TA. Processed meats. 3rd edition. New York (NY): Springer; 1996.

23. Youssef Fatma E. Chemical profile of some frozen poultry meat. ph.D. Thesis(Meat hygiene). Faculty of .Veterinary Medicine. Benha.University. 2013.

24. Gill CO. Meat spoilage and evaluation of potential storage life of fresh meat. *J.Food Prot*. 1983; 46(5): 444-452. doi: 10.4315/0362-028X-46.5.444

25. Kanemaru K, Miyamoto T. Inhibitory effects on the growth of several bacteria by brown mustard and Allyl isothiocyanate. *Nippon Shokuhin Kogyo Gakkaishi*. 1990; 37(10): 823-829. doi: 10.3136/nskkk1962.37.10_823

26. Mayerhauser CM. Survival of enterohemorrhagic Escherichia coli O157:H7 in retail mustard. *J Food Prot*. 64: 783-787.

27. Ockerman HW. Quality control of Post-Mortem Muscle Tissue Dept of Animal Sciences. The Ohio State University; Columbus, OH, USA. 1985.

28. SAS. User's Guide. SAS Institute, Cary, NC, 2001.

29. Shedeed NA. Evaluation of Microwave cooking of chicken meat. M.V.Sc. Thesis Faculty of Agric. Cairo University. 1999.

30. Sharma HK, Ingle S, Singh C, Sarkar BC, Upadhyay A. Effect of various process treatment conditions on the allyl isothiocyanate extraction rate from mustard meal. *J. Food Sci.Technol*. 2012; 49(3): 368-372. doi: 10.1007/s13197-011-0282-7

31. Winton AL, Winton KB. Oxide distillation volumetric method for the determination of volatile nitrogen. In:the Analysis of Food. Edition. Wikysons. J. N ew York, Chapman and Hull, London. 1958; 840.

32. Zhang Y, Yao S, Li J. Vegetable drived isothiocyanates:antiprolierative activity mechanisms of action. *Proc Nutr Soc*. 2006; 65(1): 68-75.