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Physicochemical and sensory characteristics of traditional Kırklareli meatballs with added cowpea (*Vigna unguiculata*) flour

Esra Kahraman*, Orhan Dağlioğlu and İsmail Yilmaz

Abstract

The effects of cowpea (*Vigna unguiculata*) flour on some physical, chemical, textural and sensory properties of Kırklareli meatballs were investigated. For this purpose, cowpea flour was added to the traditional Kırklareli meatball formulation in four different proportions (2, 4, 6 and 8%). As a result of the analysis on cowpea flour; pH, water activity (a_w), moisture, protein, fat, ash, carbohydrate, acidity, starch, total dietary fiber, total monounsaturated fatty acids, total polyunsaturated fatty acids, total unsaturated fatty acids and total saturated fatty acids were found as 6.25, 0.52, 10.20, 20.35, 0.53, 2.94, 65.43%, 0.06, 45.09, 20.90, 5.86, 59.88, 65.74 and 34.26%, respectively. Depending on the increase in incorporation rate of cowpea flour, changes in *L** (43,40-53,88), *b** (13,92-18,11), pH (5,83-5,94), a_w (0,96-0,98), moisture (44,03-50,63%), protein (17,70-21,89%), fat (19,49-22,97%), carbohydrate (6,77-12,11%), salt (1,28-1,74%), total dietary fiber (2,81-5,08%) values of the raw samples and *a** (5,64-9,44), *b** (9,77-18,06), moisture (39,27-45,24%), protein (19,92-23,45%), fat (23,08-26,19%), carbohydrate (5,92-11,30%), total dietary fiber (3,28-5,40%) values of the cooked Kırklareli meatball samples were statistically significant ($P < 0.05$), while the changes in weight loss, ash, free fatty acidity, texture and sensory results were found insignificant ($P > 0.05$). Total saturated, total unsaturated and *trans* fatty acid contents of cowpea flour added meatball samples were significantly ($P < 0.05$) different from the control samples. In the sensory analysis, meatball samples with 4% cowpea flour received the highest general acceptability score. According to the obtained data, cowpea flour can be added up to 4% on basic meat values without changing the textural and sensory properties of Kırklareli meatballs. Cowpea flour could be added as a functional ingredient in meatballs.

Keywords: Cowpea, Meatball, Functional food, Dietary fiber

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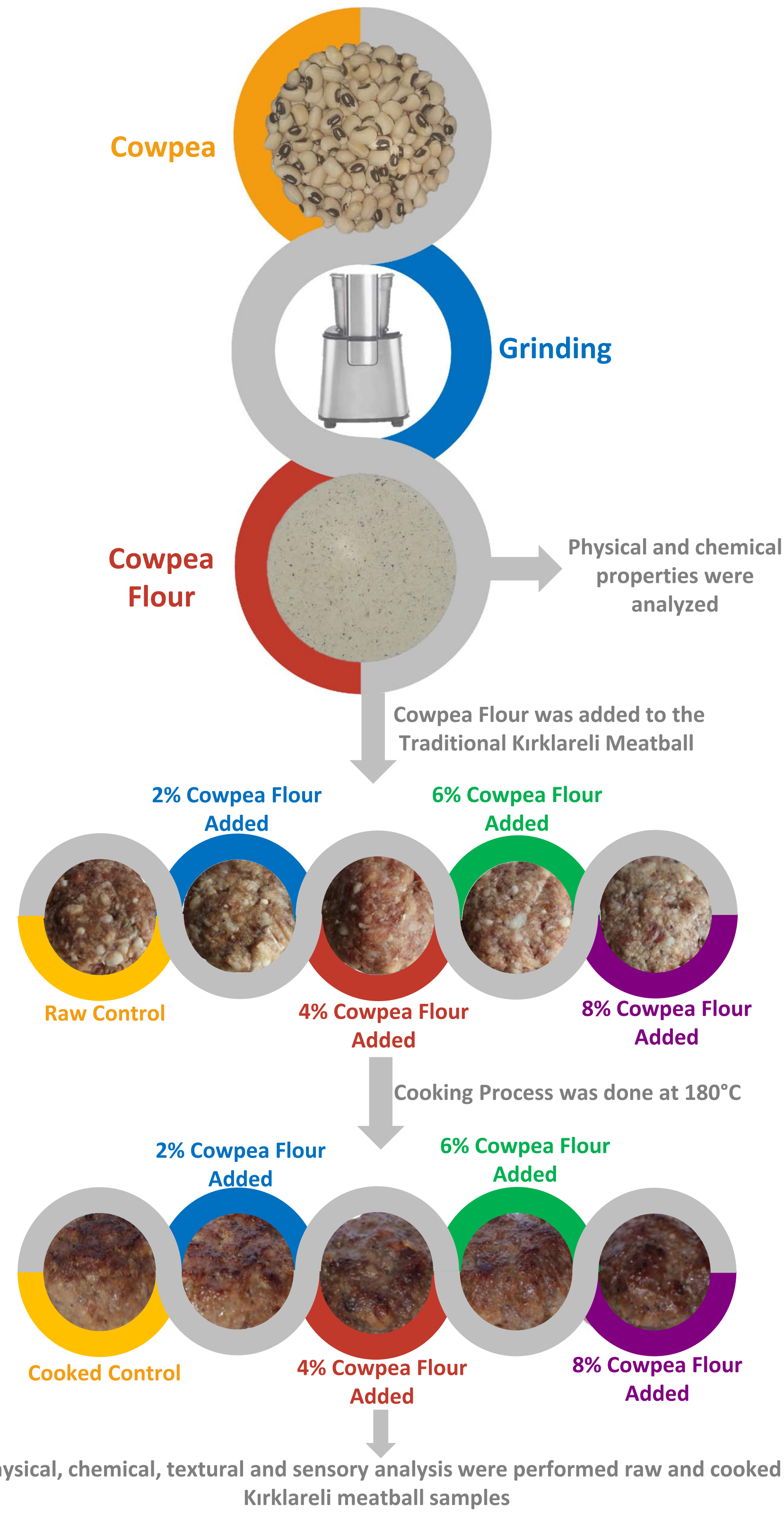
Graphical Abstract



Introduction

People prefer to consume functional foods, especially by investigating the effects of nutritional components on health in their daily diets. Functional food is fresh, processed, fortified food which has health promoting, preventing against diseases and nutrient supplying property. Meat and meat products do not directly belong to the functional food group. Meat and meat products can be improved by adding components that are considered beneficial and by eliminating or reducing the components that are thought to be harmful. Functional meat and product development strategies are focused on increasing the presence of beneficial compounds and limiting ingredients that have negative health impacts of meat and meat products. (Nisa et al. 2017; Tomar et al. 2022; Xu et al. 2022; Singh 2022).

Meat as a component of human nutrition provides a good source of nutriments including protein, fatty acids, vitamins, minerals and various bioactive components. Some of these nutriments such as essential amino acids, vitamin B_{12}, iron, zinc, phosphorus and folic acid do exist or don't in variable but small in other food. However, high consumption of meat and meat products may be associated with undesirable health effects such as hypertension, coronary heart disease, stroke, certain types of cancer and obesity due to their high content of saturated fatty acids and cholesterol (Jiménez-Colmenero et al. 2001; Bilek and Turhan 2009; Şimşek and Kılıç 2016; Turp, Reçber and Gençoğlu 2016; Denktaş 2017).

The meatball is one of the most preferred meat products of the Turkish cuisine all through the time. Within the Turkish cuisine culture, meatballs are called according to their regions, cooking methods and utensils that are used while cooking. Kırklareli is a city located in the European part of Turkey which is surrounded by Strandzha Mountains. In the local cuisine of the city, meatball is one of the well-known traditional food as well as its meat coming from the grazing animals in Strandza Mountains. Spices are not used in the formula in order not to overcome the meat taste (Anonymous 2018a; Anonymous 2018b; Saçılık and Çevik 2019).

Various additives are included in the production of meatball to reduce the amount of fat, slow down lipid oxidation as well as to increase shelf life and to improve sensory and functional properties. In some researches on this subject, the chemical, physical and sensory properties of meatball type meat products have been examined by adding organic additives such as legume flour (Serdaroğlu, Yıldız-Turp and Abrodímov 2005; Teye and Boamah 2012; Akwetey, Oduro & Ellis 2014; Aslinah, Yusoff & Ismail-Fitry 2018) and dietary fiber (Yaşarlar, Dağlıoğlu & Yılmaz 2007; Modi, Yashoda & Naveen 2009; Turp et al. 2016; Kehlet, Pagter, Aaslyng, & Raben 2017a; Kilincceker and Yilmaz 2019; Niu, Fang, Huo, Sun, Gong & Yu 2020; Zhao, Guo, Liu, & Xiao 2021) to increase their functional properties.

Cowpea (*Vigna unguiculata*) is a low cost, quite nutritious, heat and drought tolerant legume with global production (dry cowpea) of about 8.9 million tons in 2020 harvest season. It's consumed to complete dietary requirements as a protein and micronutrient in many parts of the world. Besides te contents of high protein and carbohydrate with a low fat content, cowpea includes many bioactive components such as dietary fiber (soluble and insoluble), polyphenols, minerals and vitamins. Due to rich and well-balanced nutritional composition it has very useful effects in the control and prevention of chronic diseases such as diabetes, cancer and cardiovascular diseases. Among the prevention mechanisms of chronic diseases, the most widely accepted are related to the presence of components such as dietary fiber, phytochemicals, and proteins and peptides in cowpea. Although there are many studies to determine the higher nutritional content and the positive effects of cowpea in terms of health there are not enough studies on the use of cowpea as a functional additive in food by processing it with various methods (Cavalcante et al. 2016; Awika and Duodu 2017; Uzun 2017; Jayathilake et al. 2018; Adjei-Fremah et al. 2019; FAO 2020).

To the best of our knowledge, there is no any study investigating the addition of cowpea flour to meatballs to formulate low-fat and functional food rich in dietary fiber. The aim of this study was to examine the physical, chemical and textural properties of raw and cooked meatball samples by adding cowpea flour in different proportions to the formulation of Kırklareli meatballs and to determine the functional ingredient potential of cowpea flour.

Material and methods

The dry cowpea (*Vigna unguiculata*) samples used in the formulation of Kırklareli meatballs were purchased from a local producer at the Kırklareli public market in 2020 harvest season. Seeds were searched for foreign substance and the imperfect ones were discarded. Cowpeas were ground into flour by grinding with an electric grinder (Fakir, Roxy 220 W) in the laboratory of Tekirdağ Namık Kemal University Food Engineering Department.

In the production of traditional Kırklareli meatballs, 70% minced beef and 30% minced lamb were used as meat. Depending on the total minced meat amount of (w/w), 10% bread crumbs, 1.5% salt and 1% onion were added but no spices in the meatball formulation.

All ingredients in Kırklareli meatball recipe were kneaded until acquiring a homogeneous blend. Meatball dough (10 kg in total) prepared actually to the traditional recipe was divided into five equal parts (2 kg for each sample) and one part was used for control meatball samples. 2, 4, 6 and 8% cowpea flour was added to the resting four pieces of meatball dough, respectively, and each dough was kneaded again until getting a homogeneous mixture. Each meatball sample has become 30 g in weight and then rounded and shaped slightly, and rested at + 4 °C for one day like having been done traditionally.

The cooking process of Kırklareli meatball samples was actualized on a hot plate at 180 °C and both sides of them were cooked for 3 minutes. Raw and cooked meatball samples were placed in polyethylene boxes and stored at − 18 °C throughout the analysis. Physical, chemical, textural and sensory analysis were performed on raw and cooked meatball samples. Some physical and chemical properties of cowpea flour were also analyzed.

Sieve analysis of the cowpea flour were done according to the methods described by Uluöz (1965). Moisture analysis of the samples was determined according to the methods described by AOAC (1990); pH and free fatty acidity analysis by Gamlı (2015); fatty acid composition by AOCS (1993); protein, fat and carbohydrate analysis by AOAC (2000), Bilek and Turhan (2009) and Cemeroğlu (2013); ash analysis by Gökalp, Kaya, Zorba and Tülek (1993); starch analysis by ICC (2017); total dietary fiber analysis by AOAC (1995) and salt analysis by AOAC (2000).

Fat extracted from meatballs was used in fatty acid analysis. In order to detect fatty acid profile with GC-FID, fat extracts were converted into methyl ester by transesterification. Methylation was done $NaOCH_3$/methanol (0.5 ml and 1 N) for 10 min at 50 °C followed by an excess of BF3/methanol for 10 min at 50 °C (AOCS 1993).

The fatty acid methyl esters (FAME) were separated by gas chromatography using a Shimadzu 2100 Gaseous Chromatography System equipped by an automatic split injector, a polar capillary column TR-CN100 (0.25 mm × 100 m × 0.2 mm) that was used for the analysis of the fatty acids. Inlet temperature was set to 250 °C. Helium was used as carrier gas and its flow rate (He) was adjusted to 30 ml/min. Heating program started at 100 °C elevating to 240 °C with an increasing rate of 3 °C/min and was applied for a total of 60 minutes out of which 10 minutes were at 240 °C (100 m, 0.25 mm i.d., 0.2 μm film thickness), and a flame ionization detector. Helium was used as carrier gas. Each peak was identified and quantified using a 37 component FAME mix standard (Buchanan, Stenerson & Sidisky 2020).

Colour measurements (L^* (lightness), a^* (redness) and b^* (yellowness)) were done using Konica Minolta CR-5 with illuminant D65, 2° observer angle, diffuse/O mode, 8 mm aperture for illumination and 8 mm for measurement and evaluation was performed according to Hunt et al. (1991). Water activity (a_w) measurements were carried out using Aqua Lab (model 4TE) measuring device (Can Karaca, Guzel & Ak 2016). Weight loss analysis of the meatball samples were performed according to Yılmaz (2004). Textural analysis of Kırklareli meatball samples were done using a texture analyzer (Stable Micro Systems TA HD PLUS Texture Analyzer) under 25 kg load cell at 2.6 mm/s test speed. Firmness and toughness parameters were calculated upon the data recorded by the device.

Sensory evaluation was carried out according to the testing procedures of AMSA and IFT (1985). Samples used in sensory evaluation were simultaneously cooked and taken into sensory evaluation again. The sensory evaluation of the cooked meatball samples was made by 9 panel-trained experts from Tekirdağ Namık Kemal University, Department of Food Engineering. The ages of the panelists participating in the sensory evaluation were

Table 1 Physical and chemical analysis results of cowpea flour

Parameters	Cowpea Flour
Particle size (%) > 500 μm	32.25 ± 0.03
Particle size (%) 500–300 μm	21.78 ± 0.01
Particle size (%) < 300–100 μm	25.67 ± 0.02
Particle size (%) < 100 μm	20.30 ± 0.02
L^*	90.24 ± 0.04
a^*	−0.17 ± 0.00
b^*	2.47 ± 0.00
Water activity (a_w)	0.52 ± 0.00
pH	6.25 ± 0.10
Acidity (%)	0.06 ± 0.01
Moisture (%)	10.20 ± 0.02
Protein (%)	20.35 ± 0.03
Fat (%)	0.53 ± 0.01
C16:0	22.47 ± 0.66
C18:0	5.60 ± 0.30
C18:1n9c	5.86 ± 0.28
C18:2n6c	29.79 ± 0.79
C20:0	1.57 ± 0.06
C18:3n6	30.09 ± 1.07
C22:0	2.86 ± 0.07
C24:0	1.76 ± 0.05
Total monounsaturated	5.86 ± 0.29
Total polyunsaturated	59.88 ± 1.09
Total unsaturated	65.74 ± 1.11
Total saturated	34.26 ± 0.91
Ash (%)	2.94 ± 0.01
Carbohydrate (%)	65.43 ± 0.36
Starch (%)	45.09 ± 0.03
Total dietary fiber (%)	20.90 ± 0.01

Values are means ± standard error of three replicates

Table 2 Analysis results of raw Kırklareli meatball

Parameters	Treatments*				
	1	2	3	4	5
*L**	43.40 ± 1.14[b]	50.69 ± 0.71[a]	50.94 ± 1.60[a]	53.88 ± 1.26[a]	53.14 ± 1.22[a]
*a**	8.63 ± 0.64[a]	8.09 ± 0.29[a]	7.84 ± 0.71[a]	7.53 ± 0.40[a]	7.06 ± 0.45[a]
*b**	13.92 ± 0.58[b]	17.26 ± 0.35[a]	17.21 ± 0.22[a]	16.39 ± 0.51[a]	18.11 ± 0.39[a]
Water activity (a_w)	0.98 ± 0.01[a]	0.97 ± 0.00[ab]	0.97 ± 0.00[ab]	0.97 ± 0.01[ab]	0.96 ± 0.00[b]
pH	5.83 ± 0.02[c]	5.89 ± 0.00[b]	5.92 ± 0.01[ab]	5.92 ± 0.00[ab]	5.94 ± 0.01[a]
Moisture (%)	50.63 ± 0.13[a]	49.37 ± 0.32[a]	47.11 ± 0.34[b]	44.83 ± 0.39[c]	44.03 ± 0.21[c]
Protein (%)	17.70 ± 0.20[c]	18.90 ± 0.10[b]	19.82 ± 0.22[b]	21.53 ± 0.20[a]	21.89 ± 0.10[a]
Fat (%)	22.97 ± 0.14[a]	22.04 ± 0.19[ab]	21.40 ± 1.22[ab]	20.30 ± 0.40[ab]	19.49 ± 0.22[b]
Ash (%)	1.94 ± 0.04[a]	2.02 ± 0.02[a]	2.48 ± 0.47[a]	2.48 ± 0.52[a]	2.49 ± 0.49[a]
Carbohydrate (%)	6.77 ± 0.32[c]	7.64 ± 0.66[c]	9.20 ± 0.38[bc]	10.90 ± 0.42[ab]	12.11 ± 0.53[a]
Salt (%)	1.74 ± 0.03[a]	1.56 ± 0.02[ab]	1.51 ± 0.06[b]	1.40 ± 0.04[bc]	1.28 ± 0.01[c]
Total dietary fiber (%)	2.81 ± 0.05[e]	3.23 ± 0.03[d]	3.77 ± 0.03[c]	4.17 ± 0.04[b]	5.08 ± 0.05[a]
Free Fatty Acidity (%)	1.61 ± 0.33[a]	1.57 ± 0.05[a]	1.46 ± 0.03[a]	1.43 ± 0.03[a]	1.46 ± 0.10[a]
Hardness (N)	4.62 ± 0.50[a]	4.83 ± 0.23[a]	5.02 ± 0.19[a]	5.39 ± 0.45[a]	5.83 ± 0.12[a]
Firmness (g.sn)	4073.01 ± 85.4[a]	4251.22 ± 100.5[a]	4657.58 ± 66.4[a]	4684.59 ± 80.3[a]	4752.95 ± 61.8[a]

Values are means ± standard error of three replicates

*(1): Raw control sample, (2): 2% cowpea flour was added raw sample, (3): 4% cowpea flour was added raw sample, (4): 6% cowpea flour was added raw sample, (5): 8% cowpea flour was added raw sample. Means within the same row with differeent superscripts are significantly different ($P < 0.05$)

Table 3 Analysis results of cooked Kırklareli meatball

Parameters	Treatments[a]				
	1	2	3	4	5
Weight loss (%)	10.67 ± 0.84[a]	8.67 ± 1.07[a]	8.01 ± 1.00[a]	7.83 ± 0.93[a]	6.67 ± 0.13[a]
*L**	38.12 ± 0.95[a]	38.44 ± 0.71[a]	38.99 ± 0.44[a]	39.00 ± 0.33[a]	39.39 ± 2.19[a]
*a**	5.65 ± 0.48[c]	6.48 ± 0.52[c]	7.28 ± 0.30[bc]	8.79 ± 0.34[ab]	9.44 ± 0.47[a]
*b**	9.94 ± 0.16[b]	9.77 ± 0.27[b]	16.08 ± 0.99[a]	16.43 ± 0.46[a]	18.06 ± 1.30[a]
Water activity (a_w)	0.96 ± 0.01[a]	0.96 ± 0.00[a]	0.96 ± 0.01[a]	0.95 ± 0.02[a]	0.94 ± 0.02[a]
pH	6.03 ± 0.01[a]	6.03 ± 0.01[a]	6.04 ± 0.01[a]	6.07 ± 0.01[a]	6.08 ± 0.01[a]
Moisture (%)	45.24 ± 0.31[a]	42.66 ± 0.21[b]	41.18 ± 0.44[c]	40.56 ± 0.10[cd]	39.27 ± 0.30[d]
Protein (%)	19.92 ± 0.10[c]	20.89 ± 0.06[c]	21.23 ± 0.65[bc]	22.69 ± 0.14[ab]	23.45 ± 0.08[a]
Fat (%)	26.19 ± 0.24[a]	25.94 ± 0.20[a]	25.48 ± 0.13[ab]	23.63 ± 0.50[ab]	23.08 ± 0.17[b]
Ash (%)	2.74 ± 0.02[a]	2.75 ± 0.08[a]	2.84 ± 0.07[a]	2.89 ± 0.12[a]	2.91 ± 0.07[a]
Carbohydrate (%)	5.92 ± 0.70[c]	7.77 ± 0.41[bc]	9.28 ± 0.65[ab]	10.24 ± 0.66[ab]	11.30 ± 0.20[a]
Salt (%)	1.86 ± 0.06[a]	1.75 ± 0.04[a]	1.62 ± 0.12[a]	1.54 ± 0.07[a]	1.49 ± 0.09[a]
Total dietary fiber (%)	3.28 ± 0.03[a]	3.60 ± 0.02[b]	3.97 ± 0.04[c]	4.80 ± 0.01[d]	5.40 ± 0.04[e]
Free fatty acidity (%)	1.52 ± 0.06[a]	1.58 ± 0.05[a]	1.58 ± 0.04[a]	1.60 ± 0.05[a]	1.44 ± 0.10[a]
Hardness (N)	14.09 ± 2.28[a]	14,68 ± 1.01[a]	15.58 ± 0.45[a]	16.11 ± 3.01[a]	16.55 ± 0.22[a]
Firmness (g.sn)	10,410.52 ± 684[a]	10,655.62 ± 558[a]	10,974.81 ± 576[a]	11,897.77 ± 994[a]	12,482.74 ± 622[a]

Values are means ± standard error of three replicates[a](1): Cooked control sample, (2): 2% cowpea flour was added cooked sample, (3): 4% cowpea flour was added cooked sample, (4): 6% cowpea flour was added cooked sample, (5): 8% cowpea flour was added cooked sample. Means within the same row with differeent superscripts are significantly different ($P < 0.05$)

between 24 and 55 years old, and 5 of them men and 4 women. In the pre-evaluation test we conducted, it was determined that the panelists' income and the amount of meat they consumed per month were quite close to each other. Samples were served to the panelists randomly around 60 °C. Panelists scored the appearance, colour, smell, taste, texture and general acceptability criteria of the meatballs according to the hedonic scale: very good

Table 4 Fatty acid composition of raw Kırklareli meatball

Fatty acids (%)	Treatments*				
	1	2	3	4	5
Total trans	2.99 ± 0.52^{c}	3.37 ± 0.45^{a}	3.28 ± 0.64^{b}	1.99 ± 0.56^{d}	1.97 ± 0.51^{d}
Total saturated	52.61 ± 1.78^{d}	54.31 ± 1.68^{c}	54.78 ± 1.71^{b}	54.87 ± 1.75^{b}	55.32 ± 1.69^{a}
Total monounsaturated	43.49 ± 1.61^{a}	42.00 ± 1.38^{b}	41.30 ± 1.52^{c}	40.78 ± 1.36^{d}	40.84 ± 1.59^{d}
Total polyunsaturated	3.87 ± 0.38^{a}	3.15 ± 0.64^{d}	3.47 ± 0.54^{c}	3.77 ± 0.52^{b}	3.79 ± 0.51^{ab}
Total unsaturated	47.36 ± 1.32^{a}	45.15 ± 1.36^{b}	44.77 ± 1.24^{c}	44.55 ± 1.35^{d}	44.63 ± 1.34^{d}
Total unsaturated/ Total saturated	0.90	0.83	0.82	0.81	0.81

Values are means ± standard error of three replicates[a](1): Raw control sample, (2): 2% cowpea flour was added raw sample, (3): 4% cowpea flour was added raw sample, (4): 6% cowpea flour was added raw sample, (5): 8% cowpea flour was added raw sample. Means within the same row with diffeerent superscripts are significantly different ($P < 0.05$)

Table 5 Fatty acid composition of cooked Kırklareli meatball

Fatty acids (%)	Treatments[a]				
	1	2	3	4	5
Total trans	2.76 ± 0.28^{b}	2.85 ± 0.31^{a}	2.71 ± 0.34~~b~~^{c}	2.66 ± 0.21^{c}	2.58 ± 0.25^{d}
Total saturated	54.00 ± 1.56^{c}	53.16 ± 1.62^{d}	56.61 ± 1.69^{a}	54.54 ± 1.57^{b}	54.69 ± 1.59^{b}
Total monounsaturated	42.90 ± 1.52^{b}	43.33 ± 1.57^{a}	42.99 ± 1.59^{b}	41.48 ± 1.54^{c}	41.53 ± 1.53^{c}
Total polyunsaturated	3.08 ± 0.34^{c}	3.20 ± 0.29^{c}	3.40 ± 0.26^{b}	3.55 ± 0.31^{ab}	3.70 ± 0.32^{a}
Total unsaturated	45.98 ± 1.35^{b}	46.53 ± 1.38^{a}	46.39 ± 1.49^{a}	45.03 ± 1.46^{d}	45.23 ± 1.51^{c}
Total unsaturated/ Total saturated	0.85	0.83	0.82	0.83	0.83

Values are means ± standard error of three replicates[a](1): Cooked control sample, (2): 2% cowpea flour was added cooked sample, (3): 4% cowpea flour was added cooked sample, (4): 6% cowpea flour was added cooked sample, (5): 8% cowpea flour was added cooked sample. Means within the same row with diffeerent superscripts are significantly different ($P < 0.05$)

(9), good (7–8), medium (4–5-6) and bad (1–2). Sensory evaluation was repeated three times with the same panelists.

In order to determine the effects of cowpea flour addition at different ratios on each turn, the data obtained as a result of three replication of chemical, physical, textural and sensorial analysis was subjected to one-way analysis of variance (ANOVA). For of the all analysis that was conducted, a linear mixed model ANOVA with different cowpea flour concentrations as a fixed effect and replicates as a random terms was used.

For the analysis of factors affecting each sensory analysis (appearance, colour, smell, taste, texture and general acceptability criteria), different cowpea flour concentrations were fitted as fixed term. Panelist and session were included as a random term in the model for the sensory data. The analysis was evaluated by JMP 5.0.1. statistical package program and differences among the meat samples as a model factor were compared using Tukey HSD test. Differences among meatball samples were considered significant at $P < 0.05$. (Mayuoni-Kirshinbaum, Daus & Porat 2013; Biffin, Smith, Bush, Morris & Hopkins 2020).

Results and discussion

Analysis results of cowpea flour

Physical and chemical analysis results of cowpea flour are given in Table 1. Sieve analysis was performed to determine the particle size of cowpea flour used in the production of Kırklareli meatball samples. According to the results, 32.25% of cowpea flour is bigger than 500 µm in particle size, 47.45% is between 500 and 100 µ and 20.30% of it is smaller than 100 µm. Cowpea flour has higher L^* (brightness) value (90.24 ± 0.07) and lower a^* (redness) (− 0.17 ± 0.01) and b^* (yellowness) values (2.47 ± 0.01) than the results of Naiker, Gerrano & Mellem (2019) who found the L^*, a^* and b^* values between 85.10–87.60; 0.76–1.49 and 11.35–13.10 respectively for five kinds of cowpea flour. Water activity (a_w), pH and acidity values of the cowpea flour were found as 0.52 ± 0.00, 6.25 ± 0.17 and 0.06 ± 0.01 respectively (Table 1) however no data found in the literature related with these parameters.

As a legume cowpea has low moisture and high protein content. The moisture (10.20% ± 0.04), protein (20.35% ± 0.06), ash (2.94% ± 0.01) and carbohydrate (65.43% ± 0.62) contents of cowpea flour sample were found similar to the findings of Naiker et al. (2019), Serdaroğlu, Yıldız-Turp & Abrodímov (2005) and Sreerama, Sashikala, Pratape & Singh (2012); the total dietary fiber content (20.90% ± 0.01) were higher than the data of Sreerama et al.(2012); fat (0.53% ± 0.01) and starch (45.09% ± 0.05) contents were found lower than the values of Serdaroğlu et al. (2005) and Naiker et al. (2019). Differences with the literature values could be resulting from the genotype, climate, growing conditions of cowpea as well as the extraction degree of cowpea flour.

Analysis results of raw and cooked Kırklareli meatballs

Moisture

The addition of cowpea flour affected ($P < 0.05$) the moisture content of the raw meatball samples and gradual decrease was observed as the addition of it increased. While moisture content of the raw samples was between 50.63 to 44.03% (Table 2), %8 cowpea flour added meatball sample had the lowest value ($P < 0.05$). Serdaroğlu et al. (2005) and Teye and Boamah (2012) reported higher moisture values respectively in legume flour (blackeye bean flour, chickpea flour and lentil flour) added low-fat meatballs (63.1–65.0%) and cowpea flour added beef burgers (75.75–78.11%) and hamburgers (61.94–66.39%). Cooked meatball samples had a moisture content ranging from 39.27 to 45.24% (Table 3). The moisture contents of the cooked samples decreased with more cowpea flour addition. Meatballs with added 8% cowpea flour have higher moisture during cooking than meatballs with other addition levels. The cowpea flour addition significantly ($P < 0.05$) reduced the moisture contents of raw and cooked Kırklareli meatball samples. Similar findings have been reported previously for meatballs formulated with different plant-based materials (Yılmaz 2004; Serdaroğlu 2006; Kılınççeker 2020; Ran et al. 2020).

Protein

The protein contents of raw and cooked meatball samples ranged between 17.70 to 21.89% (Table 2) and 19.92 to 23.45% (Table 3), respectively. Cooked meatball samples exhibited higher protein contents than raw samples. The highest protein content was 23.45% for 8% cowpea flour added sample and the lowest was 19.92% for control sample. Results clearly showed that addition of cowpea flour significantly ($P < 0.05$) increased protein contents of meatball samples. The protein contents of all meatball samples were within the limits (min. 12%) of Turkish Food Codex (TFC 2019). These results seem quite consistent with the studies performed by Serdaroğlu et al. (2005); Teye and Boamah (2012) and Zhao et al. (2021).

Fat content

The fat contents of raw and cooked Kırklareli meatball samples are given in Table 2 and Table 3, respectively. The lowest fat content was 23.08% for 8% cowpea flour added cooked sample and the highest was 26.19% for cooked control sample. Cowpea flour addition gradually decreased the fat content of the samples however a significant ($P < 0.05$) reduction was obtained at 8% cowpea flour level. Results revealed that cowpea flour addition may help to reduce calorie level and to increase protein content of meatballs and some other meat products. The fat values for all samples were within the limits (max. 25%) of Turkish Food Codex (TFC 2019). Our results are in accordance with Yılmaz (2004), Yılmaz (2005) and Bağdatlı (2018).

Fatty acids

Fatty acid composition and *trans* fatty acids of control and cowpea flour added (2–8%) raw and cooked Kırklareli meatball samples are shown in Table 4 and Table 5, respectively. Total saturated and total unsaturated fatty acid contents of raw and cooked control samples were significantly ($P < 0.05$) different from the cow pea added raw and cooked samples. There were also significant ($P < 0.05$) differences among the amounts of total polyunsaturated fatty acids of cowpea added controls and both raw and cooked samples. While the ratio of total unsaturated fatty acids and total saturated fatty acids was 0.83, 0.82, 0.83 and 0.83 in the cowpea added cooked samples 2, 4, 6 and 8% respectively, it was 0.85 for the cooked control samples. Yılmaz (2004), Yılmaz (2005) and Ran et al. (2020) have reported similar results for the values of total saturated and total unsaturated fatty acids.

Trans fatty acids (TFAs) are formed artificially during the partial hydrogenation process of vegetable oils for production of margarine and vegetable shortening. They are also produced in ruminants via biohydrogenation, and naturally occur in dairy and meat fats. Concerns have existed related with the unwanted effects of TFAs in the diet, because of a possible relationship between TFAs intake and cardiovascular disease. Long term population based metabolic studies have shown that intake of TFSs increase plasma concentrations of low-density-lipoprotein (LDL) and reduce concentrations of high-density lipoprotein (HDL). In addition, TFSs increased the total cholesterol to HDL approximately twice compared to the saturated fats. To promote cardiovascular health, diets should contain a very low content of TFAs (hydrogenated oils and fats). In practice, intake of TFAs should be less than 1% of daily calorie intake, with a shift in fat consumption away from saturated fats and TFAs to unsaturated fats. In many countries food items such as margarines, shortenings, baking goods and deep-fried foods were previously loaded with industrial TFAs. In the latest years however, the contents of TFAs in these food are very low, which has resulted in a substantial decrease in the intake of industrial TFAs (Lichtenstein 1998; WHO 2003; Oteng and Kersten 2020; Hirata 2021; Nagpal et al. 2021). Limited consumption of TFA sourced food is the most effective way of reducing TFA intake. However, TFAs cannot be completely eliminated from human diets due to their existence in the meat and dairy products of ruminants. Animal fats can contain up to 8% of trans fatty acids, and the predominant trans-fat in animal fats is vaccenic acid (11-*trans* C18:1) which represents 50–80% of the total ruminant TFAs intake. Elaidic acid (9-*trans* C18:1) is found in industrial products (Oteng and Kersten 2020; Nagpal et al. 2021).

The total *TFA* contents of raw and cooked meatball samples are given in Table 4 and Table 5, respectively. As in the raw meatball samples, the total *TFAs* of 6 and 8% cowpea added cooked samples were lower ($P<0.05$) than control cooked sample. The lowest amount of *TFAs* was measured in 8% cowpea flour added raw (1.97%) and cooked (2.58%) meatball samples. Yılmaz and Dağlıoğlu (2003) reported that the addition of oat bran into the meatballs decreased the content of total *TFAs* compared to the control samples. Similar results were also reported by Yılmaz (2004) for rye bran added meatballs and by Yılmaz (2005) wheat bran added meatballs.

Free fatty acidity

The free fatty acidity content of raw and cooked meatballs changed from 1.46 to 1.61% (Table 2) and 1.44 to 1.52% (Table 3), respectively. Addition of cowpea flour caused a decrease in free fatty acidity values of meatballs but the differences among the values were insignificant ($P>0.05$). Our results were found higher than the ones of Yılmaz (1998).

Ash content

The ash contents of both raw and cooked meatball samples also revealed a slight increase as the cowpea flour inclusion level increased (Table 2 and Table 3). Cooked samples had higher ash contents than raw ones. The highest value was 2.91% for 8% cowpea flour added cooked sample and the lowest was 1.94% raw control sample. Similar results were reported by Yaşarlar et al. (2007), Serdaroğlu (2006) and Yılmaz (2005).

Salt content

The salt content for both raw and cooked meatballs was lowest 8% for cowpea added samples and the highest in the control samples. The salt contents of 8% cowpea added raw and cooked samples were 1.28 and 1.49%, and that of raw and cooked control samples were 1.74 and 1.86%, respectively. The salt contents of both raw and cooked meatballs revealed a slight ($P>0.05$) decrease as the cowpea flour incorporation level increased. The salt values of all samples were within the limits of (max. 2%) Turkish Food Codex (TFC 2019). Similar results have been revealed by Yılmaz and Dağlıoğlu (2003), Serdaroglu, (2006), Turhan et al. (2007) and Bilek and Turhan (2009).

Carbohydrate content

The carbohydrate contents of raw and cooked meatball samples ranged from 6.77 to 12.11% (Table 2) and 5.92 to 11.30% (Table 3), respectively. Cooked meatball samples exhibited carbohydrate contents higher than raw samples due to loss of water during cooking process. The highest carbohydrate content was 11.30% for 8% cowpea flour added cooked samples and the lowest was 5.92% for control sample. Results reveal that addition of cowpea flour significantly ($P<0.05$) increased protein contents of meatball samples. The obtained results are consistent with the studies performed by Serdaroğlu et al. (2005) and Teye and Boamah (2012).

Dietary fiber

Dietary fiber (DF) is defined as a complex of plant-based polysaccharides resistant to digestion of human gastrointestinal enzymes. This complex includes indigestible nonstarch polysaccharides, cellulose, hemicellulose, oligosaccharides, pectins, gums and waxes. According to well-documented studies, DF consumption has been recognized to play a significant role in many physiological processes and it is related to the decrease in the incidence of various diseases such as type 2 diabetes, cardiovascular diseases, obesity, certain types of cancer and constipation (Galanakis et al. 2010; Cronin et al. 2021; Tuffi et al. 2021). Since meat is one of the major protein sources in daily diet and using the combination of both meat and DF in the formulation of meat products becomes a good way to enrich the diet (Tuffi et al. 2021). On the other hand, health authorities suggest that consumption of diets high in DF for both healthy and risk group populations means an increase in plant-based sources of protein and a reduction in animal protein intake. A recent study revealed that plant protein sourced diets improve satiety ratings and decrease energy intake than animal protein sourced diets in healthy men. However, these effects can be attributed to the higher DF or carbohydrate content of the plant-based diets and not just the protein source (Kristensen et al. 2016; Kehlet et al. 2017b). Therefore, cowpea flour with high protein (–20%) and DF (–20%) content is a good alternative to enrich meat products.

The total dietary fiber contents of raw and cooked meatball samples ranged from 2.81 to 5.08% (Table 2) and 3.28 to 5.40% (Table 3), respectively. The highest dietary

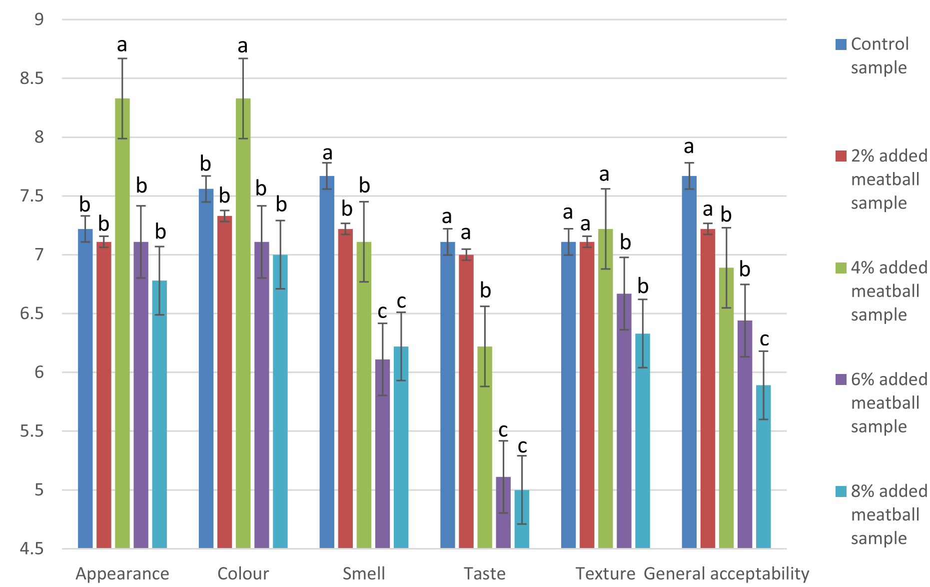


Fig. 1 Change in sensory analysis scores of Kırklareli meatball samples

Scores are presented on a 1–9 scale with 1 being bad and 9 being very good. Differences between means with a different letters exceed the estimate of least significant difference at 5% critical value. Comparisons were made on an individual trait basis and are applicable across infusion treatments within each trait (appearance, colour, smell, taste, texture and general acceptability).

fiber contents was 5.40% for 8% cowpea flour added cooked samples and the lowest was 2.81% for raw control samples. Results showed that addition of cowpea flour significantly ($P<0.05$) increased total dietary fiber contents of Kırklareli meatball samples. Cooked samples had also higher values than the raw ones due to the loss of water during cooking. These results are consistent with the work of Yaşarlar, Dağlıoğlu & Yılmaz (2007) and Ran et al. (2020).

Water activity (a_w)

The results of statistical analysis showed that values water activity (a_w) were not affected ($P>0.05$) by cowpea flour inclusion up to 8% level for raw samples (Table 2) and in all addition levels for cooked samples (Table 3). The a_w values of meatball samples were similar to the data of Elgasim and Al-Wesali (2000) that were added different ratio of samh flour and soya protein to beef meatballs (0.90–0.97), and higher than the average a_w value (0.88) of Malini, Arief, & Nuraini (2016) which were added durian and tapioca flour to meatballs.

pH

pH measurement is an important parameter because it directly affects water holding capacity, cooking yield, colour and shelf life of meat and meat products (Gökalp, Kaya and Zorba 2004). The pH values of raw and cooked meatball samples changed from 5.83 to 5.94 (Table 2) and 6.03 to 6.08 (Table 3) respectively. The pH value of cowpea flour (6.25 ± 0.17) (Table 1) is higher than the one of the raw control sample (5.83 ± 0.03). A gradual increase ($P<0.05$) was revealed in pH values of cowpea flour added samples. Although the pH value of raw samples gradually increased ($P<0.05$) by cowpea flour addition, cooking process has not affected ($P>0.05$) the pH value of the samples. Akwetey et al. (2014) reported similar findings (pH 5.88–5.94) in meatloafs formulated with the whole cowpea flour.

Colour

The Hunter L^* (lightness), a^* (redness) and b^* (yellowness) values of the raw and cooked Kırklareli meatball samples were given in Table 2 and Table 3, respectively. The L^* and b^* values of the raw control samples were significantly lower ($P<0.05$) than those of 2% cowpea flour added samples. However, there were no statistically significant differences ($P>0,05$) in the L^*, a^* and b^* values among the cowpea flour added raw meatball samples in all inclusion levels (Table 2). Cowpea flour addition has not also affected the a^* (redness) values of the cooked samples up to the 6% addition level and b* values up to the 2% level. The highest a^* and b^* values of cooked ones were obtained for 8% cowpea addition level. On the other hand, cowpea flour addition did not affect ($P>0.05$)

the meatball lightness, as measured by Hunter-L value (Table 3). The obtained results are consistent with the results of Yılmaz (2005) and Ran et al. (2020).

Hardness and firmness

Hardness and firmness values of both raw and cooked meatball samples showed a slight increase as the cowpea flour addition level increased (Table 2 and Table 3). The meatball sample produced with the incorporation of 8% cowpea flour had the highest hardness and firmness values however, addition of cowpea flour to the traditional Kırklareli meatball formula had no significant ($P>0.05$) effect on hardness and firmness values of all the samples. Our results are in accordance to the ones of Yılmaz and Dağlıoğlu (2003), Yılmaz (2004) and Serdaroğlu et al. (2005).

Weight loss

The weight loss values of meatball samples are shown in Table 3. The lowest value was 6.67% for 8% cowpea flour added samples and the highest was 10.67% for control samples. Addition of cowpea flour resulted in a slight decrease in weight loss values of meatballs but the differences among the values were insignificant ($P>0.05$). Similar results were also found by Yılmaz (2004) and Yılmaz (2005).

Sensory analysis

Sensory analysis scores of meatball samples are shown in Fig. 1. Addition of cowpea flour at 4% level improved the sensory preferences on appearance and colour. Preference scores showed that 8% cowpea flour addition gave the lowest taste (5) and general acceptability scores (5.89) ($P<0.05$). General acceptability scores also decreased as the cowpea flour content of the meatballs increased ($P<0.05$). Similar results have been revealed by Mansour and Khalil (1997) for wheat fiber added beef-burgers, wheat bran added meatballs (Yılmaz 2005), rye bran added meatballs (Yılmaz 2004), hazelnut pellicle added burgers (Turhan et al. 2007).

Conclusion

The addition of cowpea flour into the traditional Kırklareli meatball formula at the levels of 2, 4, 6 and 8% respectively would improve nutritional value and health benefits. The gradual cowpea flour addition has significantly affected certain quality characteristics of the meatball samples. Cowpea flour added meatballs have been seen to have higher protein, ash, carbohydrate, dietary fiber contents, L^* and b^* colour values whereas lower fat, salt, moisture contents and a^* values than the control samples. The reduction in weight loss of meatballs was improved with cowpea flour addition. The total trans fatty acids lower in cowpea flour added (≥4%) meatballs compared to control sample. There are also significant differences between texture (hardness and firmness) and sensory properties of meatball samples with cowpea flour addition. According to the obtained results, cowpea flour addition can be acceptable up to 4% in Kırklareli meatball production to improve nutritonal value without sacrificing traditional taste and flavour.

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Availability of supporting data
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Authors' contributions
The consultancy of this study was carried out by OD and IY, and the planning was carried out by OD, IY and EK. Laboratory analyzes of the study were done by EK. The authors contributed to the article writing and OD, EK, and IY reviewed and approved the final version.

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Declarations

Ethics approval and consent to participate
Not applicable (The manuscript does not report on or involve the use of any animal or human data or tissue).

Consent for publication
All authors have been consenting for publication of this manuscript.

Competing interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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