**Table 6.** **Some physico-chemical properties of the shortening and oleogels before and after cooking**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fatty acid composition (%) | Safflower oil | | Shortening . | | | | OR5 . | | | | OR7 . | | | | OR10 . | | | |
| pre-cooking | | post-cooking | | pre-cooking | | post-cooking | | pre-cooking | | post-cooking | | pre-cooking | | post-cooking | |
| Capric acid 10:0 | ---- |  | 0.27 | ±0.03aA | 0.37 | ±0.04aA | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  |
| Lauric acid 12:0 | ---- |  | 2.97 | ±0.17bA | 3.26 | ±0.11bA | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  |
| Myristic acid 14:0 | 0.10 | ±0.01a | 1.96 | ±0.10bA | 2.11 | ±0.03cA | 0.13 | ±0.00aA | 0.13 | ±0.01aA | 0.14 | ±0.01aA | 0.12 | ±0.01aA | 0.16 | ±0.03aA | 0.13 | ±0.01aA |
| Palmitic acid 16:0 | 6.52 | ±0.10a | 37.11 | ±2.31bA | 37.81 | ±0.01bA | 6.95 | ±0.07aA | 7.15 | ±0.27aA | 6.96 | ±0.01aA | 7.11 | ±0.17aA | 7.01 | ±0.01aA | 7.10 | ±0.31aA |
| Palmitoleic acid 16:1(n-7) | 0.09 | ±0.00a | 0.18 | ±0.01cA | 0.16 | ±0.01bA | 0.09 | ±0.00aA | 0.10 | ±0.00aA | 0.10 | ±0.01aA | 0.10 | ±0.00aA | 0.10 | ±0.01aA | 0.10 | ±0.00aA |
| Margaric acid 17:0 | ---- |  | 0.13 | ±0.01aA | 0.12 | ±0.00aA | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  |
| Stearic acid 18:0 | 3.08 | ±0.14a | 8.49 | ±0.10cB | 7.54 | ±0.04bA | 3.05 | ±0.01aA | 3.04 | ±0.17aA | 3.11 | ±0.04aA | 3.06 | ±0.08aA | 3.04 | ±0.01aA | 3.02 | ±0.13aA |
| Oleic acid 18:1(n-9) | 18.67 | ±0.99a | 32.05 | ±1.32bA | 31.69 | ±0.10bA | 17.22 | ±0.04aA | 17.62 | ±1.61aA | 17.55 | ±0.18aA | 17.89 | ±1.73aA | 17.00 | ±0.02aA | 17.68 | ±1.24aA |
| Linoleic acid 18:2(n-6) | 70.29 | ±4.57b | 14.09 | ±0.82aA | 15.37 | ±0.04aA | 71.45 | ±0.07bA | 70.59 | ±2.15bA | 71.00 | ±0.20bA | 70.30 | ±2.84bA | 71.56 | ±0.04bA | 70.51 | ±3.21bA |
| Linolenic acid 18:3(n-3) | 0.12 | ±0.01a | 0.25 | ±0.03bA | 0.74 | ±0.00cB | 0.11 | ±0.00aA | 0.25 | ±0.03bB | 0.12 | ±0.01aA | 0.24 | ±0.03bB | 0.11 | ±0.00aA | 0.25 | ±0.03bB |
| Arachidic acid 20:0 | 0.53 | ±0.07a | 0.45 | ±0.03aA | 0.48 | ±0.01aA | 0.48 | ±0.00aA | 0.48 | ±0.03aA | 0.50 | ±0.01aA | 0.49 | ±0.03aA | 0.49 | ±0.01aA | 0.49 | ±0.03aA |
| Gondoic acid 20:1(n-9) | 0.22 | ±0.03b | 0.12 | ±0.01aA | 0.24 | ±0.01bB | 0.22 | ±0.01bA | 0.22 | ±0.03bA | 0.21 | ±0.00bA | 0.24 | ±0.03bA | 0.22 | ±0.00bA | 0.24 | ±0.03bA |
| Behenic acid 22:0 | 0.38 | ±0.06b | ---- |  | 0.15 | ±0.01a | 0.32 | ±0.02bA | 0.33 | ±0.04bA | 0.35 | ±0.01bA | 0.37 | ±0.03bA | 0.34 | ±0.01bA | 0.38 | ±0.03bA |
| SFA | 10.61 | ±0.99a | 51.38 | ± 3.39bA | 51.84 | ±8.56bA | 10.93 | ±1.20aA | 11.13 | ±1.20aA | 11.06 | ±1.06aA | 11.15 | ±0.92aA | 11.04 | ±1.48aA | 11.12 | ±1.13aA |
| MUFA | 18.98 | ±1.98a | 32.35 | ±4.31bA | 32.09 | ±2.83bA | 17.53 | ±2.19aA | 17.94 | ±2.76aA | 17.86 | ±2.62aA | 18.23 | ±2.19aA | 17.32 | ±2.55aA | 18.02 | ±1.98aA |
| PUFA | 70.41 | ±8.63a | 14.34 | ±1.63bA | 16.11 | ±1.56bA | 71.56 | ±10.68aA | 70.84 | ±8.27aA | 71.12 | ±8.63aA | 70.54 | ±6.43aA | 71.67 | ±9.40aA | 70.76 | ±9.12aA |
| UFA | 89.39 | ±9.90a | 46.69 | ±5.37bA | 48.20 | ±4.53bA | 89.09 | ±10.04aA | 88.78 | ±9.62aA | 88.98 | ±9.90aA | 88.77 | ±9.55aA | 88.99 | ±8.49aA | 88.78 | ±9.19aA |
| PUFA/SFA | 6.64 | ±0.64a | 0.28 | ±0.00bA | 0.31 | ±0.07bA | 6.55 | ±0.78aA | 6.36 | ±0.64aA | 6.43 | ±0.78aA | 6.33 | ±0.78aA | 6.49 | ±0.71aA | 6.36 | ±0.64aA |
| UFA/SFA | 8.43 | ±1.77a | 0.91 | ±0.14bA | 0.93 | ±0.07bA | 8.15 | ±0.79aA | 7.98 | ±0.99aA | 8.05 | ±0.92aA | 7.96 | ±0.92aA | 8.06 | ±0.64aA | 7.98 | ±0.85aA |
| Parameters |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| PV | 3.76 | ±0.53a | 27.76 | ±2.98eB | 4.80 | ±0.50abA | 14.80 | ±0.29cA | 13.21 | ±0.78cA | 15.88 | ±0.42cA | 16.32 | ±0.40dA | 20.45 | ±0.05dB | 17.91 | ±0.40dA |
| FFA | 0.04 | ±0.01a | 0.08 | ±0.01abA | 0.22 | ±0.05cB | 0.08 | ±0.01abA | 0.17 | ±0.03bcB | 0.08 | ±0.00abA | 0.17 | ±0.02bcB | 0.09 | ±0.01abA | 0.16 | ±0.02bcB |
| K232 | 1.35 | ±0.21a | 5.27 | ±0.21cB | 4.47 | ±0.15abA | 2.91 | ±0.16bA | 5.62 | ±0.04abcB | 3.03 | ±0.21bA | 5.61 | ±0.78abcB | 5.39 | ±1.09cA | 5.71 | ±1.01bcA |
| K270 | ---- |  | 3.26 | ±0.08bA | 2.46 | ±0.28cA | ---- |  | 1.81 | ±0.04abc | ---- |  | 1.78 | ±0.24abc | 2.05 | ±0.36aB | 1.97 | ±0.62bcA |
| 3-MCPD | ---- |  | ---- |  | 1.89 | ±0.13c | ---- |  | 0.93 | ±0.04b | ---- |  | 0.95 | ±0.08b | ---- |  | 1.06 | ±0.10b |
| Glycidyl | ---- |  | ---- |  | ---- |  | ---- |  | 0.32 | ±0.03a | ---- |  | 0.39 | ±0.07a | ---- |  | 0.81 | ±0.04b |

Values are shown as mean ± standard deviation (n = 3); Different lowercase letters on the same line as exponents indicate that the difference between the means is significant (p<0.05); Capital letters given as exponents on the same line and in the same sample indicate that the difference between pre-cooking and post-cooking averages is significant (p<0.05); SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; UFA, unsaturated fatty acids; PV, peroxide value; FFA, free fatty acids; K232, conjugated dienes; K270, conjugated trienes; 3-MCPD, esters of 3-chloro-1,2-propanediol; OR5, oleogel made with safflower oil + 5% rice bran wax; OR7, oleogel made with safflower oil + 7% rice bran wax; OR10, oleogel made with safflower oil + 10% rice bran wax

**Table 6. Some physico-chemical properties of the shortening and oleogels before and after cooking (continued)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fatty acid composition (%) | Safflower oil | | Shortening . | | | | OB3 . | | | | OB5 . | | | | OB10 . | | | | | |
| pre-cooking | | post-cooking | | pre-cooking | | post-cooking | | pre-cooking | | post-cooking | | pre-cooking | | | post-cooking | | |
| Capric acid 10:0 | ---- |  | 0.27 | ±0.03aA | 0.37 | ±0.04aA | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- | |  |
| Lauric acid 12:0 | ---- |  | 2.97 | ±0.17bA | 3.26 | ±0.11bA | ---- |  | ---- |  | 0.10 | ±0.00a | ---- |  | ---- |  | ---- | |  |
| Myristic acid 14:0 | 0.10 | ±0.01a | 1.96 | ±0.10bA | 2.11 | ±0.03cA | 0.13 | ±0.03aA | 0.12 | ±0.01aA | 0.16 | ±0.03aA | 0.12 | ±0.01aA | 0.11 | ±0.01aA | 0.11 | | ±0.00aA |
| Palmitic acid 16:0 | 6.52 | ±0.10a | 37.11 | ±2.31bA | 37.81 | ±0.01bA | 6.86 | ±0.17aA | 6.84 | ±0.13aA | 6.85 | ±0.23aA | 6.80 | ±0.21aA | 6.63 | ±0.16aA | 6.63 | | ±0.13aA |
| Palmitoleic acid 16:1(n-7) | 0.09 | ±0.00a | 0.18 | ±0.01cA | 0.16 | ±0.01bA | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- | |  |
| Margaric acid 17:0 | ---- |  | 0.13 | ±0.01aA | 0.12 | ±0.00aA | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- | |  |
| Stearic acid 18:0 | 3.08 | ±0.14a | 8.49 | ±0.10cB | 7.54 | ±0.04bA | 3.01 | ±0.37aA | 3.02 | ±0.10aA | 2.99 | ±0.21aA | 2.96 | ±0.16aA | 2.93 | ±0.17aA | 2.85 | | ±0.17aA |
| Oleic acid 18:1(n-9) | 18.67 | ±0.99a | 32.05 | ±1.32bA | 31.69 | ±0.10bA | 17.16 | ±1.47aA | 17.56 | ±1.85aA | 16.99 | ±1.53aA | 17.25 | ±2.04aA | 16.70 | ±1.22aA | 16.70 | | ±1.50aA |
| Linoleic acid 18:2(n-6) | 70.29 | ±4.57b | 14.09 | ±0.82aA | 15.37 | ±0.04aA | 70.38 | ±2.90bA | 69.63 | ±2.26bA | 69.67 | ±4.00bA | 69.53 | ±3.58bA | 68.47 | ±2.39bA | 67.34 | | ±2.88bA |
| Linolenic acid 18:3(n-3) | 0.12 | ±0.01a | 0.25 | ±0.03bA | 0.74 | ±0.00cB | 0.11 | ±0.01aA | 0.24 | ±0.03bB | 0.11 | ±0.01aA | 0.22 | ±0.01bB | 0.10 | ±0.00aA | 0.22 | | ±0.01bB |
| Arachidic acid 20:0 | 0.53 | ±0.07a | 0.45 | ±0.03aA | 0.48 | ±0.01aA | 0.73 | ±0.03bA | 0.80 | ±0.01bcA | 0.89 | ±0.11cA | 0.89 | ±0.04cA | ---- |  | 0.48 | | ±0.01a |
| Gondoic acid 20:1(n-9) | 0.22 | ±0.03b | 0.12 | ±0.01aA | 0.24 | ±0.01bB | 0.21 | ±0.01bA | 0.24 | ±0.01bA | 0.21 | ±0.03bA | 0.22 | ±0.01bA | 0.22 | ±0.01bA | 0.21 | | ±0.01bA |
| Behenic acid 22:0 | 0.38 | ±0.06b | ---- |  | 0.15 | ±0.01a | 0.56 | ±0.04cA | 0.61 | ±0.04cdA | 0.70 | ±0.03eA | 0.69 | ±0.03deA | 0.97 | ±0.08f | ---- | |  |
| SFA | 10.61 | ±0.99 a | 51.38 | ± 3.39bA | 51.84 | ±8.56bA | 11.29 | ±1.13a | 11.39 | ±1.27a | 11.69 | ±1.27a | 11.46 | ±1.06a | 10.64 | ±1.06a | 10.07 | | ±0.92a |
| MUFA | 18.98 | ±1.98a | 32.35 | ±4.31bA | 32.09 | ±2.83bA | 17.37 | ±2.05a | 17.80 | ±2.55a | 17.20 | ±2.40a | 17.47 | ±2.19a | 16.92 | ±2.26a | 16.91 | | ±2.26a |
| PUFA | 70.41 | ±8.63a | 14.34 | ±1.63bA | 16.11 | ±1.56bA | 70.49 | ±9.19a | 69.87 | ±8.27a | 69.78 | ±9.62a | 69.75 | ±8.27a | 68.57 | ±8.13a | 67.56 | | ±6.72a |
| UFA | 89.39 | ±9.90a | 46.69 | ±5.37bA | 48.20 | ±4.53bA | 87.86 | ±11.10aA | 87.67 | ±9.40aA | 86.98 | ±8.49aA | 87.22 | ±9.76aA | 85.49 | ±9.33aA | 84.47 | | ±14.78aA |
| PUFA/SFA | 6.64 | ±0.64a | 0.28 | ±0.00bA | 0.31 | ±0.07bA | 6.24 | ±0.64aA | 6.13 | ±0.64aA | 5.97 | ±0.35aA | 6.09 | ±0.57aA | 6.44 | ±0.78aA | 6.71 | | ±0.57aA |
| UFA/SFA | 8.43 | ±1.77a | 0.91 | ±0.14bA | 0.93 | ±0.07bA | 7.78 | ±0.71aA | 7.70 | ±0.71aA | 7.44 | ±0.78aA | 7.61 | ±0.85aA | 8.03 | ±0.92aA | 8.39 | | ±1.27aA |
| Parameters |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |  |
| PV (meqO2/kg) | 3.76 | ±0.53a | 27.76 | ±2.98eB | 4.80 | ±0.50abA | 7.72 | ±0.39bB | 5.60 | ±0.47abA | 4.30 | ±0.08aA | 6.36 | ±0.01bB | 4.76 | ±1.03aA | 4.59 | | ±1.42aA |
| FFA (% oleic acid) | 0.04 | ±0.01a | 0.08 | ±0.01abA | 0.22 | ±0.05cB | 0.07 | ±0.00aA | 0.05 | ±0.04aA | 0.07 | ±0.00aA | 0.05 | ±0.03aA | 0.09 | ±0.00bA | 0.11 | | ±0.01abA |
| K232 | 1.35 | ±0.21a | 5.27 | ±0.21cB | 4.47 | ±0.15abA | 2.01 | ±0.13abA | 6.12 | ±0.26cB | 2.34 | ±0.16abA | 6.03 | ±0.36cB | 1.73 | ±0.39aA | 4.37 | | ±0.28aB |
| K270 | ---- |  | 3.26 | ±0.08bA | 2.46 | ±0.28cA | ---- |  | 1.69 | ±0.13ab | ---- |  | 1.43 | ±0.21ab | ---- |  | 1.12 | | ±0.08a |
| 3-MCPD (mg/kg) | ---- |  | ---- |  | 1.89 | ±0.13c | ---- |  | 0.54 | ±0.06a | ---- |  | 0.37 | ±0.03a | ---- |  | 0.52 | | ±0.04a |
| Glycidyl (mg/kg) | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | ---- |  | 0.27 | ±0.01a | ---- |  | 1.01 | | ±0.16b |

Values are shown as mean ± standard deviation (n = 3); Different lowercase letters on the same line as exponents indicate that the difference between the means is significant (p<0.05); Capital letters given as exponents on the same line and in the same sample indicate that the difference between pre-cooking and post-cooking averages is significant (p<0.05); SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; UFA, unsaturated fatty acids; PV, peroxide value; FFA, free fatty acids; K232, conjugated dienes; K270, conjugated trienes; 3-MCPD, esters of 3-chloro-1,2-propanediol; OB3, oleogel made with safflower oil + 3% beeswax; OB5, oleogel made with safflower oil + 5% beeswax; OB10, oleogel made with safflower oil + 10% beeswax