Biotechnological
Communication

BBRC
Bioscience Biotechnology
Research Communications

Biosc.Biotech.Res.Comm. Vol 13 (3) July-Aug-Sep 2020 Pp-1055-1062

Effect of *Moringa oleifera* leaf and Flax Seed on Physicochemical and Sensory Characteristics of Chicken Burger

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ABSTRACT

Moringa oleifera is a significant food item which has had huge consideration the 'natural nutrition of the tropics'. *M. oleifera* is very important for its nutritional and medicinal value. Flaxseed are also emerging as a "super food" as more scientific research points to their health benefits. Therefore, in this study, various levels of both M. oleifera and flaxseed were incorporated into chicken burger manufacture to supplement this important food product with their nutritional and therapeutic values. Analyses of the physicochemical and sensory characteristics, phenolic compounds, cooking properties and fatty acids content of burger were conducted. The results indicated that the partial replacement of chicken meat by different levels of FS flour and ML powder gradually increased the total fat and dietary fibers contents from 6% to 9 % and from 1.36 % to 12.47%, respectively. The ash, total phenols and flavonoids content of chicken burger formulations containing FS/ ML markedly increased from 1.8 g/100 g to 3.6 g/100g, 0.0067g/100g to 0.046g/100g and 0.004g/100 g to 0.112 g/100g, respectively. The total unsaturated fatty acid UFA of chicken burger samples increased from 10.018 mg/100g in the control treatment to 20.69 mg/100g in T2. On the other hand, linoleic acid was the most abundant polyunsaturated fatty acids (15.054 mg/100g) found in T1 and T2. The polyunsaturated fatty acid (PUFA)/saturated fatty acid index increased from 0.82 in the control to 1.41 in T1. Various formulations of burger contained appreciable amounts of the macro-minerals as well as the micro-mineral iron. The cooking characteristics of chicken burger were improved while the sensory attributes were slightly decreased. The study concluded that a combination of FS and ML can be utilized as novel fixings to create chicken burger with high nutritive value and organoleptic properties. Future research include investigation of the pharmacological properties of different parts of *M. oleifera* multipurpose tree as well as incorporation in other food items.

KEY WORDS: CHICKEN MEAT, MORINGA OLEIFERA, COOKING CHARACTERISTICS, NUTRITIVE VALUE, CHICKEN BURGER, FLAXSEED.

Article Information:
Corresponding author email: *abuelhadi@hotmail.com*
Received 12/07/2020 Accepted after revision 27/09/2020
P-ISSN: 0974-6455 E-ISSN: 2321-4007
Thomson Reuters ISI Clarivate Analytics
Web of Science ESCI Indexed Journal

Identifiers & Pagination:
Vol 13(3) E-Pub 30th Sep 2020 Pp- 1055-1062

Published by Society for Science & Nature India
DOI: *http://dx.doi.org/10.21786/bbrc/13.3/10*

INTRODUCTION

Obesity is the excessive or or irregular collection of fat or fat tissue in the body that hinders impairs health through its relationship to the danger of advancement of diabetes mellitus, cardiovascular disease, hypertension, and hyperlipidemia. It is a significant public health epidemic which has progressively worsened over the past 50 years (Kozlov 2019) has experienced stamped dietary changes and quick urbanization in later decades, it was assessed that 26.6% and 10.6% of youths matured 13–18 years are overweight or hefty, respectively (El Mouzan, 2010). A vital sector of the world population has a few confinements to meat and meat products utilization due to saturated fats, cholesterol, salt contents and its relationship with certain sorts of cancer (Cross et al., 2007).

With expanded customer concerns on the utilize of manufactured cancer prevention agents, utilize of common cancer prevention agents in muscle foods is becoming highly relevant in the food industry. Changes in eating propensities emerging from the advancement of society in later decades have led individuals to look for reasonable and more beneficial food with palatable taste and worthy appearance. Hence, the food industry ceaselessly looks for to adjust and crate unused details outlined to progress quality, food safety and shelf life (Selani et al., 2011). A great procedure is to alter the nutritional profile of chicken burger by combining flaxseed and moringa olifera in this way offer choices to those consumers that look for food with a health condition. Numerous herbs and spices are known to contain assortments of phytochemicals, which are potential sources of characteristic cancer prevention agents and antimicrobial compounds that incorporates polyphenols, flavonoids, carotenoids, tannins and phenolic acids (Devatkal et al. 2010).

The *Moringa oleifera* commonly known as drumstick, is local to India, Africa, Arabia, Southeast Asia and South America (Sengupta & Gupta 1970) and customarily being utilized for dietary purposes as vegetable. *M. oleifera* is of extraordinary intrigued in nourishment conservation since in expansion to contributing taste and smell to nourishments, it too contains a assortment of bioactive substances, which are of significant utilize in amplifying rack life.

Lipid oxidation represents one of the most important causes of deterioration in meat and meat products and it affects unsaturated fatty acids particularly polyunsaturated fatty acids (PUFA) in membrane phospholipids as well as cholesterol, mainly low density lipoprotein (LDL) cholesterol. The final end-products of this process can damage the aroma, color, flavor as well as sensorial attributes of meat and allied products; hence reduce the nutritive value [Luna et al., 2010]. Besides nutritional deterioration, lipid oxidation generates cytotoxic and genotoxic compounds which are deleterious for humans health (Botsoglou et al., 2014). The oxidative damage to meat based products results in problems like tissues damaging, purification, loss of nutrients,enhanced free radical generation and malonaldehydes production that reduce the antioxidant capacity of products (Ahn et al., 2009).

The replacement of red meat with chicken in burger production is becoming more popular due to its high fat content and because of no cultural or religious constraints to the consumption of poultry (Mikhail et al., 2014). Among the choices of utilizing nontraditional fixings for the advancement of new poultry products are flaxseed (FS) and Moringa olifera leaves powder (ML). This study amied to ivestigate the effect formulation of combinations of Moringa oleifera and flaxseed on physicochemical and sensory characteristics of chicken burger.

MATERIAL AND METHODS

Chicken meat samples: Chicken meat was prepared as described by Ibrahim et al., 2014. Fresh chicken meat was obtained from a commercial supermarket in Abha, Saudi Arabia , it was washed carefully,deboned , minced using a meat mincer and then chilled at 4±1 for 24 hours before using in processing of chicken burgers. Flaxseed, *Moringa oleifera*, salt, white pepper, black pepper, garlic and onion were obtained from the local market, Abha, Saudi Arabia, and used for preparation of chicken burger.). Treatments were as follows: control = 0%FS + 0% MLP; T1 = 20%FS + 0% MLP; T2 = 5%FS + 15% MLP; T3 = 10%FS + 10% MLP; T4 = 15% FS + 5% MLP; and T5 = 0%FS + 20% MLP.

Preparation of chicken burger: Fresh chicken burger samples were prepared as described by Table (1). All ingredients were minced twice, after mincing, 50 gram portions were shaped into burger using a burger– forming machine to obtain round discs 8.1 cm diameter and 0.5 cm thickness. The burger samples were cooked for 20 min in pre-heated hot air oven at 180± 1^{0}c to an internal temperature of 75 °c. To ensure uniform cooking, the burgers were turned over at 10 min interval.

Table 1.Ingredients (%) of five blends of chicken burgers formulated with flaxseed flour and *Moringa oleifera* leaf

Ingredients (%)	Control	T1	T2	T3	T4	T5
Chicken meat	81	61	61	61	61	61
Cold water	15.40	15.40	15.40	15.40	15.40	15.40
Salt	1.0	1.0	1.0	1.0	1.0	1.0
White pepper	0.2	0.2	0.2	0.2	0.2	0.2
Black pepper	0.2	0.2	0.2	0.2	0.2	0.2
Garlic powder	0.2	0.2	0.2	0.2	0.2	0.2
Onion powder	2.0	2.0	2.0	2.0	2.0	2.0
Flaxseed flour	0	20	15	10	5	0
Moringa oleifera powder	0	0	5	10	15	20

Chemical analysis: Determination of the contents of moisture, protein, fat and ash were determined according to AOAC (2000) methods. Moisture content by using the air oven drying method , the protein content by the Kjeldahl method, while the fat content by the Soxhlet method.

Determination of total phenols content: Total phenolic contents of samples were determined according to the method (Boyer & Hai Liu, 2004). One ml of extract was mixed with 5 ml of 10 % Folin-Ciocalteu reagent in distilled water and 4 ml of 7.5 % sodium carbonate solution. The samples were maintained at room temperature for 30 min, the absorbance at 765 nm (UV-VIS spectrophotometer, Apel, Japan) was measured. The calibration curve was constructed within the concentration range 0.075–0.6 mg/ml of gallic acid. Means were calculated from three parallel analyses as gallic acid equivalents in g/100 g of dry plant material using the following equation: $C = a \times \gamma \times (V/m) \times 100$,
C: total phenols g/100g as gallic acid; a: dilution number; γ: concentration obtained from calibration curve (mg/ml); V: volume of extract (ml); m: weight of sample (g).

Estimation of total flavonoids: Flavonoid contents of samples were determined according to the method described by Lamaison and Carnat (1990) using AlCl3.6H2O with slight changes. A stock solution of 1 mg/ml of quercetin (standard) was prepared using 50% methanol solvent, and the previous samples' stock solutions were used. Forty microliters of samples and quercetin (of six different dilutions) were separately mixed with 200 µl 2% (w/v) AlCl3.6H2O. The mixture was incubated for 10 min at ambient temperature, and absorbance values at 440 nm were obtained. Calibration curve for quercetin standard was plotted. Regression equation of the curve, absorbance value = 0.0401 (quercetin concentration)–0.0017 with R2 value, 0.9992 was obtained. The equation was used to calculate the quercetin content in 1 g of sample (mg quercetin equivalence (QE)/g of sample.

Physical chrateristics of burger: Weight losswas calculated by the differences in weight between uncooked and cooked burgers, divided by the weight of uncooked burger. Diameter was calculated by the differences in diameter between uncooked and cooked burgers, divided by the diameter of uncooked burger. pHwas measured by pH meter.

Minerals analysis: For determination of mineral elements contents (Inuwa et al., 2011) was employed. These elements incudedcalcium, magnesium, potassium, sodium, phosphorous and iron. The mineral solution obtained from ashed materials wasfiltrated and used to determine mnerals contents using Varian Spectra AA atomic absorption spectrometer.

Determination of cooking properties: The cooking yield was determined as reported by Murphy et al. (1975) as follows: Yield of cooked burger =

$$\frac{\text{weight of cooked burgers}}{\text{weight of raw burgers}} \text{ X } 100$$

Fat retention was calculated according to Murphy et al. (1975) as follows: Fat retention = cooking yield

$$\text{X } \frac{\text{\% fat in cooked burgers}}{\text{\% fat in raw burgers}}$$

Based on the method of El- Magoly et al., (1996), the moisture retention was determined as follows: Moisture retention = cooking yield

$$\text{X } \frac{\text{\% moisure in cooked burgers}}{\text{\% moisure in raw burgers}}$$

Dimensional shrinkage: The dimensional shrinkage (DS) was calculated according to the formula of Murphy et al., (1975) as follows:

$$DS = \frac{(\text{raw thickness} - \text{cooked thickness}) + (\text{raw dimeter} - \text{cooked dimeter})}{\text{raw thickness} + \text{raw dimeter}} \text{X } 100$$

Where DS: Dimensional Shrinkage

Sensory evaluation: Twenty panelists from the students of Home Economic Faculty, King Khalid University, Saudi Arabia, conducted the sensory tests using a 5-hedonic scale test according to Pimentel et al., 2016). The panelist were given a hedonic questionnaire to test the taste, flavor, juiciness, tenderness, texture, color and overall acceptability of coded burger samples. The samples were scored on a scale of 1 – 5 (1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent).

Determination of fatty acids content: The fatty methyl esters were analyzed in a Shimadzu Model GC-QP-2010, injection volumes were 1µl/sample. Methyl esters of the different samples were identified by their relative retention times compared to those of the reference standards (GLC-68, NuChek Prepn. Inc., Elysian, MN) and quantified by their relative peak areas. Oil-freshly chicken meat was extracted from sample (1g) using petroleum ether as solvent. The solvent mixture was evaporated to dryness under nitrogen and then transesterified with sulfuric acid in the presence of methanol for 3h at100°C. The resulting fatty acid methyl ester was run through a column containing $MgSO_4$ plus silica and evaporated again to dryness by heating the solution to 60°C while flushing with nitrogen.

The fatty methyl esters were re-dissolved in 1-2ml of hexane and analyzed in a Shimadzu Model GC-QP-2010, injection volumes were 1µl/sample. Methyl esters of the different samples were identified by their relative retention times compared to those of the reference standards (GLC-68, NuChek Prepn., Inc., Elysian, MN) and quantified by their relative peak areas.The oils were converted to methyl esters by transesterification in methanol with hydrogen chloride catalyst. The esters were examined by GLC and the composition was estimated by measuring the peak areas. The GLC analyses were made using a copper column at 185' and a thermal conductivity (thermistor) detector. The liquid phase was a diethylene glycol - succinic acid polyester.

Statistical analysis: Results were analyzed using analysis of variance (ANOVA) using the SPSS statistical package program, and differences among the means were compared using the Duncan's Multiple Range test. At a significance level of 0.05 was chosen to evaluate different chicken burger samples.

RESULTS AND DISCUSSION

Effect of flaxseed flour and *Moringa oleifera* leaf powder on chemical composition of chicken burger.The effect of flaxseed flour (FS) and Moringa oleifera leaf powder (ML) on chemical composition of chicken burger is shown in Table (2). The partial replacement of FS and ML in chicken burger gradually increased their content of total fat and dietary fibers contents from 6% to 9 % and from1.36 % to 12.47%, respectively, as shown in Table(2). Also it could be noticed that protein and moisture contents of chicken burger supplemented with flaxseed flour (FS) and moringa leaf powder (ML) gradually decreased from 85.2 g/100 g to 56.75 g/100 g) and from 80g /100g to70g/100g, respectively with increasing FS/ML levels, as compared with those of the control sample.

Moreover, it could be noticed that ash, total phenols and flavonoids content of chicken burger formulations containing FS/ ML markedly increased from 1.8 g/100 g to 3.6 g/100g, 0.0067g/100g to 0.046g/100g and 0.004g/100 g to 0.112 g/100g, respectively. Mahima, et al., (2014)reported that the leaves of *Moringa olifera* contained moisture 72.39%, ether extract 2.525 %, crude protein 14.125%, crude fiber 23.09%, total ash 9.15%, nitrogen free extract 51.11%, cellulose 11.0% hemicellulose 10.24% and lignin 2.41%. An analysis of brown Canadian flax averaged 41% fat, 20% protein, 28% total dietary fiber, 7.7% moisture and 3.4% ash, which is the mineral-rich residue left after samples are burned (Morris et al., 2011).

Generally these results are in agreement with those obtained by A.ElifBilek & SadettinTurhan (2009) who concluded that fat and ash content of raw patties increased, while moisture and protein content decreased with increased flaxseed flour. The same trend (except fat content) was also observed after cooking. The addition of flaxseed flour did not affect pH values of raw and cooked beef patties. Nahla, (2014) reported that Beef burger is one of the foremost favorable foods in hotels and fast food merchants. Moringa leaves is rich source of antioxidants and biocompounds that have numerous parts in aniscipatig numerous illnesses. Johnsson, et al., (2002) detailed that phenolic compounds in flaxseed may work as blocking or trapping agents for chemically actudated cancers caused by fragrant carcinogens.

Table 2. Effect of flaxseed flour and *Moringa oleifera* leaf powder on chemical composition of chicken burger (mean D.W)

Samples	Fat (g/100g)	Moisture (g/100g)	Ash (g/100g)	Protein (g/100g)	Fiber (g/100g)	Phenols (g/100g)	Flavonoids (g/100g)
Control	6.0+0^{d}	80+1.15^{a}	1.8+0.2^{c}	85.2+ 0.006^{a}	1.36+ 0.006^{f}	0.0067+ 0.0003^{f}	0.004+ 0.001^{e}
T1	6.3+0.3^{c}	78+2.08^{b}	3.0+0.58^{ab}	52.62+ 0.006^{d}	12.12+ 0.006^{b}	0.011+ 0.0003^{e}	0.044+ 0.001^{d}
T2	6.8+0.42^{c}	75+2.89^{b}	3.0+0.0^{b}	57.92+ 0.012^{b}	12.47+ 0.006^{a}	0.023+ 0.00^{d}	0.06+ 0.0003^{b}
T3	7.5+0.5^{b}	73+3.0^{c}	3.27+0.41^{a}	55.78+ 0.006^{c}	10.59+ 0.003^{c}	0.027+ 0.0001^{c}	0.06+ 0.0^{b}
T4	8.0+0.58^{b}	72+1.15^{c}	3.3+0.38^{a}	55.5+ 0.003^{c}	7.72+ 0.006^{d}	0.046+ 0.0^{a}	0.112+ 0.001^{a}
T5	9.0+0.35^{a}	70+1.53^{c}	3.6+0.4^{a}	56.75+ 0.006^{b}	6.01+ 0.0^{e}	0.038+ 0.001^{b}	0.055+ 0.0003^{c}

Effect of flaxseed flour and *Moring oleifera* leaf powder on fatty acid profile (mg/100g) of chicken burger: The effect of partially replacement chicken meat burger with flaxseed flour and M. oleifera leaf powder on saturated fatty acids (SFA) and unsaturated fatty acids (USFA) contents of produced chicken burger was shown in Table (3). From the table, it could be noticed that total saturated fatty acid of chicken burger samples was in the range of 12.193 to 32.325 mg/100g. However, the higest fatty acids found in (T5) burger were Magaric acid (11.801 mg/100g) and tridecylic acid (6.638 mg/100g). Moreover, myristic, pentadecylic acid and arachidic fatty acids were also present in significant amounts (4.74, 1.687 and 1.091 mg/100g, respectively). Mean while, total unsaturated fatty acid UFA reached 10.018 mg/100g and linoleic acid (5.931 mg/100g) was the most abundant polyunsaturated fatty acids. While the contents of oleic and linolenic acids were 3.841 mg/100g and

0.246 mg/100g, respectively, the identified UFA content gradually increased in different chicken burger samples supplemented with SF and MLP.Whereas the increase in monounsaturated fatty acids (MUFA) oleic acid and polyunsaturated fatty acids (PUFA)linoleic acid and linolenic acid contents for those different chicken burger formulations was 25.61 %and 154.88%, respectively when compared with control formula.

Kang et al., (2005) indicated that it is a desirable to maintain to a p/s ratio(polyunsaturated/saturated fatty acids) approximately (1.0-1.5) with an ideal pI value (app. 80-90) in the diet in order to reduce the risk of cardiovascular disease (CDV) and oxidative stress. The ratio of unsaturated and saturated fatty acids content is expressed as U/S index .From Table (3) the U/S ratio of formulated chicken burgers, especially in burger formula (T1 and T2) were the highest U/S index (1.41 and 1.22) when compared with values of other burger formulation. The ratio of unsaturated and saturated fatty acids content is expressed as U/S index. WHO, (2015) reported that it is important the ratio U/S value be higher than 1 due to the essential character of the linoleic fatty acid.

Table 3. Effect of flaxseed flour and *Moringa oleifera* leaf powder on fatty acid profile (mg/100 g) product of chicken burger

Fatty acid	Control	T1	T2	T3	T4	T5
Caprylic acid (C8:0)	N.D	N.D	N.D	N.D	0.108	0.318
Pelargonic acid (C9:0)	0.046	N.D	N.D	N.D	N.D	N.D
Capric(10:0)	N.D	N.D	N.D	N.D	0.163	0.446
Undecylic acid)C11:0)	0.165	N.D	N.D	0.085	0.464	1.369
Tridecylic acid (C13:0)	0.908	N.D	N.D	0.456	2.436	6.638
Myristicacid (C14:0)	0.657	N.D	N.D	0.332	1.738	4.749
Pentadecylic acid (C15:0)	0.253	N.D	N.D	0.114	0.605	1.687
Palmitic acid (C16:0)	0.407	0.787	0.787	0.434	0.284	0.592
Margaric acid (C17:0)	9.757	7.509	7.509	4.815	4.164	11.801
Oleic acid (C18:1)	3.841	4.825	4.825	2.72	2.145	3.901
Linoleic acid (C18:2)	5.931	15.054	15.054	8.006	5.992	9.583
Linolenic acid (C18:3)	0.246	0.69	0.69	0.298	0.234	0.375
Nondecylic acid (C19:0)	N.D	5.565	5.565	2.183	1.433	0.314
Arachidic acid (C20:0)	N.D	0.859	0.859	1.257	N.D	1.091
Heneicosanoic acid (C21:0)	N.D	N.D	N.D	N.D	0.098	N.D
Behenicacid (C22:0)	N.D	2.024	2.024	2.545	3.011	3.321
Saturated fatty acids (SA)	12.193	14.72	16.744	12.221	14.504	32.325
Unsaturated Fatty acids (US)	10.018	20.089	20.569	11.024	8.371	13.859
U/S index	0.82	1.41	1.22	0.95	0.577	0.448

Means with the same letter are not significantly different (P= 0.05)

Table 4. Effect of flaxseed flour and *Moringa oleifera* leaf powder on mineral content of chicken burger

samples	Mg (ppm) Fresh weight	Fe (ppm) Fresh weight	P (ppm) Fresh weight	Na (ppm) Fresh weight	K (ppm) Fresh weight	Ca (ppm) Fresh weight
242.812^{d}	12.385^{c}	2102.850^{c}	7687.39^{b}	3555.54^{d}	291.694^{d}	Control
726.286^{c}	20.185^{c}	3158.040^{a}	7857.70^{b}	4682.16^{c}	589.784^{c}	T1
734.718^{c}	17.557^{c}	2893.145^{a}	7312.56^{c}	4820.92^{c}	1293.243^{b}	T2
1099.084^{b}	94.063^{b}	2592.382^{b}	8490.42^{a}	5628.51^{a}	2711.197^{a}	T3
1307.998^{a}	126.843^{a}	2381.640^{bc}	6982.20^{d}	5013.28^{b}	3654.172^{a}	T4
1442.675^{a}	128.741^{a}	2137.906^{c}	7823.46^{b}	5402.07^{ab}	3654.172^{a}	T5

Means with the same letter are not significantly different (P= 0.05)

Effect of flaxseed flour and *Moringa oleifera* leaf powder on mineral content of chicken burger: Table (4) presents the mineral composition of chicken burger formula: calcium content of T4 and T5 were higher than the control that of the control which was 291.694 and 3654.172 ppm,respectively. In addition, Table (4) reveals that formula (T5) was higher in Fe, Mg compsred with the control formula. Phosphorus of formula (T1) was

3158.040 ppm, which is more than 50 % in the control sample. Potassium and sodium of formula (T3) were 5628.51 ppm and 8490.42 ppm, respectively, which are more than 58% and 10.44% respectively in control sample.

Lakshmipriya & Kumar, (2016) reported that Moringa has lot of minerals that are essential for growth and development among which calcium is considered as one of the important minerals for human growth while 8 ounces of milk can provide 300-400mg, Moringa leaves can provide 1000 mg and moringa powder can provide more than 4000 mg. beef has only 2 mg of iron while Moringa leaves powder contain 28 mg of iron. Singh et al., (2011a) reported that flaxseeds are source of minerals as calcium, mangnesium and phosphorus. It is of great importance, being that a 30 portion of the seed constitutes 7 % to 30 % of the recommend dietary allowances (RDAs) for these minerals. Rockwood et al., (2013) stated that Moringa provides 17 times more calcium than milk, 15 times more poatasium than bananas and 25 times more than spinach.

Effect of flaxseed flour and *Moringa olifera* leaf powder on cooking properties of chicken burger: The cooking characteristics of chicken burgerare depicted in Table (5). The addition of flaxseed flour and Moringa olifera leaf powder to chicken burger significantly ($P \leq 0.05$) affected cooking characteristics of chicken burger. Data represented in Table (5), indicated that the control sample showed a significant decrease in cooking yield when compared with other treatments in all cases. Furthermore, the treatment T5 (at 0% flaxseed flour +20% *Moringa olifera* leaf powder) showed significant increase in cooking yield when compared with other treatments. Moisture retention was significantly ($P \leq 0.05$) high in all treatments compared to control samples. The improvement in moisture retention of the patties may be attributed to increases in the water absorption capacity of heated protein flours, the heat dissociation of proteins, the gelatinisation of starch in the flour and the swelling of the legume fibre (Modi, et al., 2004).

Table 5. Effect of flaxseed flour and *Moringa olifera* leaf powder on cooking properties of chicken burger

Samples	Cooking yield (%)	Fat retention (%)	Moisture Retention (%)	Dimension Shrinkage (%)
Control	60+0[e]	56+3.06[c]	54.01+0.82[c]	22.09+0.003[a]
T1	72+0[b]	68.87+7.60[a]	67.46+1.78[a]	12.79+0[b]
T2	64+0.58[d]	62.11+3.76[b]	59.81+2.32[b]	8.14+0.006[d]
T3	70+0[c]	68.35+1.65[a]	65.34+1.75[a]	10.47+0.006[c]
T4	64.33+0.33[d]	62.22+10.28[b]	53.33+0.17[d]	10.47+0[c]
T5	74+0.58[a]	70.97+4.20[a]	52.83+0.47[d]	12.79+0[b]

Table 6. Sensory characteristics of cooked chicken burger formulated with flaxseed flour and *Moringa oleifera* leaf.

Parameter	T4	T3	T2	T1	Control	T5
Flavor	2.28±0.346	2.47±0.342	2.71±0.34	3.66±0.354	4±0.281	1.857±0.303
Taste	1.476±0.148	1.76±0.238	2.19±0.235	3.52±0.289	4.19±0.281	1.381±0.128
Color	1.666±0.232	1.761±0.247	2.57±0.320	3.57±0.305	4.42±0.162	1.333±0.1436
Texture	1.571±0.189	1.666±0.242	2.66±0.326	3.28±0.324	3.76±0.247	1.666±0.221
Juiciness	1.428±0.176	1.381±0.188	1.80±0.272	2.42±0.28	3.33±0.326	1.333±0.173
Tenderness	1.285±0.140	1.523±0.224	2.38±0.304	3.28±0.331	3.5±0.305	1.238±0.117
Overall acceptance	1.761±0.257	1.952±0.280	2.38±0.262	3.7±0.33	4.14±0.295	1.571±0.202

Fat retention was significantly ($P \leq 0.05$) high in T1 (at 20% flaxseed flour +0% *Moringa olifera* leaf powder) , T2 (at15% flaxseed flour +5% *Moringa olifera* leaf powder and T3) at 10% flaxseed flour +10% Moringa olifera leaf powder) when compared with control samples. The increase in fat retention may be due to the fact that the swelling of the starch and fibre as well as the fat absorbed by the fibre may interact with the protein of the ground meat matrix to prevent migration of fat from the product (Alakali et al., 2010).

The shrinkage was measured by difference between two diameters of burger before and after cooking. Moreover, it can be considered as one of important quality attributes measurements. From these results, it could be observed that the control sample showed significant increase in shrinkage compared with other treatments. Similar results were obtained with Darwish et al., (2012); Alakali et al., (2010); Al-Juhaimi et al., (2016) Shrinkage in patties during heating is caused by muscle protein denaturation and partly from the evaporation of water and drainage of melted fat and juices (Alakali et al., 2010). Treatment T2 with 5% MLF + 15% FS had the highest dimension shrinkage when compared with other treatments.

Sensory characteristics of cooked chicken burger formulated with flaxseed flour and Moringa oleifera leaf powder: The mean sensory scores of cooked chicken burger formulated with flaxseed flour and Moringa olifera leaf powder are shown in Table (6). It was observed that all sensory attributes evaluated decreased as MLF level increased and FS flour levels decreased in chicken burger formulation. The sensory attributes (taste, flavor, juiciness, tenderness, texture, color and overall acceptability) of the cooked chicken burger were significantly ($P\leq 0.05$) decreased in T2, T3, T4 and T5 treatments compared to control samples. Similar results were obtained with Pelser et al. (2007) who reported that incorporation of FS flour into meat products had an adverse effect on sensory attributes. Al-Juhaimi et al. (2015) obtained that the sensory attributes (appearance, juiciness, flavour, taste, tenderness and overall acceptability) of the cooked patties decreased with increasing MSF levels (M. oleifera seed flour). Treatment T1 with 0% MLF + 20% FS had the highest sensory score when compared with other treatments.

CONCLUSION

In the present study, the effect of *Moringa oleifera* and flaxseed combinations on physicochemical and sensory characteristics of chicken burger was investigated. The study concluded that a combination of FS and ML can be utilized as novel fixings to create chicken burger with high nutritive value and organoleptic properties in addition to their health benefits.

ACKNOWLEDGEMENTS

The authors would like to thank Cairo University Research Park (CURP)-Faculty of Agriculture for providing laboratory facilities to conduct the various experiments.

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