# THE USE OF HERBAL SUPPLEMENTS FOR INCREASING THE HEALTHINESS AND STORAGE STABILITY OF MDCM BURGERS

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**ABSTRACT.** *The storage stability of burgers made from mechanically deboned chicken meat (MDCM) was investigated. Ten different types of burgers were subjected to the test. The main components of the burgers were mechanically deboned chicken meat, water, soy concentrate, breadcrumbs and salt. The effects of 3% and 6% of linseed oil or dodderseed oil with and without added seabuckthorn (SB) berry powder as in antioxidants on lipid oxidation were studied. The burgers were cooked in the microwave oven for three minutes in 800 W and stored at +6 °C. The rancidity was assessed by measuring of the thiobarbituric acid reactive substances (TBARS) on the cooking day (0), on the 3^rd^, 6^th^, 9^th^ and 12^th^ day. It was concluded that the addition of ω-3 polyunsaturated fatty acids accelerates the lipid oxidation measured by TBARS value and the addition of SB powder decreases the formation of oxidation products during 12 days of storage up to 3–5 times.*

**Keywords:** *mechanically deboned chicken meat (MDCM), functional food additive, linseed oil, dodderseed oil, sea buckthorn, TBARS.*

## Introduction

Many attempts have been made to fortify chicken or pork with polyunsaturated fatty acids (PUFA) by feeding linseed oil or rapeseed oil additives. The process is slow and thus unresponsive to demand changes, so an alternative and more efficient approach would be necessary to alter meat fatty acid profile with PUFA-rich plant oil additives by mixing them directly to the minced meat. An advantage of this approach is the opportunity to vary product contents quickly and in compliance with the consumers' preferences. In addition, such an approach would be useful for elaborating methods for the analysis of the quality and storage stability of the modified products. In this study the properties of the chicken burgers enriched with polyunsaturated fatty acids have been investigated. Mechanically deboned chicken meat (MDCM) was used as a raw material, which was fortified with linseed and dodderseed oil. Seabuckthorn berry powder was added to hinder the oxidative rancidity of burgers.

In case of hand deboning, 24% of the edible fraction of chicken is not recovered (Trindale *et al.*, 2004). Mechanical deboning of chicken, implemented in the USA in the 1950's, permits recovery of neck, back and other residual meat or whole carcasses of hens. The resultant MDCM has the appearance of finally comminuted meat. MDCM is frequently used in the formation of comminuted meat products due to its fine consistency and relatively low cost. Yet consumers often perceive MDCM as a low-value and possibly even hazardous type of meat. Mechanical deboning involves grinding meat and bone together and forcing the mixture obtained through a fine screen or slotted surface to remove bone particles. When using such a deboning process, some fine bone particles (ø<0.5 mm) remain in the meat mass, so MDCM has a higher calcium content. Ca content in chicken meat is on average 17 mg/100 g, but in MDCM it varies from 60 to 280 mg/100 g. Different countries have set different limits on Ca content: 1.5% of dry matter in Brazil, 0.75% in USA, 0.25% in Denmark (Trindale *et al.*, 2004). Commision Regulation (EC) No. 2704/2005 lays down that calcium content of mechanically separated meat shall not exceed 0.1% (100 mg/100 g) of fresh meat.

MDCM contains significantly higher quantities of sarcoplasmic proteins and as a result of the infusion of bone marrow in MDCM there is greater variation in fatty acid content and a higher percentage of cholesterol and phospholipids in MDCM (Al-Najdawi, Abdullad, 2002). Furthermore, the release of heme, oxidative enzymes and the incorporation of oxygen into the product during mechanical deboning promote the autooxidation of polyunsaturated fatty acids which makes MDCM highly susceptible to oxidative deterioration (Mielnik *et al.*, 2003; Petterson, 2004).

The usage of MDCM as the raw material and the increased content of the PUFAs both accelerate the oxidation of the products and call for antioxidants to hinder rancidity. Several antioxidants have been used for prolonging the safe storage period of meat products. Synthetic antioxidants are very effective but their use is debated due to their potential carcinogenicity. What is more, consumers have a general reluctance towards synthetic additives. Hence there is a growing interest in natural herbal antioxidants as an alternative to the synthetic ones. The extracts of garlic (Sallam *et al.*, 2004), rosemary (Mielnik *et al.*, 2003; Han, Rhee, 2005), green tea (Hassan, Fan, 2004), grape seeds (Ahn *et al.*, 2004), cloudberry, beet root and willow herb (Rey *et al.*, 2004) and rosemary leaves (Racanicci, 2004) have been used as antioxidants in meat products. Seabuckthorn berries, blackberries and blueberries are also known to have strong antioxidative properties.

In this study seabuckthorn (SB) powder was added to reduce the rancidity of burgers. Seabuckthorn berries contain both hydrophilic and lipophilic antioxidants (Guliyev, 2004), while seabuckthorn is also the main source of plant phytosteroids beside soy beans (Li, 2002).

## Materials and Methods

**Linseed oil and dodderseed oil** were produced in Estonia in Jõgeva Plant Breeding Institute's Mooste experimental station by cold-pressing method.

**Seabuckthorn berry powder (SB)** was produced in Estonia in company Tervix. The solid residue of seabukthorn berries left after the removal of juice by pressing was dried at 40 °C, stored in black polyethylene bags at room temperature and milled shortly before usage.

**Soy protein concentrate** ARCON FM was produced in Archer Danield Midland Company. ARCON FM binds water and fat at a ratio of 1:4.5:4.5, resulting in a stable emulsion. The product tastes neutral. Ingredients: humidity max 9%, proteins 65+5%, fat (pet.ether) max 1.5%, fat (acid hydrolysis) max 3.5%, diet fibres 18%, energetic value 290 kcal/100 g.

**Mechanically deboned chicken meat (MDCM)** was received from AS Tallegg, being produced from chicken skeletons on bone press Weiler Beehiv PSTD 06 and obtained frozen at –18 $^{o}$C.

**Preparation of burgers.** MDCM in 20 kg blocks was thawed overnight and mixed with soy concentrate (5%), breadcrumbs (2%), salt (1.8%) and water (20%). The burgers were cooked in the microwave oven for three minutes at 800 W, cooled at room temperature, packed into polyethylene bags and stored in the refrigerator at +6 °C for 12 days.

**Table 1.** The content of burgers

| Component / type | 0 | I | II | III | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|---|---|---|
| MDCM, % | 71.2 | 68.2 | 65.2 | 68.2 | 65.2 | 67.2 | 64.2 | 61.2 | 64.2 | 61.2 |
| Linseed oil, % | | | | 3 | 6 | | | | 3 | 6 |
| Dodderseed oil, % | | 3 | 6 | | | | 3 | 6 | | |
| SB powder, % | | | | | | 4 | 4 | 4 | 4 | 4 |

**Organoleptical evaluation.** The 5 point scale was used: 5 – excellent; 4 – good; 3 – satisfactory; 2 – poor; 1 – very poor. The following weights were used in calculating the total score: appearance – 1, consistence – 3, aroma – 4 and taste – 5.

**Dry material content** was obtained by drying at 103±2 ºC (ISO 1442:97 (E)).

**Fat content** was assayed by the Soxhlet method (AOAC 960.39) with samples taken according to the ISO standard 3100/EVS 723 : 1995.

**Protein content** was evaluated on the basis of nitrogen content with analyzer Kjeltek 1035.

**Fatty acid content** of MDCM and burgers was determined by gas-liquid chromatography. Lipids were extracted and saponified from material by a mixture of chloroform and methanol, fatty acids were converted to their methyl esters and analyzed by Agilent 6890N Gas Chromatograph using capillary column Carbovax 30 m × 0.25 mm at 180–210 $^{o}$C. The content of individual fatty acids was expressed as percentage of total fatty acid content.

**Assay of thiobarbituric acid reactive substances (TBARS).** Extraction method (Esterbauer, Cheeseman, 1990) was used. 10 g of MDCM was homogenized during 1 min at 10 000 rpm in 40 ml of 4% perchloric acid containing BHA 90 mg/100 g (0.5 ml 7.2% solution of butylated hydroxyanisole (BHA)) to retard the oxidative processes. The obtained mixture was filtrated through glassfiber filter. 5 ml of the filtrate and 5 ml of 0.02 M thiobarbituric acid solution was pipetted into the test tubes that were closed with stopper and heated in water bath at 80±0.2 °C during 1 hour. Test tubes were cooled in a cold water bath during 1 min and absorption of the solution was determined with the spectrophotometer Specord 200 (Analytik Jena, Germany) at $\lambda$ = 532 nm. Respective quantities of malonic dialdehyde (MDA), mg MDA/kg of sample, were calculated using calibration curves obtained with standard compound 1,1,3,3-tetraetoxypropane (TEP). The measurements were made on the cooking day (0) and on the third, sixth, ninth and twelfth day.

## Results and discussion

Fat content of the chicken meat is 0.3–0.7% in the breast meat, 1.3–2% in the red meat, 30–42% in skin, 57–70% in inner and subcutaneous fat (Tikk, Lember, 2004). It can be seen from Table 3 that MDCM contains over ten times more fat than breast or sartorial muscles. Trindade (Trindade *et al.*, 2004) found the fat content of MDCM to be 15–20% and protein content 14–16%.

**Table 2.** The chemical composition of MDCM and burgers

| Component /type | 0 | I | II | III | IV | V | VI | VII | VIII | IX | MDCM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MDCM, % | 71.2 | 68.2 | 65.2 | 68.2 | 65.2 | 67.2 | 64.2 | 61.2 | 64.2 | 61.2 | 100 |
| Dry material, % | 36.8 | 40.2 | 40.1 | 40.5 | 42.5 | 38.6 | 41.0 | 40.8 | 39.9 | 42.8 | 36±2 |
| Fat, % | 11.6 | 14.8 | 15.2 | 15.3 | 18.8 | 14.4 | 14.3 | 15.5 | 13.8 | 16.8 | 17%±2 |
| Protein, % | 19.1 | 18.1 | 17.2 | 17.5 | 17.2 | 17.9 | 18.3 | 16.9 | 16.8 | 16.8 | 16±2% |
| Ash, % | 3.3 | 3.2 | 3.2 | 3.4 | 3.1 | 3.2 | 3.3 | 3.2 | 3.3 | 3.1 | 2.0 |

**Table 3.** The fatty acid pattern of MDCM and chicken broiler meat, % of total lipids

| Fatty acid | White meat* | Red meat* | Skin* | MDCM |
|---|---|---|---|---|
| Hexadecanoic, 16:0 | 23.8 | 22.6 | 24.0 | 23.9 |
| Cis-9-hexadecenoic, 16:1 (n7) | 4.5 | 6.3 | 4.4 | 5.7 |
| Octadecanoic, 18:0 | 7.5 | 7.6 | 5.1 | 5.4 |
| Cis-9-octadecenoic, 18:1 | 29.1 | 32.0 | 39.4 | 42.3 |
| 9,12-octadecadienoic, 18:2 (n6) | 17.8 | 18.3 | 18.2 | 17.8 |
| 9,12,15-octadecatrienoic,18:3 (n3) | 0.5 | 0.7 | 1.0 | 1.6 |
| Cis-11-eicosenoic, 20:1 | 0.5 | 0.5 | 0.6 | 0.5 |
| 5,8,11,14-eicosatetraenoic, 20:4 (n6) | 5.0 | 3.7 | 0.6 | 0.36 |
| Cis-13-docosenoic, 22:1 (erucic) | 0.4 | 0.6 | 0.4 | 0.11 |
| Total ω-3 PUFA | 3.9 | 2.8 | 1.6 | 1.6 |
| Total ω-6 PUFA | 22.8 | 22.0 | 18.8 | 18.3 |

* Ratnayake *et al*., 1989

**Table 4.** The fatty acid pattern of burgers, seabuckthorn powder (SB), dodderseed oil (D) and linseed oil (L), % of total lipids

| Fatty acid | **0, V*** | **I, VI*** | **II, II*** | **III, III*** | **IV, IX*** | **SB** | **D** | **L** |
|---|---|---|---|---|---|---|---|---|
| Tetradecanoic, 14:0 | 0.7 | 0.5 | 0.4 | 0.5 | 0.4 | 0.2 | 0.1 | 0.0 |
| * | 0.6 | 0.5 | 0.4 | 0.5 | 0.4 | | | |
| Hexadecanoic, 16:0 | 24.8 | 20.7 | 17.9 | 20.5 | 17.3 | 22.1 | 6.8 | 5.3 |
| * | 24.8 | 19.4 | 17.1 | 19.1 | 17.5 | | | |
| Cis-9-hexadecenoic, 16:1 | 5.8 | 4.4 | 3.5 | 4.5 | 3.4 | 22.4 | 0.2 | 0.1 |
| * | 6.1 | 4.6 | 3.7 | 4.5 | 3.7 | | | |
| Octadecanoic, 18:0 | 5.4 | 4.7 | 4.5 | 4.9 | 4.7 | 1.6 | 2.6 | 3.5 |
| * | 5.2 | 4.7 | 4.4 | 5.0 | 4.8 | | | |
| Cis-9-octadecenoic, 18:1 | 41.5 | 35.8 | 31.2 | 37.3 | 34.5 | 14.2 | 13.9 | 22.1 |
| * | 41.1 | 34.8 | 30.9 | 36.6 | 33.7 | | | |
| 9,12-octadecadienoic, 18:2 (n6) (linolic acid) | 17.6 | 18.4 | 18.9 | 17.0 | 16.7 | 22.4 | 20.8 | 15.0 |
| * | 17.7 | 18.8 | 19.2 | 17.5 | 17.0 | | | |
| 9,12,15-octadecatrienoic, 18:3 (n3) (α-linolenic acid) | 1.5 | 8.4 | 13.5 | 12.9 | 20.6 | 16.1 | 33.4 | 53.3 |
| * | 1.9 | 9.4 | 14.1 | 14.4 | 20.8 | | | |
| Eicosanoic, 20:0 | 0.1 | 0.4 | 0.5 | 0.1 | 0.1 | 0.3 | 1.4 | 0.1 |
| * | 0.1 | 0.4 | 0.6 | 0.1 | 0.1 | | | |
| Cis-11-eicosenoic, 20:1 | 0.5 | 3.3 | 5.3 | 0.4 | 0.3 | 0.1 | 13.4 | 0.2 |
| * | 0.5 | 3.7 | 5.5 | 0.4 | 0.3 | | | |
| 11,14-eicosadienoic 20:2 (n-6) | 0.1 | 0.6 | 0.9 | 0.1 | 0.1 | 0.0 | 2.1 | 0.1 |
| * | 0.1 | 0.6 | 0.9 | 0.1 | 0.1 | | | |
| 5.8.11,14-eicosatetraenoic, 20:4 (n6) | 0.4 | 0.2 | 0.3 | 0.3 | 0.3 | | | |
| * | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | | | |
| Cis-13-docosenoic, 22:1 | 0.1 | 0.6 | 1.0 | 0.1 | 0.0 | 0.0 | 2.8 | 0.0 |
| * | 0.1 | 0.8 | 1.1 | 0.0 | 0.1 | | | |

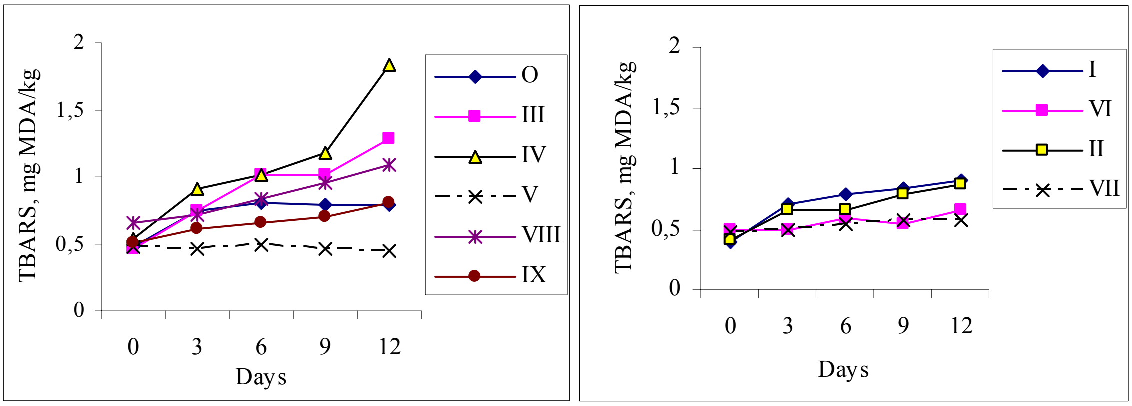
* marked rows show the fatty acid content of burgers with the addition of 4% SB powder (types V, VI, VII, VIII ja IX)

The high fat content may be a result of the high proportion of skin, bone marrow and inner fat in MDCM. The fatty acid pattern of MDCM resembles chicken skin rather than muscular meat. There is more oleic acid and linolenic acid and less long chain polyunsaturated fatty acids in MDCM. Although broiler fat is rather rich in PUFA, the ratio of ω-6 to ω-3 in MDCM is about 12 (favourable ratio is 2–4), so it would be beneficial to fortify it with ω-3-PUFA by adding linseed or dodderseed oil.

The fatty acid pattern of linseed oil, dodderseed oil and SB powder is presented in table 4. Addition of 1% linseed oil to MDCM allows to raise its content of linolenic acid from 1.6 to 5.2%, 1% of dodderseed oil raises it to 4% and 3% of linseed or dodderseed oil raises it to 11.5% or 8%, accordingly. On addition of linseed or dodderseed oil the linolenic acid content of burgers increases and 3% of dodderseed oil reduces the ratio of PUFA ω-6 and ω-3 from 12 to 2.3 which is already too low from health aspect. Although the fat content of SB berries is rather high, ~10% in seeds and 16–34% in berry skin (Yang, Kallio, 2002), it can be seen from Tables 2 and 4 that an additional 4% of SB powder to burgers has no significant influence on their fatty acid pattern.

Due to the fatty acid pattern of added oils, the highest content of ω-3 fatty acids was obtained in burgers with linseed oil while the ω-6 fatty acids were found most in burgers with dodderseed oil. It is considered most beneficial for human health to have the ratio of ω-6:ω-3 fatty acids between 3:1 and 10:1. This condition was satisfied best in burgers with 3% of dodderseed oil, the burgers containing linseed oil had too high content of α-linolenic acid. The high content of PUFAs can also accelerate rancing of MDCM.

Figures 1A and 1B demonstrate that the addition of vegetable oils accelerates the formation of malonedialdehyde and other TBA reactive substances (TBARS). The addition of dodderseed oil (I and II in Figure 1B) and especially linseed oil (II and IV in Figure 1A) substantially enhanced TBARS measured oxidation. Rather high TBARS values were observed already immediately after cooking (0.4–0.5 mg MDA/kg) and on the third storage day the TBARS value for control was 0.74 mg MDA/kg while being 0.89 for burgers with 6% linseed additive on the 3rd day and 1.80 mg MDA/kg on the 12th day. The addition of 4% SB powder hindered oxidation measured by TBARS in every burger mixture. In burgers without oil there were no changes in TBARS during the whole storage period and even in burgers with 6% linseed oil TBARS on the 12th day was 0.78 instead of 1.80 mg MDA/kg in burgers without SB powder.




**A** **B**

**Figure 1.** Lipid oxidation (TBARS) during the storage at +6 °C of control burgers (0), burgers fortified with linseed oil (A) and dodderseed oil (B) together with 4% of SB powder (V–IX) or without SB powder (0–IV): 3% dodderseed oil (I), 6% dodderseed oil (II), 3% linseed oil (III), 6% linseed oil (IV), 4% SB + 3% dodderseed oil (VI), 4% SB + 6% dodderseed oil (VII), 4% SB + 3% linseed oil (VIII), 4% SB + 6% linseed oil (IX)

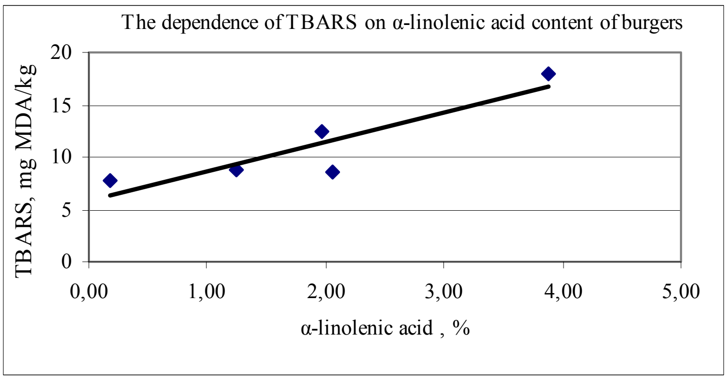



**Figure 2.** The dependence of TBARS on α-linolenic acid content of burgers (stored 12 days)

Despite the equal total fat content, the burgers with dodderseed oil were less susceptible to oxidation than burgers with linseed oil. Figure 2 shows that the increase of TBARS values is proportional ($r = 0.896$) to burgers' linolenic acid content.

Table 5 contains the numerical results of the organoleptic evaluation. For better assessment of the effect of added oil and SB, the burgers were flavoured only with salt. Burgers with linseed oil (III, IV, VIII, IX) achieved higher total scores than the control burgers (0, V), but the addition of dodderseed oil resulted in "turnip taste", uncharacteristic for burgers and thus lowering the score. The SB powder used was coarse-grained which made the burgers too dry and crumbly and the score lower. To avoid this mistake, finer grained SB powder should to be used in future experiments.

**Table 5.** The results of organoleptic evaluation

| Burger | Appearance (coef. = 1) | | Flavour (coef. = 4) | | Consistence (coef. = 3) | | Taste (coef. = 5) | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | value | value × coef. | value | value × coef. | value | value × coef. | value | value × coef. | |
| 0 | 3.7 | 3.7 | 3.6 | 14.4 | 4.3 | 12.9 | 4.0 | 20.0 | 51.0 |
| I | 3.8 | 3.8 | 3.4 | 13.6 | 4.4 | 13.2 | 3.7 | 18.5 | 49.1 |
| II | 3.9 | 3.9 | 4.0 | 16.0 | 4.4 | 13.2 | 4.2 | 21.0 | 54.1 |
| III | 4.0 | 4.0 | 3.8 | 15.2 | 4.3 | 12.9 | 4.6 | 23.0 | 55.1 |
| IV | 4.1 | 4.1 | 3.8 | 15.2 | 4.2 | 12.6 | 4.0 | 20.0 | 51.9 |
| V | 3.7 | 3.7 | 4.1 | 16.4 | 3.4 | 10.2 | 3.8 | 19.0 | 49.3 |
| VI | 3.9 | 3.9 | 3.9 | 15.6 | 3.3 | 9.9 | 3.1 | 15.5 | 44.9 |
| VII | 3.9 | 3.9 | 3.7 | 14.8 | 3.4 | 10.2 | 3.2 | 16.0 | 44.9 |
| VIII | 4.1 | 4.1 | 3.9 | 15.6 | 3.5 | 10.5 | 3.4 | 17.0 | 47.2 |
| IX | 3.8 | 3.8 | 3.8 | 15.2 | 3.5 | 10.5 | 3.6 | 18.0 | 47.5 |

## Summary and conclusions

The addition of linseed oil and dodderseed oil to mechanically deboned meat enables the enrichment of meat products with biologically important ω-3 fatty acids. However, it must be taken into account that polyunsaturated fatty acids oxidize easily. The addition of unsaturated fatty acids, especially α-linolenic acid, to burger mixture accelerates the oxidative rancidity of contained fat. The TBARS number, showing the amount of malonedialdehyde and other thiobarbituric acid reactive substances, grows 3–5 times faster in burgers with oil additives. The addition of sea-buckthorn powder decreases the formation of oxidation products during storage (oxidation of control sample stops completely, oxidation of burgers with linseed oil is reduced 3 to 5 times) and it could be used as a healthy additive to improve the storage of meat products.

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